*Human–Wildlife Interactions* 16(2):217–232, Fall 2022 • digitalcommons.usu.edu/hwi

# U.S. public opinion of reproductive control options for free-roaming horses on western public lands

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***Abstract:*** Free-roaming horses (*Equus ferus caballus*; horses) inhabit public rangelands located primarily in 10 western U.S. states. Recent horse population increases are impacting rangeland ecosystems, native wildlife species and their habitats, and exacerbating conflicts with domestic livestock grazing. While contraceptives and physical sterilization are promising options to manage horse herd levels, public opinion concerning the use of fertility control is not well understood. To better inform policymakers, we completed a rigorous study of a random sample of public land stakeholders across the United States ($n$ = 3,500) in 2020 using a Likert scale online survey to assess their level of agreement with the general use of reproductive controls and their preferences regarding 4 available reproductive control options. We used chi-square likelihood ratio tests to determine the associations between the knowledge of horse origins in North America and horse management in the United States, and public support of contraception and sterilization methods to control horse populations. We also assessed the associations between survey responses and respondent demographics. Most respondents either "somewhat agreed" or "strongly agreed" with the use of contraceptives to control horse birth rates (36.6% and 26.9%, respectively) when no specific type of contraceptive was described. Respondents who believed horses were native to North America "strongly agreed" with the statement regarding the use of contraceptives less often (22.2%) than respondents who recognized that European explorers introduced horses (36.6%) or believed horses arrived by crossing a land bridge (35.8%); however, this association exhibited very low power to predict the response ($\lambda < 0.1$). Similarly, while there were some associations indicated by chi-square analyses between demographic variables and support for contraceptives, these associations exhibited very low power to explain the responses. When asked to rank 4 generalized population control options, more respondents ranked physical sterilization as their preferred option (37.1%). There was an association between age and ranking order of sterilization. For ages 18–53, the range was 40.6–45.3%, significantly more than older ages, 54 to ≥73, where the range was 31.1–33.8%. Knowledge did not influence the preference for control options. Our results suggest that our respondents were more supportive of the use of contraceptives or sterilization, when described in generalities, to control the birth rates in free-roaming horses. Our research provides policymakers with objective, novel insights into public knowledge and perceptions concerning the population control of free-roaming horses on designated western rangelands. We encourage the federal, state, and tribal agencies charged with the management of free-roaming horses to develop and deliver outreach programs to better educate public land stakeholders about the ecological and economic impacts of free-roaming horses on western landscapes and efficacy of available population management options to mitigate impact and sustain herds.

***Key words:*** birth control, contraceptives, *Equus ferus caballus,* free-roaming horse, management, public land, public opinion, public survey, reproduction control, sterilization

**The Wild Free-Roaming** Horses and Burros Act of 1971 assigned management authority for free-roaming horses (*Equus ferus caballus*; horses) and burros (*E. asinus*) on designated federal rangelands in the western United States to the Bureau of Land Management (BLM) and U.S. Forest Service (USFS; Public Law 92-195 1971). The number of free-roaming equids on BLM-administered lands was estimated to be 86,189 on March 1, 2021 (BLM 2021*a*), a 3.2-fold increase above the legislatively established appropriate management levels. Moreover, popu-

lation numbers were at appropriate management levels on only 35 of the 177 (19.8%) BLM herd management areas in March 2021 (BLM 2021*a*). Annual average growth rates for free-roaming horses in the western United States can reach 20% (Eberhardt et al. 1982), resulting in near exponential overall population increases in the last 15 years on BLM herd management areas (Scasta et al. 2018).

For the last 15 years, private adoption rates have declined steadily (Scasta et al. 2018). Meanwhile, the western United States is in a warming, drying climate trend, resulting in diminished grass growth and water availability, further decreasing the number of horses that these rangelands can sustainably support (Polley et al. 2013). When horses are over carrying capacity within an area, they can increase the negative effects of the current warming climate trend on rangeland plant growth, soil, and water. Beever et al. (2018) and Davies and Boyd (2019) reported substantive negative ecological impacts to soil compaction, vegetation density, and water resource availability and suitability as a result of increasing horse populations, emphasizing the need to slow their reproduction rates (Beever et al. 2018).

There are 2 general ways to control reproductive output in horses. The first is physical sterilization, such as surgically "neutering" the animals via the removal of ovaries (ovariectomy) or testes (castration, orchiectomy), and the second is immunocontraception including porcine zona pellucida (PZP) vaccines such as Zonastat-H® and PZP-22 (Science and Conservation Center, Billings, MT, USA), and SpayVac® (SpayVac-for-Wildlife, Inc., Sidney, British Columbia, Canada), and more recently the antagonist to the gonadotropin releasing hormone (GnRH) known as GonaconTM-Equine (National Wildlife Research Center, Fort Collins, Colorado, USA; Kane 2018). In addition, recent development of intrauterine devices (IUDs) for fertility control in female horses may offer an additional strategy for reducing conception rates in feral horse populations but remains in experimental stages (Gradil et al. 2021). Thus, while multiple options for fertility control exist, large-scale delivery and long-term applications of controls require additional research and consideration to ensure success (Garrott and Oli 2013). Not surprisingly, in their 2021 report, the BLM reported only 735 horses were treated with a method of immunocontraception as compared to 9,181 horses removed from herd management areas, with only 3,311 placed in adoptive private care, in a year when there were an estimated 86,000 horses on the range (BLM 2021*b*).

The National Research Council (NRC 2013) has highlighted the need to incorporate public input for the nation's free-roaming equid management programs to succeed. While the American public holds diverse beliefs and values concerning the value and management of the nation's wildlife and natural resources, and a variety of media outlets and special interests have been shown to influence public opinion (Jacobson and McDuff 2009), science-based evidence concerning public support may be lacking. Past assessments of public opinion of equid population control options include only 2 fairly recent surveys totaling approximately 700 respondents. Rodriguez (2020) reported general public support based on 150 respondents for physical sterilization and chemical contraceptives, when either emotional or scientific information was provided with the survey question. Public Policy Polling (2017) included 1 question regarding the use of contraceptives on horses. They reported that 76% of the 556 respondents supported the use of birth control.

Our survey research addresses the NRC concern to better incorporate public opinion in the management of horses and inform the public of the tradeoffs and consequences of horse population "self-limitation" (NRC 2013). Our objectives were to (1) gain greater insights into national public opinion regarding preferences for available reproductive control options for horses, and (2) assess if these opinions were associated with or influenced by respondents' demographic characteristics and basic knowledge concerning the origin of horses and the use of physical sterilization as a legitimate population control measure.

