# Public Knowledge of Free-Roaming Horses in the United States

**S. Nicole Frey**
Jack H. Berryman Institute, Department of Wildland Resources, Utah State University, Logan, Utah
**J. Derek Scasta** and **Jeffrey L. Beck**
Department of Ecosystem Science and Management, University of Wyoming, Laramie, Wyoming
**Loretta Singletary**
Department of Economics and Cooperative Extension, University of Nevada-Reno, Reno, Nevada
**Laura K. Snell**
University of California Cooperative Extension, Modoc County, Alturas, California

**ABSTRACT:** The Wild Free-Roaming Horses and Burros Act of 1971 provides federal oversight and protection for feral horses (wild free-roaming; WFR horses) that inhabit designated areas on public lands in the western United States. The Bureau of Land Management (BLM) estimated in 2019 that over 80,000 free-roaming equids inhabited 29 million hectares on 177 designated herd management areas. This population estimate exceeds the designated appropriate management level of 26,785. To provide BLM managers with insights regarding the U.S. public knowledge and perceptions about the management of WFR horses in the U.S., we surveyed the public using an online survey process. We hypothesized that respondents from the western U.S. would be more knowledgeable of the ecology and management of WFR horses, because of their proximity to most of the WFR horses managed in the U.S. We stratified the U.S. into five regions, with the intent to acquire at least 400 responses from each; we met this quota in four of the five regions (n of southwest = 376). Overall, the U.S. public was unknowledgeable about the ecology of WFR horses and legal management options to control their populations. While there were some associations between region, sex, age, income, and each of our questions, the strength of these associations was very weak. Therefore, demographics may not be useful in predicting the level of knowledge of the U.S. public concerning WFR horses. Our results highlight the need for improved outreach and communication efforts regarding the issues and consequences of free-roaming equid management approaches.

**KEY WORDS:** equid management, *Equus ferus caballus*, feral horses, public knowledge, survey, wild horses

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## INTRODUCTION

In response to conservation concerns, free-roaming horses (*Equus ferus caballus*) and burros (*E. asinus*) in the United States were given federal protection from private roundups or harassment in 1971 (Wild and Free Roaming Horse and Burros Act 1971). Across the western U.S., wild free-roaming horses (i.e., those horses not claimed by a private entity, and not corralled; hereafter "WFR horses") conjure up notions of majesty and independence, but they also present a pressing management problem. This Act created 31.6 million acres of Herd Management Areas or Wild Horse Territories, with an appropriate management level of WFR horses and burros of 26,785 animals. However, these WFR horse populations have grown on federal rangelands to a current estimated population of over 80,000 horses, far exceeding the appropriate management level (BLM 2022). The management of WFR horses is mandated to be in balance with other land uses such as wildlife, agriculture, and ecosystem function (NEPA 1970); yet, in accordance with this act, WFR horse management requires the input of U.S. citizens. As one can imagine, the opinions on how to control WFR horse populations vary greatly among U.S. citizens. Public opinion ranges from considering WFR horses on western rangelands an invasive species to support for the preservation of these horses as an American icon (Wagman and McCurdy 2011, Scasta et al. 2018, Scasta 2019). Some well-known WFR horse herds, such as the Onaqui Mountain horses of Utah and the Pryor Mountain horses of Wyoming are advertised as a popular tourist attraction (wildhorsetourist .com). In contrast, herds such as the Red Desert Complex of Wyoming (BLM 2021) and the Antelope Valley HMA of Nevada (BLM 2020) have created persistent conflicts for livestock producers and wildlife managers.

In 1982, the National Research Council (NRC) suggested that control strategies for WFR horse populations must be responsive to public attitudes; a successful management program cannot be based on biological or economic considerations only (NRC 1982). Shifts in demographics, way of life, and priorities among U.S. citizens, suggest that American society today may prefer different management practices than were preferred at the writing of the Wild Horses and Burros Act (Manfredo et al. 2018). NRC reports from 1980, 1982, and 2013 highlight the need for research into the social context of WFR horse management; particularly studies that evaluate what aspects of horse management are understood and supported by the public. Once decision makers including public land management agencies, and state and local government representatives understand the different levels of knowledge regarding WFR horses and their management on public lands, they can begin to strategically engage a diversity of backgrounds and viewpoints toward creating a management plan that would be supported by most of the public (NRC 2013). For example, Rodriguez (2020) found that respondent's acceptance of management actions was

influenced by messaging of the information, such as photographs of emaciated horses, and policy presented during surveys. Furthermore, Drijfhout et al. (2020) determined that the public acceptance of some wildlife management actions is influenced by their perception of the animal as native or invasive.

To address this need for more public input, Cooperative Extension and Agricultural Experiment Stations of land grant universities in Utah and Nevada initiated a rapid response team in 2019 to research current and future horse management strategies and the human dimensions of horse management. The team included research and extension specialists located in five western states (California, New Mexico, Nevada, Utah, and Wyoming) who study free-roaming horse biology, ecology, and management in addition to rangeland ecology and human-wildlife conflict management. To solicit public input in herd management decisions, as outlined by the NRC reports, the team committed to assess public knowledge about free-roaming horses and management options on public lands. To date, no survey of national scope had previously been conducted to determine the level of knowledge the public possesses, which could provide a baseline for creating informed opinions regarding horse management on public lands.

## METHODS

### Survey Instrument

We developed eight multiple-choice questions to assess public knowledge about free-roaming horse ecology and management in North America. Questions asked respondents to 1) identify the origin of these horses in North America; 2) estimate the total number horses on public lands; 3) estimate how many foals a healthy female horse produces each year; 4) characterize western rangeland ecosystems (as a proxy for horse forage); 5) identify what happens if you kill a wild horse on public lands; 6) identify which of the western U.S. states have free-roaming horses managed on public lands; 7) identify the tools available to the U.S. government to manage its free-roaming horse population numbers in federally designated horse management areas; and 8) indicate whether natural predators are available to control free-roaming horse populations. The survey also featured four questions to characterize survey respondents' demographic characteristics. These question items asked about state of residence, gender, age, and income. The full survey is available as an appendix to this publication, at www.usuhumanwildlifeinteractions.com/horseknowledge appendix.html.

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 U.S. 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 U.S. into five geographic regional subsets. We stratified regions of 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 - <$50K, $50K - <$75K, $75K - <$100K, $100K - <150K, $150K - <$200K, ≥$200K), and age (18-21, 22-37, 38-53, 54-72, ≥73).

