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Original Research

Western US Residents' Knowledge of Wild Free-Roaming Horses and Their Management on Federal Public Lands ☆

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ABSTRACT

Wild free-roaming (WFR) horses *(Equus ferus caballus)* occur on lands administered by the Bureau of Land Management and US Forest Service in 10 western US states. Little is known about public knowledge concerning management of WFR horse populations. In 2020, we conducted a survey to assess public knowledge with the intent of establishing baseline information that may be used to shape horse management programs and policies on the nation's public lands. We obtained responses from 1 124 residents of the western United States. Our survey asked eight knowledge-based questions of WFR horse ecology and management in the western United States. We conducted chi-square analyses to determine the influence of age, gender, region of residence, and income on respondents' ability to answer these questions appropriately. Our results indicate that these demographic characteristics had little predictive ability to explain the level of the western US public's knowledge of WFR horse ecology and management (for all comparisons, $\lambda < 0.10$). Furthermore, our respondents had little knowledge of WFR ecology and management. Approximately 30% of respondents correctly identified WFR horse origins, 8% correctly indicated WFR horse population size, and 37.5% indicated that they were unaware of legal management options. The lack of basic understanding of WFR horse ecology and management may influence the public's ability to support management efforts or determine fact from propaganda. Approximately 60% of the respondents indicated they primarily used government, university, and organization websites when seeking information. Efforts to increase dissemination of facts on multiple venues, such as social media, websites, and newspapers that link back to government and university websites, could increase public support of future management actions. Additionally, the announcement of management actions, such as round-ups, should consistently include basic background information regarding WFR horse ecology and populations to ensure that the public can make informed conclusions.

Introduction

In 2021, the United States recognized the 50th anniversary of the Wild Free-Roaming Horses and Burros Act of 1971 ("WFRHBA," Public Law 92-195, 1971), which established legal protected status for wild, free-roaming horses *(Equus ferus caballus)* and burros *(Equus africanus asinus)* on federal public lands (hereafter "WFR horses" and "WFR burros"). When not residing on federally managed public lands (e.g., Tribal lands, private sanctuaries), these animals are often referred to as wild, feral, free ranging, or free roaming. While the public may view wild free-roaming horses as iconic symbols of freedom of the American West, these animals can negatively impact our nation's natural resources in competition with wildlife and human needs (Danvir 2018). If left unmanaged, wild free-roaming horse populations can triple in numbers every 6 to 8 yr, posing a substantive threat to both horse health and the ecological health of the public lands on which these animals depend (Garrott 2018). At the time of the WFRHBA passage (1971), an estimated 17 300 horses and 8 045 burros resided on federally managed public rangelands in 10 western states. By 2022, the number of horses on public lands had increased by 273% (~64 604)

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and burros by 121% (~17 780) (Bureau of Land Management 2022). These numbers do not include an estimated 117 000 animals located within the borders of the Navajo Nation, the largest federally recognized Tribal land in the United States (Schoenecker et al. 2021; Wallace et al. 2021), or feral horses on other federally recognized Tribal lands in the western United States.

The WFRHBA tasks the US Department of Interior's Bureau of Land Management (BLM) and the US Department of Agriculture's Forest Service (USFS) with managing the nation's wild free-roaming horse populations located on federal public lands while protecting these lands located primarily in 10 western states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, and Wyoming (Bureau of Land Management 2022). The Great Basin region alone, which stretches from the Sierra Nevada to the Wasatch ranges and comprises nearly all of Nevada and the western side of Utah, is home to more than half of the nation's WFR horses (Zuehlke 2016; Bureau of Land Management 2022).

While the original WFRHBA permits lethal control options, subsequent federal laws either defund or prohibit lethal control methods such as euthanasia and slaughter for food (Jakus 2018). The federal agencies' primary WFR horse population control methods are to remove animals from rangelands to long-term holding facilities, encourage the private adoption of animals held in facilities, and control reproduction of WFR horses on public lands and those in holding facilities; the BLM and the USFS differ in their use of these methods. Since the start of the program, 1971, when private citizens adopted 1 560 animals, the numbers of adoptions peaked in 2005 with 8 159 adoptions but have declined over the years, with only 2 895 adoptions in 2021 (Bureau of Land Management 2022). Factors contributing to declining adoptions include lack of demand likely associated with the high costs of caring for these animals (Balchunas et al. 2016). Although fertility control has been used to manage WFR horses since 1995 (Kirkpatrick and Turner 2008), and research is under way to improve contraceptive methods, it may take several years before numbers can be reduced using contemporary contraception methods (Kane 2018). Current collaborative discussions focus on using a combination of adoption and fertility control in the future to manage overpopulated WFR horses and burros (Perryman et al. 2018).