## Methods

### Survey instrument

Our survey instrument included 40 questions about horse ecology and management; for this analysis, we focused on 8 questions (i.e., 4 demographic, 2 knowledge, and 2 opinion questions; Appendix 1) to assess public knowledge about horses in the United States and public opinion concerning available options to man-

age their reproductive output. Four demographic questions asked respondents to include in which region of the United States they resided, gender, age, and income (Appendix 1).

We assessed respondent knowledge of horses and their management by asking them to identify the origin of horses in North America and if sterilization (neutering/castration) is a legal option available to the U.S. government to manage horse population numbers. Next, we asked 2 opinion questions. The first question used a Likert-type 1-to-5-point scale (1 = strongly disagree, 5 = strongly agree), asking respondents to indicate their level of agreement with "using contraceptives to control the number of foals born each year." The second question was designed to measure the respondent's preferences for 3 available reproductive control strategies for horses, very generally described as "permanent sterilization," "chemical immunocontraceptives," and "no reproductive control" for horses. The question asked respondents to rate their preferences for each of these options (1 = most preferred option).

Members of the state of Utah's BLM Wild Horse and Burro Program, USFS, and a University Cooperative Extension Rapid Response Team of scientists based in the western United States reviewed drafts of the questionnaire, prior to its dissemination. Utah State University's Office of Human Subjects Research Internal Review Board reviewed and approved (#11244) this survey research protocol.

## Survey sample and recruitment

We organized our survey sample recruitment by dividing the United States into 5 geographic regional subsets. Regions were stratified by the 48 conterminous U.S. states as "Midwest" (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin), "Northeast" (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont), "Southeast" (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, West Virginia), "Southwest" (Arizona, New Mexico, Oklahoma, Texas), and "West" (California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming). We established an *a priori* minimum response of 400 respondents from each of these regional subsets. In addition to their U.S. region (Midwest, Northeast, Southeast, Southwest, West), additional demographic questions included respondents' gender (female, male, non-binary, or other), income (<$25K, $25K to <$50K, $50K to <$75K, $75K to <$100K, $100K to <$150K, $150K–$200K, and ≥$200K), and age (18–21, 22–37, 38–53, 54–72, ≥73).

We contracted with Qualtrics Experience Management (Provo, Utah, USA) to administer the online survey from June to August 2020. We provided a letter sent via email by Qualtrics to randomly recruit potential survey participants from multiple market research panels (i.e., groups of people that have already consented to taking online surveys). The letter explained the purpose of the survey research, time estimated to complete the questionnaire (approximately 10–15 minutes), assurances of anonymity, and incentives available. Incentives included respondents' choice of cash, airline miles, gift cards, redeemable points, sweepstakes entrance, or gift vouchers. To avoid self-selection bias, the recruitment letter avoided providing specific details concerning question content. Qualtrics tracked numbers of completed surveys until the number of desired respondents was attained and evenly distributed by region. While survey panels allow for a rapid national respondent pool, people with lower incomes, older than 65, and rural are less likely to participate in survey panels due to their reduced internet access (Das et al. 2018); thus, these sections of society may be under-represented. We included demographic questions of age and income in our survey to ensure that we acquired a similar proportion of these demographics as existed in the United States (Frey 2020, U.S. Census Bureau 2021). We did not include a demographic question regarding rural or urban location, based on results of a survey conducted by Wood et al. (2022), which determined that this metric did not have any predictive ability to explain a respondents' knowledge of free-roaming horse ecology and management. Qualtrics survey administrators reviewed and sorted responses for quality, rejecting those that demonstrated <5 minutes in response time to complete, selected the same response to all questions, and/or did not complete the entire set of questions. Once the *a priori* quota

of respondents was reached for region, income, and age, the survey was closed.

### Data analysis

We used Statistics Package for the Social Sciences (SPSS; IBM 2020) to analyze the survey responses. Specifically, we calculated Crosstabs descriptive statistics to compare the interactions between the level of agreement with available birth control options, demographic characteristics, and responses to the 2 knowledge questions. Within Crosstabs, we conducted a Pearson's chi-square ($\chi^2$) test for associations between each combination of responses to the questions concerning preferences for contraceptive options, respondents' demographics, and respondents' knowledge, setting a *P*-value <0.05 as statistically significant. We conducted *post-hoc* Bonferroni tests used to identify statistical differences among categories of pairwise comparisons. Additionally, we evaluated lambda (λ) for each dependent by independent variable comparison. Lambda is a measure of association that reflects the proportional reduction in error when considering the ability of an independent variable to predict the responses of a dependent variable. A value of 1 indicates that the independent variable perfectly predicts the dependent variable (Goodman and Kruskal 1954, Clason and Mormody 1994).

To compare the rank order of preference of contraceptive options, we conducted a Friedman test, comparing respondents' overall rank distribution of the options presented. A statistically significant difference in rank was recognized at a *P*-value <0.05. Next, we conducted an independent sample Kruskal-Wallace (KW) rank test to determine the associations between the ranking of 4 reproductive control options and each of the 4 demographic variables and 2 knowledge questions. A difference in ranking distribution was considered significant at *P*-value <0.05. For those combinations with statistically significant differences, we then used Bonferroni tests (Zar 1999) for differences to determine if there were differences in the proportion of responses that ranked an option as their primary option.

## Results

Our analyses determined that demographics and related knowledge of horses had very little influence on the U.S. public's opinion of reproductive management options for horses on federal public lands. Overall, the U.S. public has little knowledge as to the origin of horses in North America and the legal options available for horse management by federal agencies. Our respondents were supportive of the general idea of using contraceptives to manage horse populations on federal rangelands. Additionally, they preferred permanent reproductive control to contraceptives.

### Demographics and knowledge

Our data set for this study comprised 3,500 respondents; for our question asking respondents to rank reproductive control options, 226 respondents did not participate in this question, resulting in 3,274 responses for this question. The regional distribution of our survey sample exceeded our quota in all regions except the Southwest (Figure 1). Survey respondents were predominantly male (64%); due to a low response rate of sexes other than male or female, we continued our analyses using only these 2 sexes. The range of respondents within each income and age bracket was similar to the distributions of these metrics within the United States at the time of the survey (U.S. Census Bureau 2021; Figure 1).

Approximately one-third (33.6%) of our respondents selected that horses were introduced with European explorers; 24.1% indicated that horses were native, 16.5% indicated horses came with early humans over the Bering land bridge, and 25.8% didn't know the origin of horses in North America. The majority of our respondents (76.7%) did not indicate that sterilization (neutering, castration, etc.) was a legal option available to federal managers.