We contracted with Qualtrics Experience Management (Provo, UT) to administer the online survey from June-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 (<$5 monetary value). To avoid self-selection bias, the recruitment letter avoided providing specific details concerning question content. Qualtrics tracked 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, Shrider et al. 2021). Qualtrics survey administrators reviewed and sorted responses for quality, rejecting those that demonstrated less than five minutes 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.

### Survey Response Analysis

We used Statistics Package for the Social Sciences (SPSS; IBM 2020) to analyze the survey responses. Specifically, we used the Crosstabs analysis to conduct chi-square ($\chi^2$) measures of associations between demographic questions and knowledge questions. Two of the knowledge questions allowed for multiple responses; we coded each selection with a binomial response of not selected (0) or selected (1) and considered each selection independently. Within Crosstabs, we conducted a Pearson's $\chi^2$ test for associations between each question and respondents' demographics, setting a P-value < 0.05 as statistically

significant. We conducted *post-hoc* Bonferroni tests 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 (i.e., strength of association) 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); we considered a $\lambda > 0.20$ as a moderate indicator of predictable power for that independent variable.

## RESULTS

Our survey revealed an overall low level of knowledge regarding WFR horses and their management on public federal rangelands in the western United States. While approximately 1/3 of the respondents knew that horses were not native to the U.S., very few knew how many WFR horses were managed, and where they were managed, in western U.S. public rangelands. Very few respondents understood that the western rangelands where most WFR horses live are considered desert or shrub lands, with no common predators to contribute to WFR horse mortality. Similarly, respondents were unaware that WFR horses are protected by law and could not identify which management actions were legally available to the federal government. While there were associations among demographics (i.e., males were better able to identify legal management actions), no one demographic had strong predictive ability (i.e., the association strength was extremely poor) to explain the responses to any questions.

### Human Demographics Responses

There were 3,177 respondents with useable and interpretable responses from all five regions ranging from 376 to 861 per region (mean per region = 635 respondents; Figure 1). 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 genders other than male or female, we continued our analyses using only these two 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 (Figure 2; Shrider et al. 2021).

### Horse-Related Survey Questions and Responses

*How many free-roaming horses are currently in Herd Management Areas?*

We found that few respondents were familiar with the topic of WFR horses on public lands. Only 8.2% of the respondents were aware that there are >75,000 WFR horses on public lands, and the greatest proportion of the respondents (43.2%) did not venture to guess a population estimate. A respondent's region ($\chi^2 = 24.847$, df = 20, P = 0.207) did not have an influence on their response. More males (9.5%) than females (5.7%) were aware of the number of horses in herd management areas ($\chi^2 = 34.996$, df = 5, P = 0.00, $\lambda = 0.000$; Table 1). The knowledge of horse numbers increased with respondents' income ($\chi^2 = 243.363$, df = 30, P = 0.000, $\lambda = 0.000$). Those with the lowest incomes selected the correct response far less (3.7%), than those in the highest income bracket (18.8%; Table 1). Age also influenced the knowledge of horse numbers in herd management areas ($\chi^2 = 173.736$, df = 20, P = 0.000, $\lambda = 0.000$). Respondents ages 38-53 indicated the correct response more than any other age group (12.7%; Table 1). Based on λ values, the power of association for each test was extremely low.

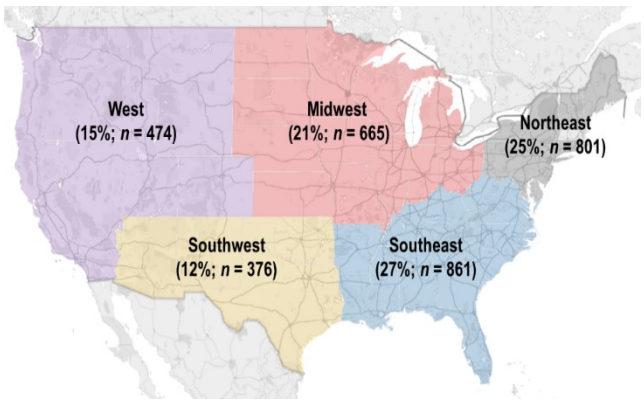


**Figure 1. Regional delineations of the U.S. where respondents completed an on-survey of public knowledge and opinion of wild and free-roaming horses, 2020.**

*What is the origin of free-roaming horses in North America?*

Only 33.2% of the respondents knew that WFR horses were introduced to North America by explorers; however, 16.9% thought horses came to North America via a land bridge. Many respondents (23.6%) thought that WFR horses are native, and 26.3% didn't even venture a guess. The region of respondents' residence influenced their response ($\chi^2 = 28.153$, df = 12, P = 0.005, $\lambda = 0.008$), as did sex ($\chi^2 = 88.1403$, df = 3, P = 0.000, $\lambda = 0.055$), income ($\chi^2 = 67.460$, df = 18, P = 0.000, $\lambda = 0.025$), and age ($\chi^2 = 91.020$, df = 12, P = 0.000, $\lambda = 0.003$). Midwestern respondents indicated horses were introduced more than western respondents (38.5%, 26.2%, respectively). More males (38.2%) than females (23.8%) indicated that horses were introduced (Table 1). Generally speaking, the knowledge of WFR horse origins increased with income bracket from 26% to 40.6%, although there was no discernable linear trend. Respondents ages 22-37 indicated that horses were introduced less than any other class (26.1%), except those ages 18-21 (29.3%; Table 1). Based on λ values, the power of association for each test was extremely low.