The National Environmental Policy Act (Public Law 91-190, 1970) requires public input in the management of federal resources, such as public lands and the plants, wildlife, and animals that occupy these lands. Furthermore in 1982, the National Research Council specified that WFR horse population control strategies must reflect public input, rather than solely rely on the recommendations of biological and/or economic research (National Research Council 1982). In fact, multiple National Research Council reports called for increased public engagement in horse management decisions (National Research Council 2013).

In 2019, Cooperative Extension and Agricultural Research Experiment Stations from land grant universities in Nevada and Utah funded a Rapid Response Team (W507) of Extension and Experiment Station professionals to research WFR horse herd management strategies. The rapid response team strategy is a national program funded by the US Department of Agriculture to promote interstate academic collaboration to resolve wildlife issues. The W507 team included research and extension specialists with land grant universities in five western states (California, New Mexico, Nevada, Utah, and Wyoming) who study WFR horse biology, ecology, and management in addition to rangeland ecology, human-wildlife dimensions, and conflict management. The team's goal was to provide timely science-based research information to assist the BLM and USFS in developing a fiscally and ecologically sustainable WFR horse management program. To solicit public input in herd management decisions, as requested by the National Research Council, the Rapid Response Team subcommittee volunteered to assess the western US public's knowledge about wild horses (i.e., including those animals not federally protected), WFR horses, and available management options on public lands. In response to requests from local agencies in Utah and Nevada, we conducted an additional analysis within these states and compared those responses with those of the other western states surveyed to examine differences. Nevada and Utah are unique among the other surveyed western states, in that these are the driest states in the United States; Nevada has the largest number of acres of federal lands in the United States and largest number of WFR horses occupying its federal lands than any other western state. One hypothesis was that the proximity of citizens to WFR horse herds may increase their knowledge of this species and their management. This is the first in a series of surveys conducted to assess public knowledge; our objective was to establish baseline information that may be used to formulate future social science research. Additionally, these baseline data can be helpful when discussing public input on horse management programs and policies that govern the use of the nation's public lands. Our findings will be useful in elucidating perspectives of the American public on WFR horse management issues, which in turn will provide insights that future education programs can use to improve public knowledge.

Methods

Survey instrument

Our survey instrument contained 40 questions about horse ecology and management to assess public knowledge about horses in the United States and public opinion concerning available options to manage their reproductive output. Four demographic questions asked respondents in which region of the United States they resided, gender, age, and income. For this analysis, we examined questions that asked respondents to 1) identify the origin of horses in North America; 2) estimate the number of wild horses on public lands; 3) estimate how many foals a healthy female horse produces each year; 4) identify which western US states manage wild horses on public lands; 5) indicate knowledge of federal protections for WFR horses, 6) identify the tools available to the US government to manage its WFR horse population numbers in federally designated horse management areas, 7) identify naturally occurring animal predators on public lands available to help control wild horse populations, and 8) indicate the primary methods in which they gathered information (Appendix 1).

Members of the State of Utah's BLM Wild Horse and Burro Program, USFS, and Rapid Response Team scientists reviewed drafts of the questionnaire in addition to faculty members with expertise in survey design. Revisions were made to improve question content, comprehension, and clarity. The same experts approved a final draft of question items before survey administration. As we were developing the online survey with Qualtrics Experience Management (Provo, UT), the draft survey was pretested on Qualtrics staff who were not experts in any natural resources field of science, to ensure that questions and their response selections were clearly written and easily understood by the general public. 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 use a market panel online method, via Qualtrics Experience Management, to collect survey responses. This method used a nonprobabilistic quota sampling strategy to stratify one factor (region of the United States; Newman et al. 2021), continuing to