### Contraceptives to birth control

Most respondents (63.5%) "somewhat agreed" or "strongly agreed" to the statement "using contraceptives to control the number of foals born each year" to manage horse populations (36.6% and 26.9%, respectively). However, there were some statistical differences in the level of support by geographic region ($\chi^2$ = 28.18, df = 16, $P$ = 0.030; λ = 0.00). Based on Bonferroni *post-hoc* tests, a larger percentage of Northeastern respondents (32.2%) strongly agreed with this statement as compared with Midwestern (24.5%) and Western (22.8%) re-

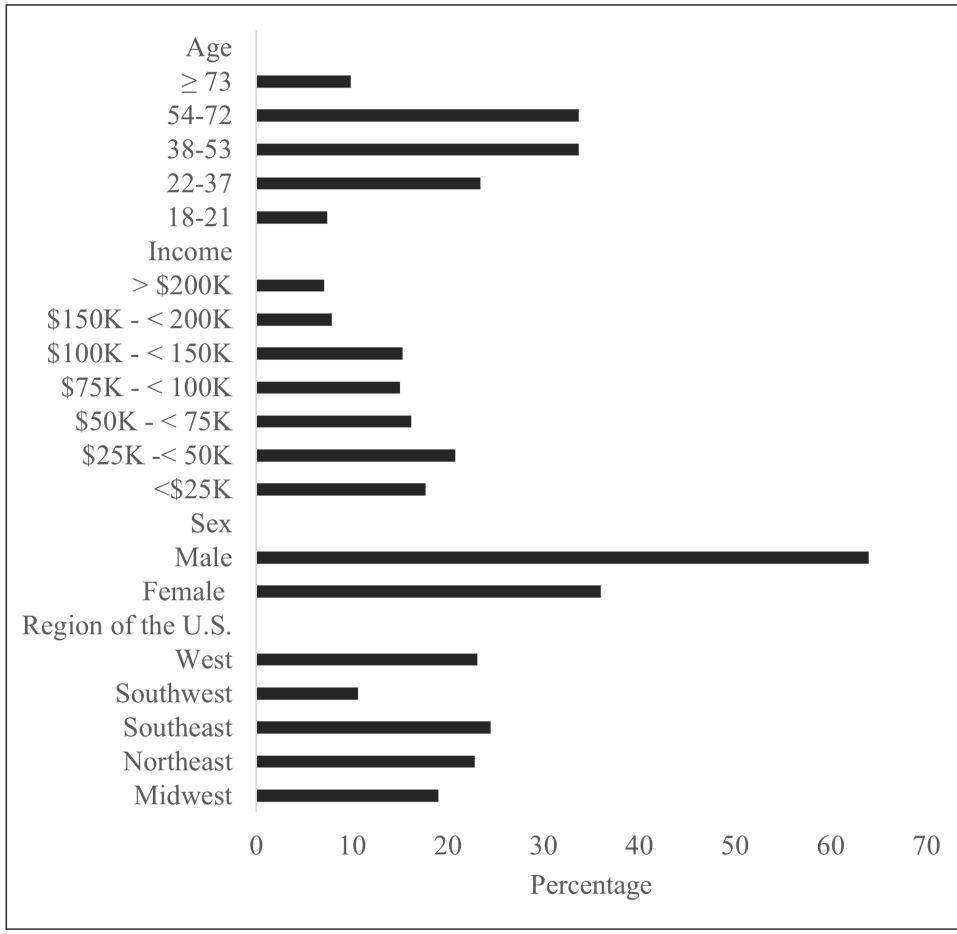


**Figure 1.** Distribution of *n* = 3,500 respondents by region of residency, sex, income, and age in a U.S. national online survey of the public knowledge of free-roaming horse (*Equus ferus caballus*) management, 2020.

spondents; a similar percentage of each region selected "somewhat agree" (range 30.5–38.4%; Figure 2). Sex also influenced support for contraceptives ($\chi^2$ = 28.42, df = 4, $P$ = 0.00; $\lambda$ = 0.00) with a larger percentage of male respondents (30.1%) indicating they strongly agreed as compared with females (21.3%; Figure 2). Income class influenced support for contraceptives ($\chi^2$ = 44.53, df = 24, $P$ = 0.007; $\lambda$ = 0.05), with a larger percentage (46%) of respondents earning $150K to <200K indicating that they "strongly agreed" with use of contraceptives to control horse populations as compared with any other income class, excepting those earning >$200K (38.3%; Figure 2). A larger percentage of respondents earning <$25K (34.7%) did not have an opinion regarding the use of contraceptives as compared with other income classes.

There were several statistically significant associations between respondents' age and agreement with use of contraceptives ($\chi^2$ = 87.60, df = 16, $P$ = 0.00; $\lambda$ = 0.03). Most respondents aged 18–21 (36.7%) reported no opinion regarding the use of contraceptives, more than any other age bracket (Figure 2). Those respondents aged 38–53 "strongly agreed" with the use of contraceptives more than any other age group (36.3%). Respondents aged 54–72 and ≥73 "somewhat agreed" with the use of contraceptives more than any other age group (41.9% and 47.2% respectively; Figure 2). Based on $\lambda$ values, however, no single demographic characteristic exhibited predictive power for support of "using contraceptives to control the number of foals born each year."

Respondents' knowledge pertaining to the origins of horses influenced their support of contraceptives; however, the predictive pow-