*Which of the following western U.S. states have free-roaming horses managed on public lands?*

We found that many respondents did not know where WFR horses live. Many respondents indicated that Montana (41.1%) and Wyoming (48.0%) have WFR horses (Figure 3); these states have 17 herd management areas and territories, combined. Conversely, 24.5% of the respondents indicated that Nevada manages WFR horses; this is quite

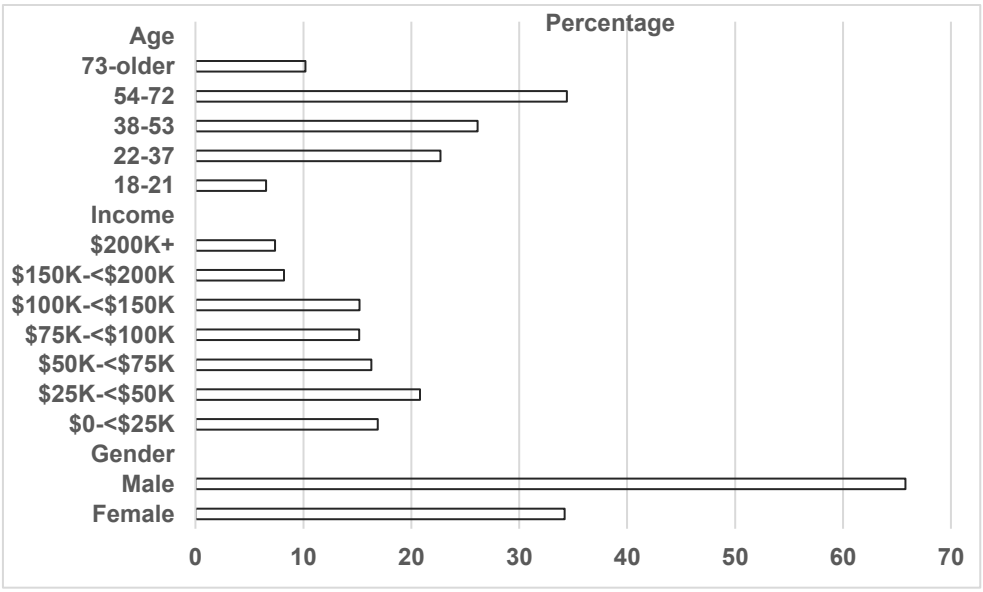


**Figure 2. The percentage of respondents from each questioned demographic, in an on-survey of public knowledge and opinion of wild and free-roaming horses, 2020.**

**Table 1. For each of five survey questions about the respondents' knowledge of free-roaming horses on western public rangelands, the percentage of each demographic that selected the most appropriate response, as indicated by the table headings. Superscripts represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of P <0.05. Online survey of US public (n=3177), 2020.**

| Demographic | There are >75,000 free-roaming horses in herd management areas | Horses were introduced to No. America by European explorers | A healthy mare can birth one foal/year | Rangelands are predominantly desert-like | Rangelands are predominantly shrub |
|---|---|---|---|---|---|
| ***Region*** | | | | | |
| **Midwest** | 7.1 | 38.5[a] | 40.9[a, b] | 8.9 | 4.4 |
| **Northeast** | 10.6 | 34.8[a, b] | 39.6[a, b] | 9.0 | 5.4 |
| **Southeast** | 7.1 | 33.1[a, b, c] | 45.1[b] | 8.6 | 6.4 |
| **Southwest** | 8.2 | 29.5[b, c] | 39.6[a, b] | 13.0 | 8.5 |
| **West** | 7.6 | 26.2[c] | 34.8[a] | 12.0 | 6.5 |
| **Sex** | | | | | |
| **Female** | 5.7[a] | 23.8[a] | 37.2[a] | 8.0[a] | 7.0 |
| **Male** | 9.5[b] | 38.2[b] | 42.5[b] | 10.7[b] | 5.4 |
| ***Income*** | | | | | |
| **$0 - <$25K** | 3.7a | 26.0[a] | 41.8 | 8.6[a, b] | 5.8 |
| **$25K - <$50K** | 4.4[a] | 29.3[a, b] | 36.8 | 7.3[b] | 4.7 |
| **$50K - <$75K** | 4.8[a, b] | 34.4[a, b, c] | 40.2 | 7.1[b] | 5.6 |
| **$75K - <$100K** | 9.3[b, c] | 37.8[b, c] | 39.6 | 9.8[a, b, c] | 7.7 |
| **$100K - <$150K** | 11.2[c, d] | 34.0[a, b, c] | 44.5 | 11.6[a, b, c] | 5.4 |
| **$150K - <$200K** | 16.5[c, d] | 40.6[c] | 44.8 | 16.1[c] | 7.7 |
| **≥$200K** | 18.8[d] | 38.9[b, c] | 39.3 | 15.0[a, c] | 6.8 |
| ***Age*** | | | | | |
| **<21** | 3.8[a] | 29.3[a, b] | 26.9[a] | 12.0[a, b] | 7.7 |
| **22 - 37** | 7.5[a] | 26.1[b] | 30.1[a] | 11.4[b] | 6.9 |
| **38 - 53** | 12.7[b] | 33.1[a] | 40.3[b] | 14.4[b] | 5.3 |
| **54 - 72** | 7.0[a] | 36.9[a] | 47.6[c] | 6.6[a, c] | 6.0 |
| **>73** | 5.3[a] | 39.6[a] | 50.8[c] | 4.0[c] | 4.3 |

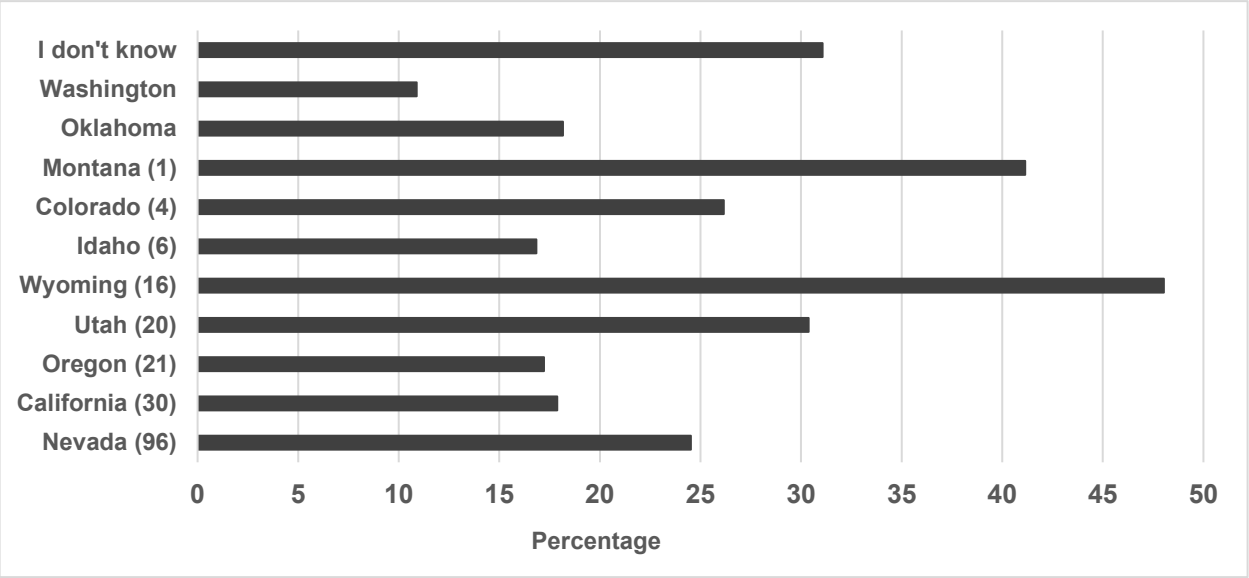


**Figure 3. The percentage of respondents that indicated a state managed free-roaming horses on public rangelands during a national online survey of the US public, 2020. Numbers in parentheses indicate the approximate number of herd management areas in that state.**

shocking, given that 96 herd management areas and territories are in Nevada (Figure 3). While there were many associations between region, gender, income, and age and the selection of each of these states, λ values for each measure of association were <0.00 indicating a very weak association (Table 2).