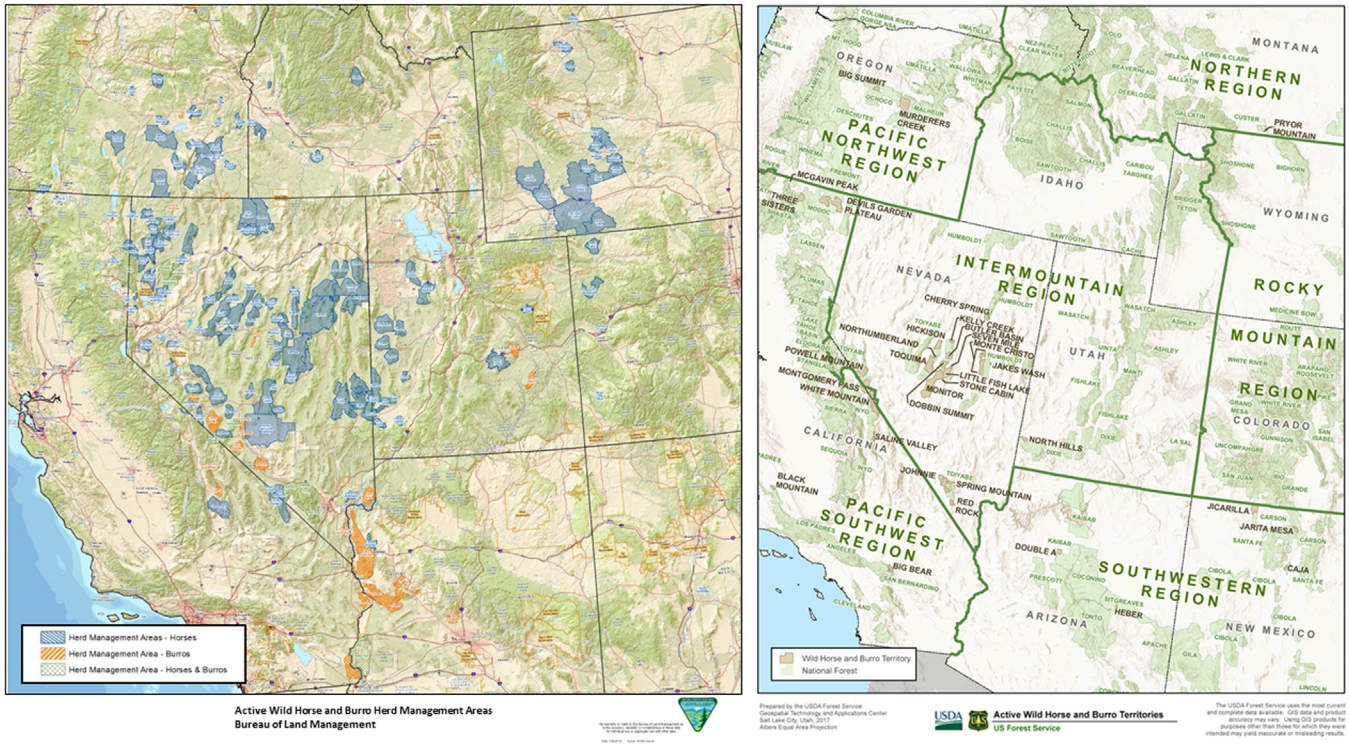

Figure 1. Map of Western U.S. states, and the location of wild and free-roaming horse and burro herd (left: management areas) and (right: territories), managed by the Bureau of Land Management (BLM) and the U. S. Forest Service, respectively. Image created using online maps provided by the Bureau of Land Management and the U. S. Forest Service, 2022.

collect responses until a demographic representation proportionate to the US Census was met for age, gender, and income. We organized our survey sample recruitment by dividing the United States into five geographic regional subsets. These subsets were based on demographic similarities that might influence respondents' knowledge and opinions, including their relative proximity to western public lands encompassing federal herd management areas (HMAs) and territories (Fig. 1). Regions were stratified within the 48 conterminous US states as Midwest, Northeast, Southeast, Southwest, and West. Additional demographic questions included respondents' gender (female, male, nonbinary or other); income ($< \$25K$, \$25K to $< \$50K$, \$50K to $< \$75K$, \$75K to $< \$100K$, \$100K to $< \$150K$, \$150K to \$200K, $\geq \$200K$); and age (18–21, 22–37, 38–53, 54–72, $\geq$ 73). Using a sample size calculator (Qualtrics 2023), we established an a priori minimum sample quota of 400 respondents from each of these regional subsets for this study.