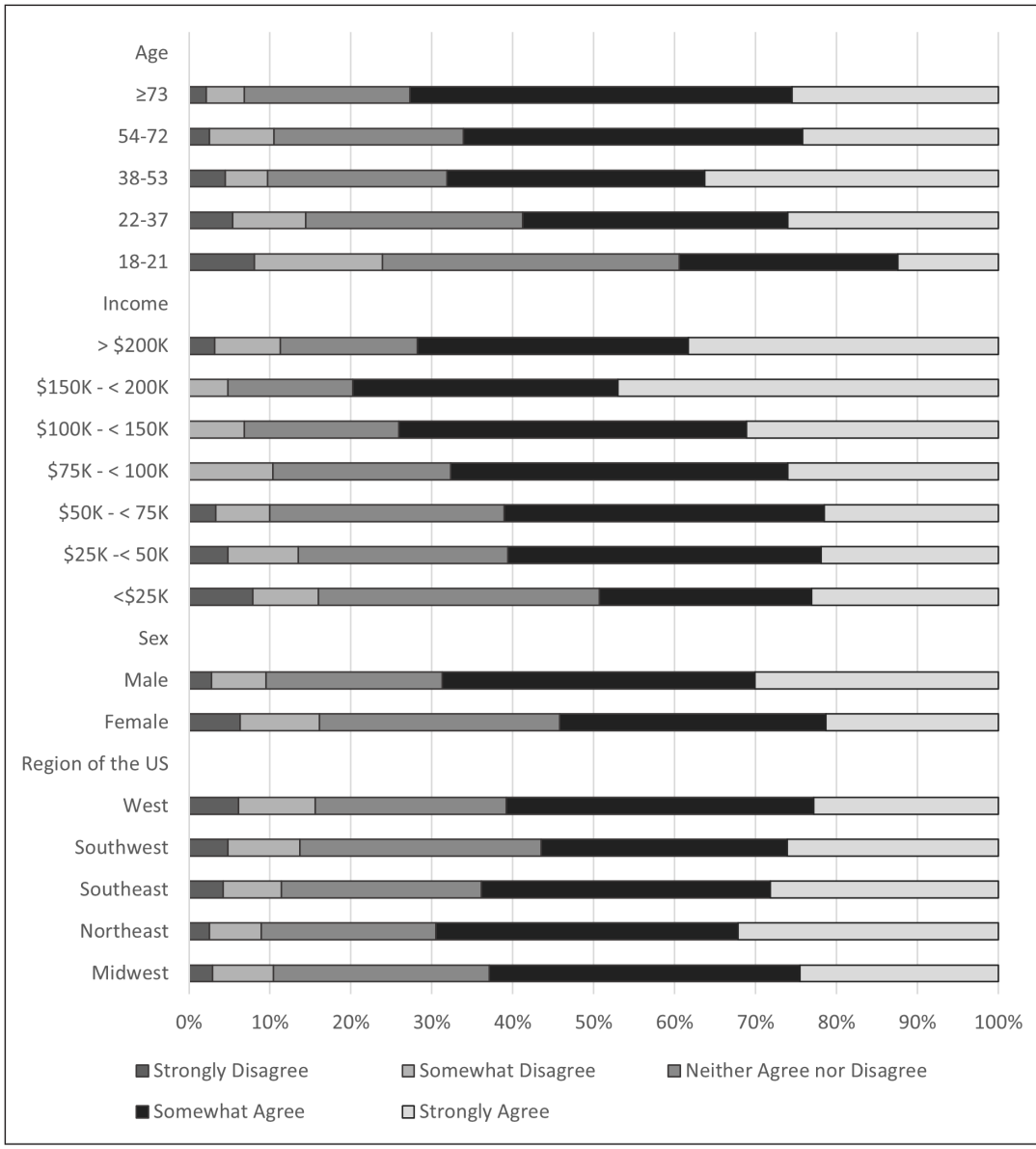


**Figure 2.** For 4 demographics, the percentage of respondents indicating their agreement to the statement "Using contraceptives to control the number of foals born each year" as a method to control free-roaming horse (*Equus ferus caballus*) populations, as indicated in an online survey of the U.S. public's knowledge and opinion of free-roaming horse management, 2020 ($n$ = 3,500).

er of this association was extremely low ($\chi^2$ = 189.95, df = 12, $P < 0.001$; $\lambda = 0.02$). Respondents who believed horses were native to North America "strongly agreed" with the statement regarding the use of contraceptives less often (22.2%) than respondents who recognized that European explorers introduced horses (36.6%) or believed horses arrived by crossing a land bridge (35.8%; Figure 3). Respondents who indicated that they "did not know" the origin of horses "strongly agreed" least often (15.7%) and selected "neither agree nor disagree" more often (38.9%) than any other group (Figure 3); other comparisons were statistically similar.

Whether respondents knew sterilization was legal influenced their opinion toward the use of contraceptive options; however, the predictive ability of this association was extremely low ($\chi^2$ = 172.505, df = 4, $P < 0.001$; $\lambda = 0.017$). A larger percentage of respondents who did

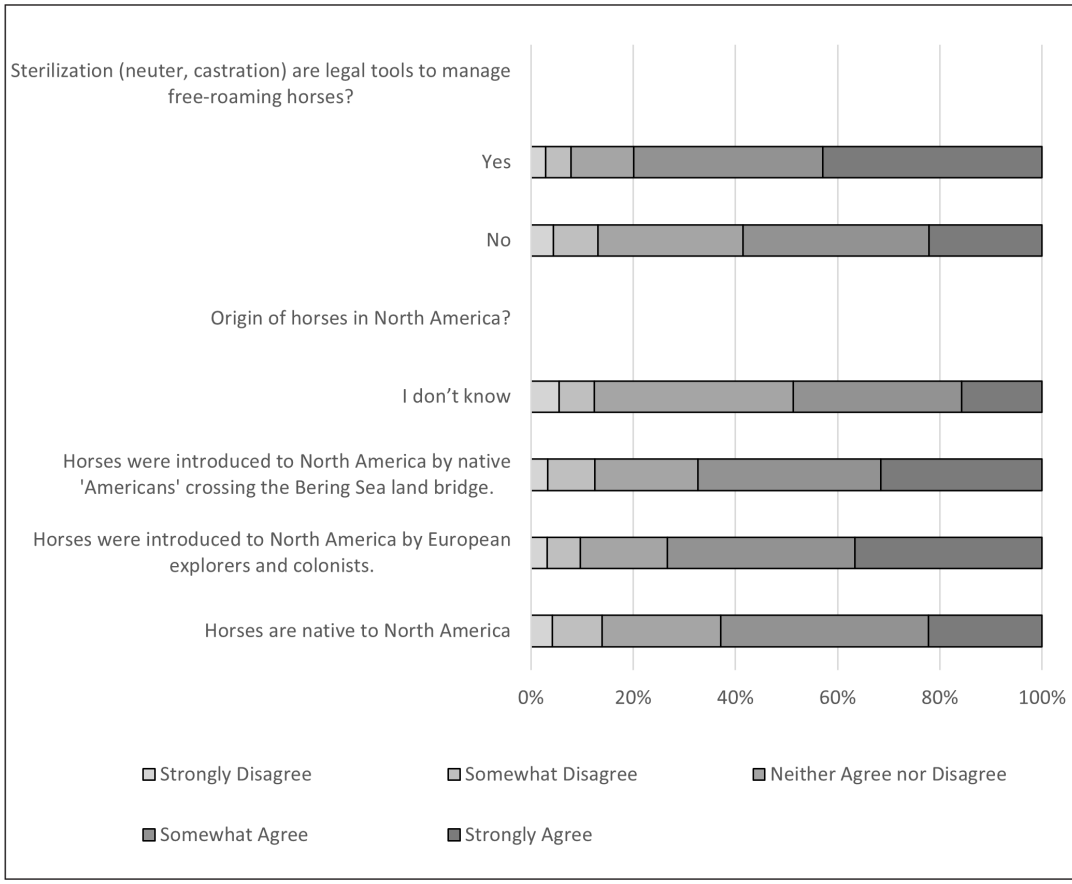


**Figure 3.** The percentage of respondents that indicated their agreement to the statement "Using contraceptives to control the number of foals born each year" as a method to control free-roaming horse (*Equus ferus caballus*) populations, compared to their knowledge of free-roaming horses, in an online survey of the U.S. public, 2020 ($n$ = 3,500).