Western residents selected "I don't know" (22.6%) less than other regions (range: 31.4% - 33.4%), and selected Utah (43.0%) and Nevada (34.4%) more than other regions (range 26.1 - 28.9, 21.8 - 24.6%, respectively; Table 3). Western residents also selected "Washington" (13.3%) more than Midwestern (8.0%) residents. Northeastern (20.5%) and Western (21.5%) residents selected "California" more than Midwestern residents (14.1%; Table 3). Males and females differed in their selection of states that managed WFR horses on federal lands. Females selected California (14.6%), Colorado (23.3%), Idaho (14.1%), Montana (38.7%), Nevada (22.0%), Utah (25.9%), and Washington (7.5%) less often than males, but selected Oregon (16.1%) more often than males (Table 3). Among income brackets and age classes, respondents had the most disparity with their selection of California, Washington, and Wyoming (Table 3); however, trends in selection were difficult to detect.

*A healthy female horse (mare) can give birth to how many foals a year?*

Only 40.6% of the respondents correctly answered that mares may give birth to one foal each year; 29.2% indicated that they did not know. A few respondents (2.1%) selected "one foal every three years", 10.2% of respondents indicated "one foal every two years", and 17.8% indicated "two foals every year". Region influenced respondents' knowledge of horse reproduction ($\chi^2 = 28.670$, df = 16, P = 0.026, $\lambda = 0.000$), as did sex ($\chi^2 = 11.394$, df = 4, P = 0.022, $\lambda = 0.000$) and age ($\chi^2 = 182.728$, df = 16, P = 0.000, $\lambda = 0.006$). Although there was an association indicated between income and this question, there was no association with income and respondents' selection of the correct response ($\chi^2 = 70.451$, df = 24, P = 0.000, $\lambda = 0.000$). Southeastern residents (45.1%) selected the correct response more than western respondents (34.8%). Females (37.2%) indicated the correct response less than males (42.5%). The selection of "one foal each year" increased with age; respondents ages 18-21 selected this response 26.9%, while those respondents ages >73 selected this response 50.8% (Table 1).

*Rangelands predominantly consist of which habitat?*

We asked participants to identify which plant community (we termed it "habitat" on the survey) WFR horses predominantly live in; either "desert-like" or "shrub" were considered accurate answers. Most respondents (60.6%) indicated grasslands as the predominant plant community. Only 9.8% of respondents selected "desert-like" and 6.0% selected "shrubs"; 18.2% of the respondents indicated they did not know the answer. While there was an association between a respondent's region and this question, a respondent's region did not influence their selection of desert-like or shrub ($\chi^2 = 43.719$, df = 16, P = 0.000, $\lambda = 0.000$; Table 1), However, sex influenced the selection for desert-like ($\chi^2 = 30.696$, df = 4, P = 0.000, $\lambda = 0.000$), as did income ($\chi^2 = 96.799$, df = 24, P = 0.000, $\lambda = 0.000$), and age ($\chi^2 = 168.431$, df = 16, P = 0.000, $\lambda = 0.000$).

Males (10.7%) selected desert-like more than females (8.0%); and selected shrub less than females (5.4%, 7.0%, respectively; Table 1). In general, those making less income selected "desert-like" more than those making $150,000 - >$200,000 annually, although this trend was not distinct (Table 1). Income did not influence the percentage of respondents selecting "shrub" as the predominant habitat. Respondents ages 18-53 selected "desert-like" more than respondents ages >54 (ranges 11.4%-14.5%, 4.0%-6.6%, respectively; Table 1); however, there was no trend for the selection of "shrub" within age brackets.

**Table 2. Chi-square tests of association between region, gender, income, and age, and which states were selected in response to the question "Which of the following western U.S. states have free-roaming horses managed on public lands?" in a national on-line survey of the US public (n= 3177), 2020. Lambda estimates of association strength (i.e. PRE) were < 0.00 for all tests of association.**

| | Region | | Gender | | Income | | Age | |
|---|---|---|---|---|---|---|---|---|
| | $X^2$ | P-value (df = 4) | $X^2$ | P-value (df = 3) | $X^2$ | P-value (df = 6) | $X^2$ | P-value (df = 5) |
| **California** | 15.270 | 0.00 | 12.346 | 0.00 | 97.159 | 0.00 | 141.338 | 0.00 |
| **Colorado** | 4.110 | 0.39 | 7.095 | 0.01 | 12.638 | 0.05 | 20.246 | 0.00 |
| **Idaho** | 5.310 | 0.26 | 8.624 | 0.00 | 18.875 | 0.00 | 30.997 | 0.00 |
| **I don't know** | 19.815 | 0.00 | 0.300 | 0.58 | 24.514 | 0.00 | 48.408 | 0.00 |
| **Montana** | 6.640 | 0.16 | 4.039 | 0.04 | 14.391 | 0.03 | 75.749 | 0.00 |
| **Nevada** | 31.348 | 0.00 | 5.857 | 0.02 | 17.892 | 0.01 | 16.723 | 0.00 |
| **Oklahoma** | 9.996 | 0.04 | 0.010 | 0.92 | 0.436 | 1.00 | 2.521 | 0.64 |
| **Oregon** | 2.563 | 0.63 | 5.016 | 0.03 | 6.320 | 0.39 | 42.338 | 0.00 |
| **Utah** | 43.344 | 0.00 | 15.443 | 0.00 | 27.683 | 0.00 | 21.140 | 0.00 |
| **Washington** | 17.621 | 0.00 | 20.125 | 0.00 | 84.083 | 0.00 | 93.700 | 0.00 |
| **Wyoming** | 6.302 | 0.18 | 0.104 | 0.75 | 25.700 | 0.00 | 73.190 | 0.00 |

*Which species is a common predator of free-roaming horses on western public lands?*

Only 4.7% of the respondents stated that there are no common predators of WFR horses, which we considered to be the correct option, given the scarcity of data concerning any regular depredation until very recently. Most respondents (51.9%) thought that cougars/mountain lions (*Puma concolor*) were common predators of WFR horses on western public lands; while cougars do sometimes kill horses where their populations overlap (Andreasen et al. 2021), this is not considered a common occurrence throughout WFR horse distribution. Additionally, 35.2% of the respondents indicated the same for wolves (*Canis lupus*). Few respondents indicated that black bears (*Ursus americanus*) (19.2%) or grizzly bears (*U. arctos horribilis*) (19.1%) were common predators of WFR horses. Many respondents (24.6%) indicated that they did not know the answer.