At the request of government representatives, we also surveyed 1 000 Utah and 1 000 Nevada residents, concurrent with our original survey effort. After analyzing our data on the nationwide survey (Frey et al. 2022), we focused on the analysis of the West subset of data by comparing the West subset to respondents from Nevada and Utah. For this analysis, West included the following states: California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. To conduct a comparison of Utah and Nevada to the rest of the Western region, we removed all respondents from these two states from our original West subset. Once we removed Utah and Nevada from our original West subset, we had 374 respondents in this region, providing us with a 95% confidence interval and a 5.1% margin of error. We created a random subset of 375 respondents each from Utah and Nevada, also resulting in a 95% confidence interval and 5.1% margin of error.

We employed Qualtrics Experience Management to administer the online survey from June to August 2020; Qualtrics tracked numbers of completed surveys until the regional quota was achieved. We developed a letter sent via email by Qualtrics to randomly recruit potential survey participants from multiple market research panels (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 ($\approx$ 10–15 min), assurances of anonymity, and incentives available. Incentives included respondents' choice of cash, airline miles, gift cards, redeemable points, sweepstakes entrance, or gift vouchers; each had a value of \$5 or less and was offered and administered by Qualtrics. To avoid self-selection bias, the recruitment letter avoided providing specific details concerning question content. Due to the nature of conducting an anonymous online survey, we were unable to account for nonresponse bias.

While survey panels allow for a rapid national respondent pool, people with lower incomes and aged 65 and older 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 underrepresented. We included demographic questions of age and income in our survey to ensure that we acquired a similar proportion of these demographics relative to their representation in the US population (Frey 2020; https://data.census.gov). Qualtrics survey administrators reviewed and sorted responses for quality, rejecting those that demonstrated less than 5-min response times 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 a region, the survey was closed.

Data analysis

For this analysis, we analyzed survey data collected by geographic region as West, Nevada, and Utah. We used the 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 responses to knowledge questions and demographic characteristics. Within Crosstabs, we conducted a Pearson's chi-square (χ^2) test for associations between each combination of responses to the questions 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 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 Dormody 1994). We considered a $\lambda >$ 0.20 as a moderate indicator of predictable power for that independent variable.

Knowledge questions 7 and 8 allowed for multiple responses, so we coded each selection with a binomial response of not selected (0) or selected (1). For these binomial responses, chi-square tests were followed by a Goodman's Tau (T) estimate, rather than λ, because T predictions are based on the total distribution of the dependent variable, which is more appropriate for binomial data (Gray and Williams 1981) using the same indicator ($P < 0.05$) of statistical significance and $T > 0.20$ as a moderate indicator of predictable power for that independent variable.

Results

Our results indicated that public knowledge of wild horses and WFR horses was low across the western United States. While there were some differences among demographics, as indicated by the chi-square analyses, low λ and T estimates (< 0.20) suggest that these differences had low ability to predict knowledge of WFR ecology and management using any one demographic.

Respondents' demographics

For this survey, survey respondent demographics were similar to the 2020 Census. Respondents' gender was evenly distributed between males (46.3%) and females (52.3%), compared with the US Census of 49.5% males and 50.4% females. Because only 1.4% of the respondents identified as "other" or "preferred not to respond," we continued our analysis using only male and female responses. The distribution 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 (Fig. 2; https://data.census.gov). However, while most of the respondents were in the middle age categories in our survey, age was slightly skewed to younger ages, compared with the US Census.

Knowledge of free-roaming horses

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

Only 30% of respondents correctly identified that horses on western public lands were introduced by European explorers and colonists; 27% identified that these horses are native. Additionally, 15% indicated horses were introduced to North America by Native Americans crossing the Bering Strait land bridge, whereas 28% of respondents indicated they did not know. Based on λ values, however, no one demographic characteristic exhibited the predictive power to explain the public knowledge of the origin of horses. However, there were some statistical differences in the level of support by geographic region (Table 1; $\chi^2 = 15.896$, df = 6, $P = 0.014$, $\lambda = 0.02$). Fewer West respondents indicated that horses were introduced than did Utahn respondents (see Table 1). Furthermore, more males than females selected the correct answer ($\chi^2 = 50.594$, df = 3, $n = 1\ 104$, $P = 0.000$, $\lambda = 0.102$). There were a few associations among age classes ($\chi^2 = 48.577$, df = 12, $n = 1\ 115$, $P = 0.000$, $\lambda = 0.032$). Respondents age $\geq$ 73 selected that horses were introduced more than any other age group. There were no differences among income classes for the selection of this response ($\chi^2 = 28.973$, df = 18, $n = 1\ 120$, $P = 0.049$, $\lambda = 0.046$).