not know sterilization was a legal birth control option were unsure of the use of contraceptive options as compared with those who knew these options to be legal (28.4% and 12.3%, respectively). Additionally, a smaller percentage of respondents who did not know sterilization was legal "strongly agreed" with the statement regarding the use of contraceptives (22.1%) as compared with those respondents who knew it was legal (42.9%; Figure 2); all other comparisons were statistically similar.

## Preference for fertility control

We asked respondents to rank their preference for 2 general methods of fertility control, "no reproductive control should be conducted on horses," and "chemical immunocontraceptives for horses in holding facilities." A Freidman's test of rank comparing the distribution of ranking preference among the 4 choices indicated a statistical difference (KW test statistic = 546.6, $n$ = 3,274, df = 3, $P < 0.001$; Figure 4). In the following sections we describe the distribution of ranking preferences for each option.

*Physical permanent sterilization (spaying/neutering/castration) of male or female free-roaming horses***.** The largest proportion of respondents ranked physical sterilization as their preferred option (37.1%). The test for associations indicated that the distribution of ranking (the percentage of respondents ranking this option first, second, third, or fourth) for physical sterilization differed by age (KW = 43.993, df = 4, $P < 0.001$) and income (KW = 12.912, df = 6, $P$ = 0.04), but not sex (KW = 0.45, df = 4, $P$ = 0.503) or region (KW = 7.56, df = 4, $P$ = 0.109). However, Bonferroni test results indicated that, within income, there was no difference in the percentage of respondents that selected sterilization as the preferred option. (Table 1). Within age class, the

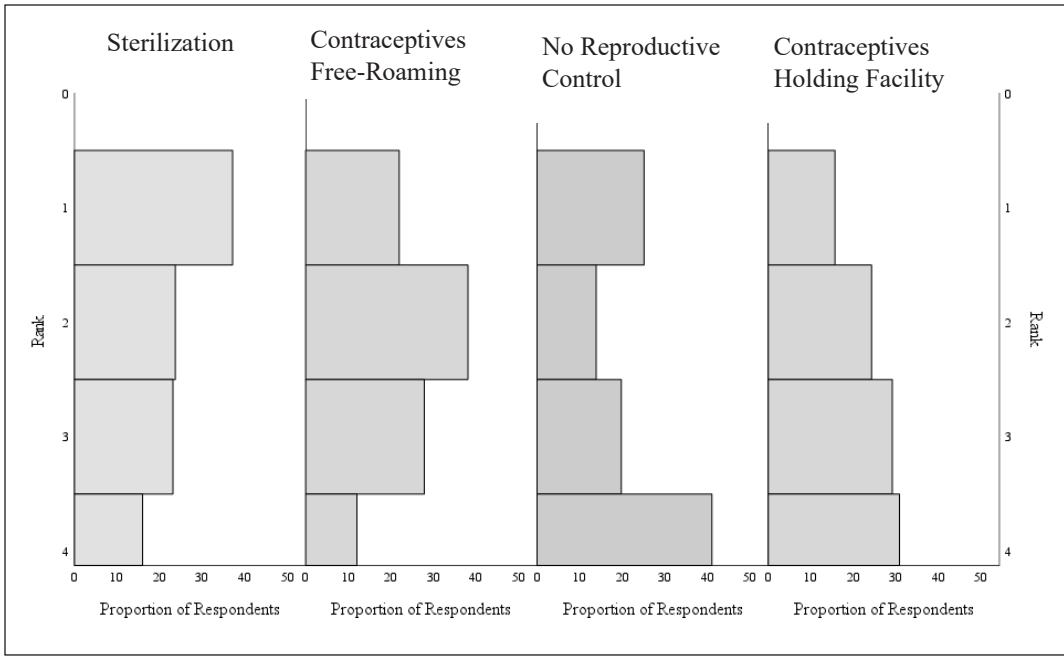


**Figure 4.** Distribution of ranks in order of preference (1 = preferred) for 4 general options of reproductive control. These 4 options were presented as a set, with the instruction to rank them in order of their preference, in an online survey of U.S. public, 2020.

largest proportion of respondents ranked sterilization as the preferred option (Table 1), and there was a difference in ranking distribution as age increased. Younger age classes (18–21, 22–37, 38–53) differed in their opinion from older age classes (54–72, ≥73). For ages 18–53, the range was 40.6–45.3%, significantly more than older ages, 54 to ≥73, where the range was 31.1–33.8%.

Knowledge influenced the percentage of respondents that selected physical sterilization as their primary option. The distribution ranks differed among those who believed horses were native compared with those recognizing horses were introduced by early explorers or did not know the origin of horses (KW = 9.38, df = 3, $P$ = 0.025). However, based on the Bonferroni test results, there were no significant differences among the proportion of respondents ranking this as the primary reproductive control option (Table 2). In general, a slightly smaller percentage of those respondents who believed horses to be native chose physical sterilization as the primary option for reproductive control as compared with those who recognized horses were introduced by explorers (39.6%) or who believed horses arrived by crossing a land bridge (35.1%). Respondents' knowledge of sterilization as a legal option for management did not influence how often they selected this as their preferred option (KW = 2.30, df = 1, $P$ = 0.129; Table 2)

*Chemical immunocontraceptives for male or female free-roaming horses*. Across demographic categories, 22.0% of the respondents ranked chemical immunocontraceptives as their preferred option (Table 1). The distribution of preferences for these contraceptives (the percentage ranking this option first, second, third, or fourth) differed between sex (KW = 6.091, df = 1, $P$ = 0.014) and among age categories (KW = 23.243, df = 4, $P$ = <0.001; Table 1); however, there were not differences among income classes (KW = 5.55, df = 6, $P$ = 0.475) or region of the United States (KW = 7.2, df = 4, $P$ = 0.125). Fewer female (19.6%) than male (23.3%) respondents ranked contraceptives for horses as the preferred option (Table 1). Younger respondents (aged 18–21) ranked this as their primary selection significantly less than those aged ≥73 (19.0% and 25.0%, respectively; Table 1).