A respondent's region did not influence the selection of cougar as a common predator ($\chi^2 = 6.601$, df = 4, P = 0.159, $\lambda = 0.001$). There was a slight association between a respondent's selection of cougar and their income, although there was no clear trend ($\chi^2 = 11.290$, df = 6, P = 0.080, $\lambda = 0.004$, Table 4). However, more males (54.2%) selected "cougar" than females (47.5%; $\chi^2 = 12.801$, df = 1, P = 0.000, $\lambda = 0.004$). There was a trend for increased selection of "cougar" as respondents increased in age ($\chi^2 = 37.483$, df = 4, P = 0.000, $\lambda = 0.003$) from 18-21 (39.4%) to >73 (53.3%; Table 4).

A respondent's region did not influence the selection of "none" when asked about common predators ($\chi^2 = 0.577$, df = 4, P = 0.966, $\lambda = 0.000$). Similarly, gender ($\chi^2 = 1.520$, df = 1, P = 0.218, $\lambda = 0.000$) and income ($\chi^2 = 10.249$, df = 6, P = 0.115, $\lambda = 0.001$) did not have an influence on this selection. There was an association between age and the selection of "none" ($\chi^2 = 11.492$, df = 4, P = 0.022, $\lambda = 0.001$). Respondents ages 54-72 selected "none" less than those ages >73 (3.7%, 7.7%, respectively; Table 4). Based on $\lambda$ values, demographic questions exhibited very low association strength with the percent of respondents that selected either "none" or "cougar".

*What happens if someone kills a free-roaming horse that was living within a horse management area on public lands?*

Management of WFR horses is not thoroughly understood by the U.S. public. Many respondents (39.1%) did know that it is a felony to shoot or harass a WFR horse or burro. However, 36.4% indicated that they did not know what the penalty for killing a WFR horse was. Few respondents (4.1%) thought that nothing would happen to a person found harassing or killing a WFR horse on public lands; 6.9% indicated a person would get an official warning, and 13.5% indicated a person would be charged a $250 fine. Based on $\lambda$ values, demographic questions exhibited very low association strength with the knowledge of felony protections for WFR horses.

There was an association with region and the knowledge that killing or harassing a WFR horse is a felony ($\chi^2 = 46.607$, df = 16, P = 0.00, $\lambda = 0.03$). Midwestern residents (32.8%) selected that it was a felony to shoot a WFR horse less than western residents (46.0%, Table 5). There was also an association with sex ($\chi^2 = 17.803$, df = 4, P = 0.001, $\lambda = 0.00$) and age ($\chi^2 = 338.280$, df = 16, P = 0.00, $\lambda = 0.008$). More females (41.7%) indicated that shooting was illegal than males (37.8%), and respondents ages >73 (30.0%) indicated this response less than any other age class, except for those ages 18-21 (Table 5). While there was an association between respondent income and this question ($\chi^2 = 128.063$, df = 24, P = 0.00, $\lambda = 0.001$) a respondent's income did not influence their selection of "felony" for their response (Table 5).

*The U.S. government is authorized to use which tools to manage free-roaming horse population numbers in horse management areas?*

U.S. respondents were relatively uninformed about what tools the federal government can use to manage WFR horse populations on public lands. Many respondents (40.1%) indicated that they did not know what options were legal; only 4.8% indicated that none of the options presented were legal tools for federal management

**Table 3. The percentage of respondents from each region, sex, income, and age that selected a state in response to the questions "Which of the following western U.S. states have free-roaming horses managed on public lands?" in an online survey of the US public (n = 3177), 2020. Superscripts represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of P <0.05.**