Today, there are how many free-roaming horses in Herd Management Areas?

We did not expect respondents to know the exact number of WFR horses in HMAs but expected them to select a reasonable estimate. When asked to estimate the number of WFR horses on HMAs in the western United States, nearly half of the respondents (41.9%) indicated they did not know. Only 8% of the respondents correctly answered that there were > 75 000 horses managed in HMAs. Chi-square test results indicated that region of residence influenced respondents' answer to this question ($\chi^2 = 22.377$, df = 10, $n = 1\ 120$, $P = 0.016$, $\lambda = 0.000$). A greater proportion of respondents from Nevada correctly selected that more than 75 000 horses are managed in HMAs in the western United States as compared with West and Utah respondents (see Table 1). There was also an association between the gender of the respondent and their answer ($\chi^2 = 36.907$, df = 5, $n = 1\ 104$, $P = 0.000$, $\lambda = 0.000$); more males than females selected the correct response. While there were some associations among income classes ($\chi^2 = 100.313$, df = 30, $n = 1\ 120$, $P = 0.000$, $\lambda = 0.000$) and ages ($\chi^2 = 45.742$, df = 20, $n = 1\ 115$, $P = 0.001$, $\lambda = 0.000$), the trends were less clear (see Table 1). On the basis of λ values, however, no one demographic characteristic exhibited predictive power for the knowledge of the number of horses currently on HMAs.

A healthy female horse can give birth to how many foals a year?

A healthy mare can become pregnant once a year, usually giving birth to one foal a year. Therefore, we expected our respondents to predominantly select this correct answer. Only 37% of the respondents correctly answered that a healthy mare can give birth to one foal per year. Nearly a third of the respondents (27.9%) indicated they did not know. Chi-square test results indicated that there were no associations among region ($\chi^2 = 7.543$, df = 8, $n = 1\ 120$, $P = 0.479$, $\lambda = 0.000$) or gender ($\chi^2 = 4.915$, df = 4, $n = 1\ 104$, $P = 0.296$, $\lambda = 0.000$) and the responses to this question (see Table 1). However, there were some associations among income ($\chi^2 = 55.941$, df = 23, $n = 1\ 120$, $P = 0.00$, $\lambda = 0.000$) and age ($\chi^2 = 70.679$, df = 16, $n = 1\ 115$, $P = 0.00$, $\lambda = 0.000$). While χ^2 test results indicated an association, post-hoc Bonferroni tests indicated no statistical differences among income classes in the proportion of those selecting the correct answer. However, among age classes, older respondents answered this question correctly more often than younger respondents (see Table 1). On the basis of λ values, however, no one demographic characteristic exhibited predictive power regarding respondents' knowledge of how often a mare can give birth to a foal.

Which of the following western US states have free-roaming horses managed on public lands?

Because we did not define "public lands" in our question, we did not expect each respondent to correctly select every state that has *federal* land management; rather, we were anticipating the proportion of selections for "wild horses" (i.e., including those not federally managed) overall would generally reflect the total number of federally managed horses (WFR horses) in each state (Bureau of Land Management 2022). However, this was not the result we observed (Fig. 3); 24% of the respondents selected "I don't know" as a response. Nearly half of the respondents indicated that "wild