Both knowledge of the origin of horses in North America (KW = 20.827, df = 3, $P$ < 0.001) and knowledge of legal population control options (KW = 9.107, df = 1, $P$ = 0.003) influenced the selection of "chemical contraceptives" as

**Table 1.** Crosstabulations indicating the percentage of respondents selecting methods of free-roaming horse (*Equus ferus caballus*) reproductive control as the highest preference among age, income, region, and sex in an online survey of U.S. residents, 2020. These 4 options were presented as a set, with the instruction to rank them in order of their preference. Superscripts indicate significant differences at $P < 0.05$ within a column | demographic for each independent variable ($n = 3276$). The complete phrasings of the statements were as follows: sterilization = physical, permanent sterilization such as neutering, castration, or spaying of male or female free-roaming horses; birth control = chemical immunocontraceptives (i.e., birth control) for male or female free-roaming horses; no population control = reproductive control should not be an option to reduce free-roaming horse populations; and birth control in holdings = chemical immunocontraceptives (i.e., birth control) for male or female horses in holding facilities.

| | Sterilization | Birth control | No population control | Birth control in holdings |
|---|---|---|---|---|
| Combined | 37.17 | 22.0 | 25.2 | 15.7 |
| U.S. region | | | | |
| Midwest | 37.5 | 20.5 | 25.0 | 17.0 |
| Northeast | 37.8 | 24.9[a] | 21.5 | 15.9 |
| Southeast | 34.6 | 22.3 | 27.0 | 16.2 |
| Southwest | 44.7 | 16.3 | 26.4 | 12.6 |
| West | 35.6 | 22.7 | 26.4 | 15.4 |
| Sex | | | | |
| Female | 37.9 | 19.6[a] | 28.7[a] | 13.7[a] |
| Male | 36.7 | 23.3[b] | 23.1[b] | 16.8[b] |
| Income | | | | |
| $0 to <$25K | 40.9 | 19.5 | 27.9 | 11.6 |
| $25K to <$50K | 35.6 | 22.8 | 27.8 | 13.8 |
| $50K to <$75K | 37.4 | 19.7 | 25.0 | 17.9 |
| $75K to <$100K | 37.0 | 20.4 | 25.7 | 16.8 |
| $100K to <$150K | 38.9 | 22.4 | 20.8 | 17.9 |
| $150K to <$200K | 34.6 | 26.8 | 19.5 | 19.1 |
| >$200K | 31.2 | 27.7 | 25.1 | 16.0 |
| Age | | | | |
| 18–21 | 45.3[a] | 19.0 | 27.5 | 8.1[a] |
| 22–37 | 40.6[a] | 21.9 | 26.5[b] | 10.9[a] |
| 38–53 | 40.8[a] | 21.8 | 24.8 | 12.6[a] |
| 54–72 | 31.1[b] | 21.9 | 26.0[b] | 21.1[b] |
| ≥73 | 33.8[b] | 25.0 | 18.1[a] | 23.1[b] |

the primary strategy for population control. A smaller percentage of respondents who believed horses were native to the United States ranked contraceptives for horses as their primary selection (18.4%) as compared with those who recognized horses were introduced by explorers (23.6%) or believed they arrived via a land bridge (26.0%; Table 2). Respondents who knew that reproductive control was a legal option selected "chemical contraceptives" for horses as their primary method more often (24.5%) than those who did not know it was legal (21.2%; Table 2).

*No reproductive control for free-roaming horses*. Across demographic categories, 25.2% of the respondents ranked "no reproductive control" as their preferred option (Table 1). The distribution of preferences for doing nothing (the percentage ranking this option first, second, third, or fourth) to control horse populations differed

**Table 2.** Crosstabulations indicating the percentage of respondents selecting methods of free-roaming horse (*Equus ferus caballus*) reproductive control as the highest preference for each response to 2 free-roaming horse management questions asked in an online survey of U.S. residents, 2020. These 4 options were presented as a set, with the instruction to rank them in order of their preference. Superscripts indicate significant differences at $P < 0.05$ within a column for each independent variable ($n = 3276$). The complete phrasings of the statements were as follows: sterilization = physical, permanent sterilization such as neutering, castration, or spaying of male or female free-roaming horses; birth control = chemical immunocontraceptives (i.e., birth control) for male or female free-roaming horses; no population control = reproductive control should not be an option to reduce free-roaming horse populations; and birth control in holdings = chemical immunocontraceptives (i.e., birth control) for male or female horses in holding facilities.

| Knowledge question and potential response | Sterilization | Birth control | No population control | Birth control in holdings |
|---|---|---|---|---|
| Origin of horses in North America? | | | | |
| Horses are native to North America. | 34.8 | 18.4[a] | 30.6[a] | 16.2 |
| Horses were introduced to North America by European explorers and colonists. | 39.6 | 23.6[b] | 20.3[b] | 16.6 |
| Horses were introduced to North America by native "Americans" crossing the Bering Sea land bridge. | 35.1 | 26.0[b] | 22.4[b,c] | 16.5 |
| I don't know. | 37.5 | 20.7 | 28.3[a,c] | 13.5 |
| Sterilization, neuter, castration are legal tools to manage wild horses? | | | | |
| Yes | 37.9 | 24.5[a] | 17.9[a] | 19.8[a] |
| No | 36.9 | 21.2[b] | 27.5[b] | 14.4[b] |

by age (KW = 97.85, df = 4, $P = 0.000$), by income (KW = 24.77, df = 6, $P < 0.001$), and sex (KW = 15.12, df = 1, $P < 0.001$); there were not differences among regions (KW = 7.16, df = 4, $P = 0.127$). More female respondents selected this as their primary option (28.7%) as compared with male respondents (23.1%). However, among those respondents selecting no control as their primary option, the Bonferroni test results indicated no statistical differences among age classes (range 18.1–27.5%) or income (range 19.5–27.9%; Table 1).