| | California | Colorado | Idaho | Montana | Nevada | Oklahoma | Oregon | Utah | Washington | Wyoming | I don't know |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Region*** | | | | | | | | | | | |
| **Midwest** | 14.1a | 26.00 | 16.50 | 41.20 | 22.3$^{a}$ | 15.90 | 16.20 | 28.9$^{a}$ | 8.0$^{a}$ | 51.40 | 33.4 $^{a}$ |
| **Northeast** | 20.5$_{b}$ | 26.00 | 15.70 | 39.00 | 24.6$^{a}$ | 20.50 | 17.40 | 28.8$^{a}$ | 13.7$^{b}$ | 45.30 | 31.6$^{a}$ |
| **Southeast** | 16.7$^{a, b}$ | 27.10 | 17.20 | 44.60 | 22.0$^{a}$ | 18.70 | 17.00 | 27.9$^{a}$ | 9.3$^{a, c}$ | 48.20 | 33.3$^{a}$ |
| **Southwest** | 17.0$_{a, b}$ | 22.30 | 14.90 | 39.90 | 21.8$^{a}$ | 20.20 | 19.90 | 26.1$^{a}$ | 10.6$^{a, b, c}$ | 46.00 | 31.4$^{a}$ |
| **West** | 21.5$_{b}$ | 28.10 | 20.00 | 39.50 | 34.4$^{b}$ | 14.80 | 16.70 | 43.0$^{b}$ | 13.3$^{b, c}$ | 49.20 | 22.6$^{b}$ |
| ***Sex*** | | | | | | | | | | | |
| **Female** | 14.6$^{a}$ | 23.3$^{a}$ | 14.1$^{a}$ | 38.7$^{a}$ | 22.0$^{a}$ | 18.1 | 19.3$_{a}$ | 25.9$^{a}$ | 7.5$^{a}$ | 47.7$^{a}$ | 31.6$^{a}$ |
| **Male** | 19.7$^{b}$ | 27.7$^{b}$ | 18.3$^{b}$ | 42.4$^{b}$ | 25.9$^{b}$ | 18.3 | 16.1$_{b}$ | 32.7$^{b}$ | 12.7$^{b}$ | 48.3$^{a}$ | 30.7$^{a}$ |
| ***Income*** | | | | | | | | | | | |
| **$0 - <$25K** | 11.2$^{a}$ | 21.4$^{a}$ | 12.5$^{a}$ | 36.4 | 20.4 | 18.0 | 18.0 | 23.0 $^{a}$ | 5.4$^{a}$ | 44.1$^{a, b}$ | 37.7$^{a}$ |
| **$25K - <$50K** | 13.5$^{a}$ | 26.9$^{a, b}$ | 16.9$^{a, b}$ | 44.0 | 22.4 | 18.0 | 18.3 | 29.8$^{a, b}$ | 7.7$^{a, b}$ | 53.1$^{c}$ | 32.4$^{a, b}$ |
| **$50K - <$75K** | 13.3$^{a}$ | 29.5$^{b}$ | 18.5$^{a, b}$ | 43.4 | 21.8 | 17.6 | 14.3 | 34.4$^{b}$ | 7.9$^{a, b, c}$ | 51.2$^{b, c}$ | 32.6$^{a, b}$ |
| **$75K - <$100K** | 17.6$^{a, b}$ | 26.1$^{a, b}$ | 19.5$^{b}$ | 41.7 | 28.0 | 19.1 | 17.2 | 36.7$^{b}$ | 11.8$^{b, c, d}$ | 50.0$^{a, b, c}$ | 26.3$^{b}$ |
| **$100K - <$150K** | 23.8$^{b, c}$ | 27.5$^{a, b}$ | 20.3$^{b}$ | 43.1 | 27.7 | 18.2 | 15.7 | 30.6$^{a, b}$ | 13.5$^{c, d}$ | 48.2$^{a, b, c}$ | 27.7$^{b}$ |
| **$150K - <$200K** | 31.8$^{c}$ | 28.4$^{a, b}$ | 12.6$^{a, b}$ | 41.0 | 28.7 | 18.4 | 19.5 | 28.7$^{a, b}$ | 22.6$^{e}$ | 41.8$^{a, b}$ | 24.9$^{b}$ |
| **$200K+** | 28.6$^{c}$ | 22.2$^{a, b}$ | 15.0$^{a, b}$ | 33.8 | 27.4 | 17.9 | 19.2 | 28.2$^{a, b}$ | 18.8$^{d, e}$ | 38.5$^{a}$ | 32.1$^{a, b}$ |
| ***Age*** | | | | | | | | | | | |
| **18 - 21** | 13.9$^{a, b}$ | 15.9$^{a}$ | 11.1$^{a}$ | 26.9$^{a}$ | 15.9$^{a}$ | 20.7 | 21.6$^{a}$ | 20.2$^{a}$ | 10.1$^{a, b}$ | 32.7$^{a}$ | 38.9$^{a}$ |
| **22 - 37** | 22.2$^{b}$ | 25.4$^{b}$ | 15.8$^{a, b}$ | 35.0$^{a}$ | 23.6$^{a, b}$ | 19.4 | 19.6$^{a}$ | 30.7$^{b}$ | 12.2$^{b}$ | 43.1$^{a}$ | 26.4$^{b}$ |
| **38 - 53** | 28.7$^{c}$ | 24.2$^{a, b}$ | 12.7$^{a}$ | 36.3$^{a}$ | 23.3$^{a, b}$ | 17.9 | 22.1$^{a}$ | 27.4$^{a, b}$ | 18.7$^{c}$ | 42.7$^{a}$ | 24.2$^{b}$ |
| **54 - 72** | 10.7$^{a}$ | 29.4$^{b}$ | 20.5$^{b}$ | 49.2$^{b}$ | 28.0$^{b}$ | 17.1 | 13.3$^{b}$ | 33.1$^{b}$ | 6.5$^{a, d}$ | 56.1$^{b}$ | 35.5$^{a}$ |
| **73 - older** | 7.1$^{a}$ | 28.8$^{b}$ | 21.4$^{b}$ | 49.8$^{b}$ | 23.8$^{a, b}$ | 18.3 | 10.2$^{b}$ | 35.3$^{b}$ | 3.4$^{d}$ | 56.0$^{b}$ | 37.8$^{a}$ |

agencies. Based on λ values, demographic questions exhibited very low association strength with the knowledge of which actions are legal tools to manage WFR horses.

A small proportion of respondents (29.2%) correctly indicated that the removal of WFR horses from public lands to federal holding facilities was a legal management tool to control WFR horse populations that are above carrying capacity. Although chi-square tests suggested an association between the region of the U.S. and the selection of this option ($\chi^2 = 8.619$, df = 4, P = 0.071, λ = 0.00), post-hoc tests detected no differences among regions (Table 5). However, more males (32.4%) than females (23.3%) selected removal to holding facilities as a legal option ($\chi^2 = 28.742$, df = 1, P = 0.000, λ = 0.00). There was an association between income and the selection of this option ($\chi^2 = 63.413$, df = 6, P = 0.000, λ = 0.00); selection increased with increasing income (Table 5). There was also an association between age and the selection of this option ($\chi^2 = 24.956$, df = 4, P = 0.000, λ = 0.00), although the trend was not clear (Table 5).

Approximately a third of the respondents (37.4%) correctly indicated that adoption and sale of WFR horses from holding facilities was a legal management option. There was no association between the region of the U.S. and the selection of this option ($\chi^2 = 1.410$, df = 4, P = 0.842, λ = 0.00). However, more males (39.6%) than females (33.1%) selected adoption and sales as a legal option ($\chi^2 = 13.075$, df = 1, P = 0.000, λ = 0.00). Respondents ages 18-21 (25.0%) and 22-37 (34.6%) selected this option less than older age classes (range 37.8% - 41.8%; $\chi^2 = 22.230$, df = 4, P = 0.000, λ = 0.00; Table 5). There was also an association between income and the selection of this option ($\chi^2 = 28.135$, df = 6, P = 0.000, λ = 0.00), although the trend was not clear (Table 5).

Few respondents (22.6%) indicated that sterilization of WFR horses (e.g., spaying, castration) was a legal management option. More Northeast residents (26.6%) than Midwest residents (18.9%) indicated that sterilization was a legal option ($\chi^2 = 13.119$, df = 4, P = 0.011, λ = 0.00).

**Table 4. The percentage of respondents within each demographic that selected either 'no common predators' or 'cougars' in response to the question "Which species is a common predator of free-roaming horses on western public lands?" in a national online survey of US residents (n = 3177), 2020. Superscripts represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of P <0.05.**

| Demographic | No Common Predators | Cougars *(Puma concolor)* |
|---|---|---|
| ***Region*** | | |
| **Midwest** | 4.2 | 55.0 |
| **Northeast** | 4.7 | 48.9 |
| **Southeast** | 5.0 | 52.3 |
| **Southwest** | 4.5 | 49.7 |
| **West** | 4.9 | 53.4 |
| ***Sex*** | | |
| **Female** | 4.1 | 47.5[a] |
| **Male** | 5.0 | 54.2[b] |
| ***Income*** | | |
| **$0 - <$25K** | 5.6 | 46.3[a] |
| **$25K - <$50K** | 5.4 | 51.4[a, b] |
| **$50K - <$75K** | 4.1 | 53.7[a, b] |
| **$75K - <$100K** | 2.7 | 51.5[a, b] |
| **$100K - <$150K** | 5.2 | 56.1[b] |
| **$150K - <$200K** | 6.5 | 53.6[a, b] |
| **≥$200K** | 3.0 | 52.1[a, b] |
| ***Age*** | | |
| **<21** | 5.3[a, b] | 39.4[a] |
| **22 - 37** | 3.9[a, b] | 45.7[a, b] |
| **38 - 53** | 5.4[a, b] | 52.8[b, c] |
| **54 - 72** | 3.7[b] | 57.3[c] |
| **>73** | 7.7[a] | 53.3[b, c] |

Like other options, more males (24.8%) than females (18.6%) selected this as a legal option ($\chi^2 = 15.934$, df = 1, P = 0.000, $\lambda = 0.00$; Table 5). Generally, more respondents selected sterilization as a legal option as income increased (range 16.4% – 20.1%; $\chi^2 = 46.682$, df = 6, P = 0.000, $\lambda = 0.00$; Table 5). Age also had an association with the selection of this management action, although the trend was not clear ($\chi^2 = 26.350$, df = 4, P = 0.000, $\lambda = 0.00$; Table 5).

Euthanasia of sick or injured WFR horses is a currently used legal management tool; however, euthanasia is not currently used to control populations. Few respondents (20.6%) indicated this option as a legal tool to manage WFR horse populations. There was an association between region of the U.S. and the selection of euthanasia ($\chi^2 = 12.804$, df = 4, P = 0.012, $\lambda = 0.00$). Southeast (18.8%) and Southwest (17.0%) respondents selected this option less than respondents from the Northeast (24.6%; Table 5). Like other management options, more males (24.4%) than females (13.3%) selected euthanasia as a legal option ($\chi^2 = 53.624$, df = 1, P = 0.000, $\lambda = 0.00$; Table 5). Generally, more respondents selected euthanasia as a legal option as income increased (range 12.6% - 26.9%; $\chi^2 = 81.402$, df = 6, P = 0.000, $\lambda = 0.00$; Table 5). Age also had an association with the selection of this management action, although the trend was not clear ($\chi^2 = 25.507$, df = 4, P = 0.000, $\lambda = 0.00$; Table 5).

## DISCUSSION

Our study represents an attempt to provide an initial assessment of the U.S. public's knowledge of free-roaming horses in our western rangelands. Our results suggest that the U.S. public lacks basic knowledge about horse ecology and management on western public lands. These findings are similar to Kellert's (1984) survey findings which reported that only a minority of the general public could be considered environmentally literate. This pervasive lack of public knowledge can be problematic for WFR horse managers because it can lead to confusion and disinformation concerning the impacts of WFR horses on western rangelands. This is a knowledge gap that could have implications for the public support of many management actions (Tisdell and Wilson 2004). Past studies suggest that public knowledge of wildlife species, including past management actions, influenced public support for conservation actions (Bremner and Park 2007, Cruz-Martinez et al. 2020, van der Ploeg et al. 2011).

If the general public does not understand how much the WFR horse population is over the management target in many areas, or where WFR horses are located, they may not understand or accept the need to increase actions to manage the overpopulation of WFR horses on western public lands. For example, less than 10% of our respondents knew how many WFR horses on our rangelands and only 25% correctly identified Nevada as having WFR horses, while about half the respondents correctly identified Wyoming as a state with WFR horses. There are several "famous" managed WFR horse herds, including the Pryor Mountain herd in Wyoming and Montana (http://www.pryormustangs.org). Perhaps the popularity of the Pryor Mountain herd influenced the proportion of the U.S. population that knew WFR horses were managed in Wyoming and Montana. However, this could also contribute to a misconception that all WFR horses a) have a distinct ancestry, b) are limited to the few distinct herd management areas that are popularized, and c) need protection from extinction throughout their distribution.

A minority of the respondents were aware that the horse is not native to North America. Similarly, Garrott's survey (2018) found that fewer than 10% of respondents knew that WFR horses are not native to the U.S. Research has determined that the native status of an animal can influence which management options will be supported by the public (Drijfhout et al. 2020). Thus, future educational endeavors should consider messaging that explains the ancestry of free-roaming horses in the U.S., and their populations and distribution across North America – including herds in the eastern U.S.

**Table 5. For each of five survey questions about the respondents' knowledge of free-roaming horses on western public rangelands, the percentage of each demographic that selected the most appropriate response, as indicated by the table headings. Superscripts represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of P <0.05. Online survey of US public (n=3177), 2020.**