Knowledge also influenced the proportion of respondents that selected "no reproductive control" as their primary option. Larger percentages of respondents who believed horses were native (30.6%) or "did not know" the origin of horses in North America (28.4%) preferred no reproductive control as compared with those who recognized horses were introduced by explorers (20.3%) or who believed they arrived by crossing a land bridge (22.4%; KW = 31.94, df = 3, $P = <0.001$; Table 2). A larger percentage of respondents who did not know that sterilization was legal selected "no reproductive control" as their primary option as compared with those who knew it was a legal option (27.5% and 17.9%, respectively; KW = 44.84, df = 1, $P < 0.001$; Table 2).

*Chemical immunocontraceptives for horses in holding facilities.* Across demographic categories, 15.7% of respondents ranked the use of contraceptives on horses in holding facilities as their preferred option. The distribution of preferences (the percentage ranking this option first, second, third, or fourth) differed among income classes (KW = 23.609, df = 6, $P = <0.001$), sex (KW = 9.005, df = 1, $P = 0.003$), and age classes (KW = 145.844, df = 4, $P = 0.000$), however, there was no difference among regions (KW = 7.834, df = 4, $P = 0.098$). Among income classes, however, there were no statistical differences among the proportion of respondents selecting this as their primary option (range 11.6–19.1%; Table 1). Female respondents ranked this option as their preferred option less than males (13.7% and 16.8%, respectively). The proportion of respondents selecting this as their first option differed among age classes. Respondents aged 54–72 and ≥73 years ranked this as

their preferred option (21.1% and 23.1%, respectively) more than those respondents aged 18–21, 22–37, 38–53 (range 8.1–12.6%; Table 1).

Knowledge also influenced the distribution of ranking preferences for using chemical immunocontraceptives on horses in holding facilities. Although there was a statistical difference among the ranking order, based on knowledge of horse origins (KW = 31.94, df = 3, $P < 0.001$), the Bonferroni test results indicated no significant differences among the proportions of respondents that selected this as their primary option (range 13.6–16.6%; Table 2). A larger percentage of respondents who were aware that reproductive control is a legal management option selected this as their primary option (19.8%) as compared with those who did not know this was a legal option (14.4%; KW = 8.90, df = 1, $P = 0.003$; Table 2).

## Discussion

Our results suggest that our respondents were generally supportive of the idea of using contraceptives to control populations of horses, similar to a survey of western U.S. citizens conducted by Rodriguez (2020). We purposefully left our questions open to consideration, providing no insight as to the costs, risks, or process involved in any control measure. This provides a glimpse of the public's general acceptance and provides a basis for future surveys to explore the intricacies of support when details are provided.

When given the choice between physical sterilization, chemical contraceptives for horses on rangelands or those held in facilities, or no reproductive controls, the largest proportion of our respondents preferred physical sterilization. Chemical contraceptives were selected less often for horses held in facilities as compared with horses on rangelands. We did not provide details on how any of these methods would be administered or which sex would be targeted, to allow for open interpretation of the question and avoid biasing a response. Rodriguez (2020) determined that using detailed informational messaging can increase respondents' reaction to a survey question. Therefore, future research can assess the extent to which such details may influence public opinion. For example, some individuals may be concerned with selecting a strategy that produces the quickest and/or most sustainable reduction in populations, or the most cost effective, while others may be more concerned with their perceived welfare and treatment of the animals. As we provide increased information regarding such risks, preferences for methods of reproductive control may change.

Our findings revealed differences for the support of contraceptives, in general, by region, sex, income, and age of respondents. However, these same demographic characteristics did not consistently predict preferences (i.e., they exhibited low $\lambda$ values), suggesting there are subtle nuances associated with each demographic characteristic. This outcome suggests that while the influence of demographic characteristics merit discussion, gross generalizations about public support (e.g., "public support increases as income increases") should be avoided when planning.

We expected western U.S. respondents to support population controls more than any other region, based on the fact these respondents are more likely to observe the issue firsthand from living near herd management areas or territories and/or more likely to have awareness of the conflicts among different user-groups of federal lands that involve horse populations. While each study region strongly agreed to the use of contraceptives, surprisingly, Northeastern respondents "strongly agreed" more so than any other region while the smallest proportion of Western respondents strongly agreed as compared to all other regions.

However, recent research suggests that "sense of place" and socialization have little effect on environmental concerns as compared with convenience and the level of financial resources (Jones et al. 1999, Kennedy et al. 2009, Reyes 2016). Sharp and Adua (2009) suggested that one's environmental concern and support for the agricultural environment may be the result of an interaction with rural recreation, rather than simply location of residence. Thus, the nuances of such factors within each region may outweigh one's proximity to horse herds and thus merits further research. One limitation of our study to explain regional differences was the smaller sample size of the southwest region of the United States compared to the other regions. While the sample size was large enough to expect a sufficient cross-section of

the U.S. public, aspects of the southwest United States may have violated this assumption. For example, rural and low economic classes often do not have access to the internet (Das et al. 2018); there are many regions of the southwest that are both rural and have a large portion of lower economic populations, such as the tribal nations. Howard and Morris (2019) determined that 18% of tribal residents do not have internet access, and 33% rely on smartphones for their internet. Often, cost is a barrier to acquiring internet access, even when it is available in their region. Therefore, a smaller representation of southwest United States respondents could equate to an under-representation of tribal nations in this region.

Sex influenced support of the general statement of using contraceptives to reduce birth rates. In our sample, males agreed with the general idea of contraception in larger numbers than did females, although both sexes were generally supportive of this management action. Second to sterilization, which was predominantly ranked as the preferred option, using no reproductive control was favored by more females than males with males favoring chemical contraception. While research has shown that females can demonstrate greater emotional bonding with animals in general, particularly those that can be perceived as companion animals, recent research has determined that both males and females are equally likely to form emotional attachments to animals (Herzog 2010).

However, conventional sex role stereotyping, as well as differing educational and employment opportunities, may lead to females having stronger environmental attitudes than males (Gökmen 2021). Perhaps sex differences in support for horse population control stem from issues other than those related to attitudes toward horses. For example, Czech et al. (2001) determined that males were less supportive of the Endangered Species Act because of the perceived restrictions the law placed on private property rights, rather than because of a lack of environmental concern, whereas females were less concerned about such restrictions. A survey of public opinion that provides more detail concerning the administration of options for contraceptives may help to tease out any substantive differences between males and females. Less than 1% of our respondents identified with "other" than a gender of male or female; therefore, we used only these 2 gender responses for simplicity of analysis. However, the opinions of other gender identifications should be considered in future assessments to gain a fuller understanding of opinions across all gender identifications.