| | Shooting or Harassing WFR Horses is a Felony | Adoption and Sales are Legal | Removal to Holding Facility is Legal | Sterilization is Legal | Euthanasia is Legal |
|---|---|---|---|---|---|
| ***Region*** | | | | | |
| **Midwest** | 32.8[a] | 36.4 | 29.6 | 18.9[a] | 19.7[a, b] |
| **Northeast** | 38.0[a, b] | 36.8 | 33.0 | 26.6[b] | 24.6[b] |
| **Southeast** | 41.2[b, c] | 37.9 | 26.9 | 22.0[a, b] | 18.8[a] |
| **Southwest** | 39.1[a, b, c] | 36.7 | 27.1 | 21.3[a, b] | 17.0[a] |
| **West** | 46.0[c] | 39.5 | 28.3 | 23.4[a, b] | 20.9[a, b] |
| ***Sex*** | | | | | |
| **Female** | 41.7[a] | 33.1[a] | 23.3[a] | 18.6[a] | 13.3[a] |
| **Male** | 37.8[b] | 39.6[b] | 32.4[b] | 24.8[b] | 24.4[b] |
| ***Income*** | | | | | |
| **<$25K** | 40.9 | 30.1[a] | 21.7[a] | 16.4[a] | 12.6[a] |
| **$25K - <$50K** | 43.1 | 36.3[a, b, c] | 23.4[a, b] | 19.4[a] | 15.0[a] |
| **$50K - <$75K** | 41.1 | 34.4[a, c] | 27.4[a, b, c] | 20.7[a, b] | 17.8[a, b] |
| **$75K - <$100K** | 39.6 | 40.0[b, c] | 30.3[b, c] | 22.6[a, b] | 22.8[b, c] |
| **$100K - <$150K** | 35.4 | 41.4[b, c] | 35.8[c, d] | 27.1[b, c] | 29.2[c] |
| **$150K - <$200K** | 32.6 | 45.6[b] | 41.8[d] | 33.7[c] | 30.7[c] |
| **≥$200K** | 32.9 | 41.0[a, b, c] | 37.2[c, d] | 29.1[b, c] | 26.9[b, c] |
| ***Age*** | | | | | |
| **<21** | 34.1[a, b] | 25.0[a] | 21.6[a] | 13.9[a] | 13.5[a] |
| **22 - 37** | 42.5[b] | 34.6[a, b] | 31.8[b] | 26.7[b] | 20.8[a, b] |
| **38 - 53** | 39.7[b] | 37.8[b] | 34.3[b] | 25.8[b] | 25.6[b] |
| **54 - 72** | 40.2[b] | 40.1[b] | 25.7[a] | 20.3[a] | 17.6[a] |
| **>73** | 30.0[a] | 41.8[b] | 27.9[a, b] | 18.9[a, b] | 22.0[a, b] |

**Free-roaming Horse Ecology**

The biggest concern in managing horse populations is regulating their growth via natality and mortality. Typically, horse populations increase 18-25% annually (Fort Collins Science Center 2016). Our survey indicated that most of our respondents did not understand the reproductive ability of horses. Similarly, few respondents indicated that were no common predators of WFR horses in the western U.S., although many indicated cougars were a common predator. Our question may have been confusing, because while cougars (mountain lions) may depredate horses in certain areas, this is not considered a common occurrence throughout their distribution (Andreasen et al. 2021). However, these responses indicate that when managers are discussing over-population concerns, the public does not understand the core concepts of population growth and decline.

The respondents also did not know the vegetation communities in which horses live; while some horses do live in grasslands, most live in high-desert and wooded environments (EPA 2022). Many respondents agreed that horses compete with wildlife for food and water. However, fewer respondents agreed that there was competition between horses and livestock. Because the western desert and woodland environments that support horses have low forage productivity, competition for resources between horses and wildlife and livestock is a concern (Scasta et al. 2018, Hennig et al. 2021). Without an understanding of competition between horses and ungulates, the public may not understand the necessity of managing carrying capacity on western rangelands. Thus, educational campaigns to explain this conflict may improve both understanding and support for WFR horse management strategies.

**Free-roaming Horse Management**

The successful management of horses on public lands generally requires the support of the public. In part, the support of management options will depend on the public knowledge and understanding of horse ecology and distribution. However, support will also depend on the public understanding of what actions are authorized for use

by federal management agencies. Our respondents were generally unknowledgeable about WFR horse management, including protections and methods to control their populations. This was similar to findings in Scotland indicating there was little understanding of wildlife population management (Bremner and Park 2007). While increased knowledge of a contentious management issue does not always lead to increased support, it can lead to increased understanding, which influences the ability of disparate groups to achieve consensus and make informed decisions (Riley and Gregory 2012). Managers should identify and implement educational and communication strategies that facilitate early and frequent access to clearly understandable information. This information may increase stakeholder ownership and engagement if it also identifies the consequences of inaction (Messmer et al. 1999, Garrott 2018, Davies and Boyd 2019).

**Influence of Human Demographics**

Demographic characteristics are often thought to be important predictors of public attitudes toward governmental policy. For example, age, race, education, and income have been shown as important predictors of support for climate change policies (Cordano et al. 2010, Holian and Kahn 2015). Within our study, respondents' demographic characteristics (region, age, gender, income) did not appear to predict the extent of their knowledge of WFR horses. While some differences existed between knowledge indicators and demographic characteristics, the power of these associations was negligible. Thus, our study findings prohibit predictive assumptions concerning public knowledge about WFR horses based on where they live within the western U.S., or their gender, age, or income. However, our survey results illustrate several trends of note. For example, respondents earning comparatively the least (≤$25K) and the youngest (18-21) were the least knowledgeable about each of the legal options available to manage WFR horses. If increasing public knowledge can increase public support for conservation actions, an effective strategy might prioritize educational outreach that targets low-income and younger constituents (often the same population).

We documented very few regional differences within our results and did not characterize respondents based on whether they lived in urban or rural settings. This may have inadvertently caused a bias in our data. For example, California, included in the West, with a population density of 252.74 people per square mile, as compared to Nevada's population density per square mile of 28.59 and Utah's 67.63 (Shrider et al. 2021) may inadvertently contribute to an "urban" influence concerning WFR horse knowledge. In a recent study conducted in Utah, rural respondents generally demonstrated more knowledge about WFR horse populations, ecology, and management issues compared with the state's urban respondents (Wood et al. 2023), although the association was similarly weak. As a rapid assessment, our analyses measured associations between one demographic variable and each question asked in the survey. Although the power of association was low, the presence of trends suggests that the analysis was too simple. Perhaps combining demographic variables with measures of environment attitude or opinion of natural resources to understand knowledge would result in a more robust predictor of knowledge.

**Management Implications**

Our survey provides insight into a gap in general knowledge that may be a tool that federal management agencies and educational institutions can fill for more successful management in the future. However, with targeted educational campaigns, the public can be more informed and engaged in management. A better-informed public, with greater understanding of the ecological classification and ecology of WFR horses, is more likely to support management decisions. Further research should be done to truly understand the public perceptions and values regarding wild horses and burros, as well as what management actions can be implemented with the public support. Research into the public values and perceptions, coupled with a messaging and communication system that includes social media may increase the public support and understanding of WFR horses and their management.

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