Mohai and Twight (1987) reported that age might be the single most important factor influencing the level of one's environmental concern, independent of education and current and past residence. Yet, when asked about their support for contraception to reduce birth rates of horses, a large portion of the youngest aged respondents (aged 18–21 years old) in our survey population did not have an opinion. Therefore, we suggest that it is this demographic that might benefit the most from targeted outreach education programs. Most of the respondents aged ≥22 agreed at least with the general idea of contraception. Each generation has a unique set of values, based on world events and culture, regardless of where in the United States a person is raised. Manfredo et al. (2021) determined an intergenerational value shift of increasing levels of mutualism (wildlife as counterparts or companions in the broader community) from "Boomers" to "Millennials," with a corresponding decrease in traditionalists (domination of wildlife within their broader community). More research is warranted concerning the influence of age on public opinion regarding horse population control. However, an increase in mutualistic values may indicate an increase in the concern for the well-being and treatment of horses during and after the administration of contraceptives. Educational outreach geared to age and that reflect generational values will improve the understanding of the programs and strategies.

## Knowledge and opinions

Prior research has shown that public support for horse population control depends on both knowledge and values (Riley and Gregory 2012, Vaske and Manfredo 2012), which can vary greatly by demographic factors. The U.S. public, while increasingly exposed to information via a suite of public and social media outlets, may possess limited knowledge pertaining specifically to wildlife and natural resource issues (Jacobson and McDuff 2009). In our study, we found associations between knowledge of

horse ecology and support for management options. However, similar to demographics, knowledge did not consistently predict preferences (i.e., the association exhibited low λ values). Therefore, while the influence of knowledge merits discussion, gross generalizations about public support (e.g., "public support increases as knowledge of carrying capacity increases") should be avoided when planning.

In our study, respondents who believed horses were native to the United States supported the use of contraceptives in lesser numbers than those who recognized that horses were introduced. A study of wild horses (brumbies) in Australia similarly found more support for contraceptives for overabundant, non-native brumbies than for over-abundant, native koalas (*Phascolarctos cinereus*; Drijfhout et al. 2020). Similarly, in New Zealand, Walker et al. (2017) found general support for contraceptive programs to manage the non-native domestic cat (*Felis catus*).

In our survey, we found that larger numbers of respondents who did not know if horses were native or not also tended to have no opinion about contraceptives as compared with those who recognized horses were non-native. Similarly, respondents who did not know about the legal reproductive control options set forth in the Wild Free-Roaming Horses and Burros Act did not support the use of contraceptives. In this case, knowledge, or lack thereof, appears to influence public support for contraceptives. Increasing the public's awareness and knowledge of wildlife and their conservation issues can shape their support for a management action. For example, in Australia, Tisdell and Wilson (2013) determined that support for the management of tree kangaroos (*Dendrolagus bennettianus* and *D. lumholtzi*) increased in relationship to increased public knowledge. Thus, increasing information about contraceptives, the treatment of horses during this process, and the legislated use of such contraceptives, might increase public support for existing and future contraceptive programs.

Our investigation into the opinions of the U.S. public regarding the role of fertility control in managing horse populations was completed as part of a larger survey of U.S. public knowledge and opinion. As such, our survey instrument asked broad questions with common vernacular that could be understood without including a definition or additional information. Our objective in doing so was to obtain an indication of the status quo of public opinion and knowledge, even though this opinion or knowledge may be based on prior incorrect or sensational information—or no prior information. In doing so, we acquired a starting point for understanding the public and for developing education strategies. However, our results may be influenced by any confusion respondents might have had because of our choice of vernacular or multiple possible interpretations of any question. Past research has indicated that these preferences could change if the public was provided more information (Cruz-Martinez et al. 2020, Rodriguez 2020).

While our survey captured the responses of many people across the United States, by no means was it a comprehensive investigation of U.S. public opinion of reproductive control of horses. Rather, it was an initial query that provided an overview of the knowledge gaps and opinions of a random sample of the U.S. public concerning reproductive control of horses. It highlighted issues that warrant more investigation—namely the knowledge, values, and beliefs characteristic of varying demographics that can influence support for future horse management practices.

Our study highlighted a diversity of opinion and lack of knowledge of the public regarding reproductive control of horses, but it only touches upon this large, complex issue. From past research, we know that in addition to knowledge, beliefs and values shape opinion. To sustain free-roaming horse populations, managers require a deeper understanding of the public's belief and value systems. Therefore, federal wild horse and burro programs must find a way to increase knowledge transfer to the public, and in a way that reflects diverse belief and value systems.

The NRC (2013) cited the general opacity of science information as a reason why members of the public distrust federal agencies, such as the BLM. Therefore, it would benefit the BLM Wild Horse and Burro Program to develop and communicate clear, concise explanations of each possible equid population control scenario. These explanations should include, for each possible scenario, media that highlight

each step of the process of administering sterilization and contraception, identifying the pros and cons, without glossing over possible deleterious effects. Future outreach educational programs should incorporate generational learning styles and communication. These programs should not assume the opinions of any population demographic, but rather build upon recent studies such as ours that identify where substantive differences in public opinion may exist.

## Management implications

Respondent opinions about reproductive control in free-roaming horses were influenced at some level by age, sex, income, and region of the United States, albeit with low predictive ability for any demographic characteristics Additionally, knowledge of horses influenced our sample population's opinion on management options, suggesting that knowledge, and potentially values and belief systems, may be related to each of these demographics. Regardless of demographic characteristic, most people were unaware of the details of how contraceptives are administered to horses. We suggest that their knowledge of sterilization was in most cases likely limited to this process for their household pets.

## Supplemental material

Supplemental material can be viewed at https://digitalcommons.usu.edu/hwi/vol16/iss2/6.

## Acknowledgments

Our article reflects an effort conducted by a collaborative group of research and extension professionals. Each member of the group assisted in creating the survey instrument and included: J. Beck, J. Hadfield, T. Messmer, M. Nelson, D. Scasta, L. Singletary, and L. Snell. We thank X. Dai, for providing statistical expertise and guidance. Our study was graciously funded by the University of Nevada-Reno Agricultural Experiment Station, Utah State University Agricultural Experiment Station, and Utah State University and University of Nevada, Reno Extension. Comments provided by A. Clark, HWI associate editor, and 2 anonymous reviewers greatly improved earlier versions of our paper.

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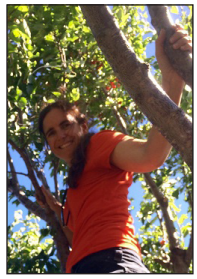

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