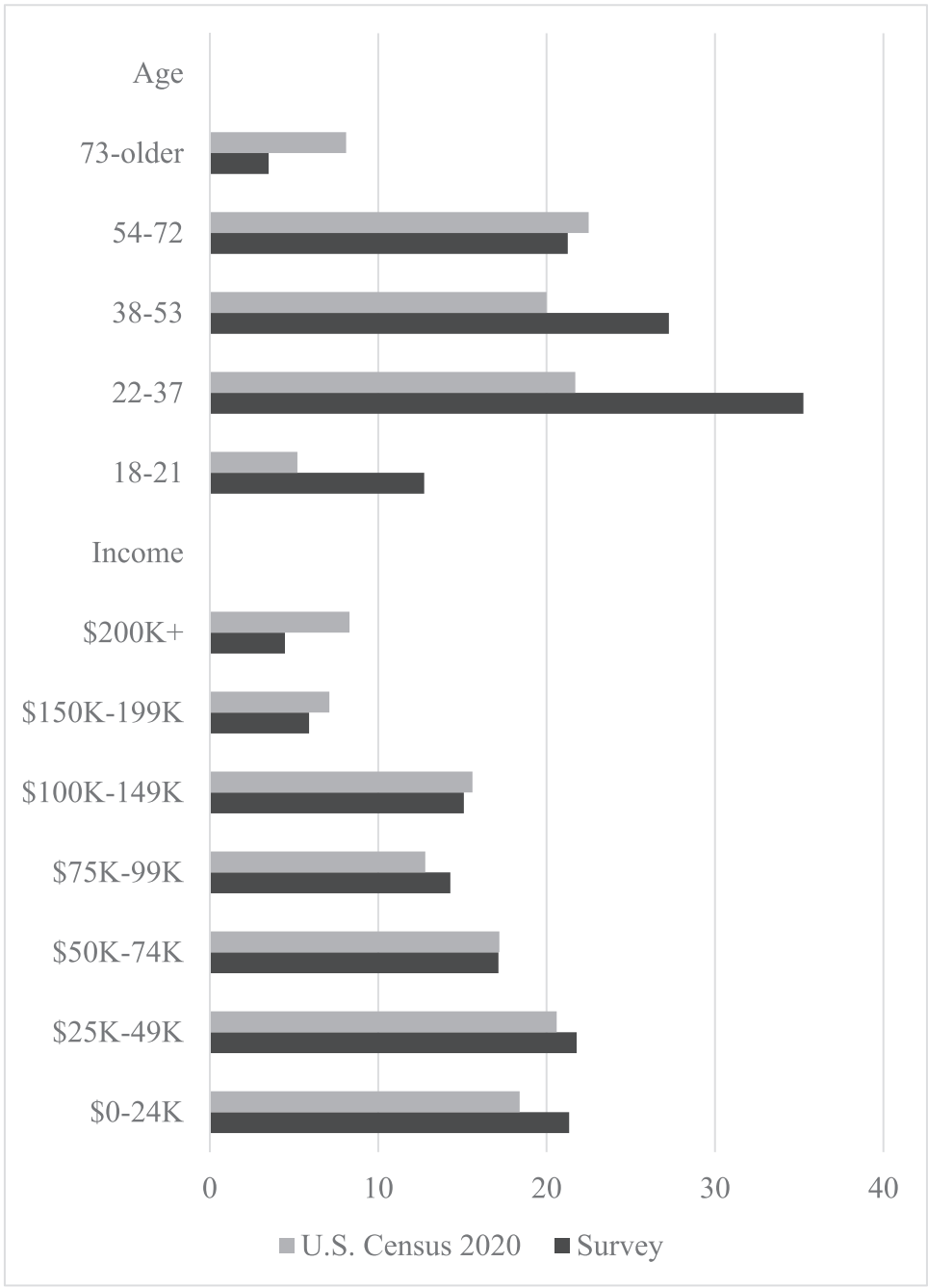

Figure 2. Distribution of n = 1124 respondents by income and age in an online survey of the public knowledge of wild, free-roaming horse (*Equus ferus caballus*) management, western U.S., 2020. Respondents resided in the following states: California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming.

horses" are managed in Nevada (45.6%) and Wyoming (48.3%), the states with the highest populations of WFR horses. However, only 16.6% of the respondents selected Oregon, the state with the third highest WFR horse population. Another interesting mismatch was Montana, which has the least number of WFR horses but was selected by 39% of the respondents. To determine trends within our demographic factors, we looked at the differences in the frequency of selection separately for each state featured in the list. While there were several associations among demographic parameters and the responses to this question, no one demographic exhibited predictive ability on which states were selected, as evidenced by T values of 0.000–0.07 (Table 2). Next, we provide details regarding those associations indicated by χ^2 analysis, between demographics and the possible response selections; all other possible associations have a $P > 0.05$ (Table 3).

West respondents indicated that wild horses are managed in California more than Utah respondents, while Nevada respondents' selection was similar to both. Utah respondents indicated Idaho and Montana as having wild horses more often than West respondents. Nevadans and Utahns both indicated that wild horses are managed in each of their states more than the other regions. West respondents indicated Washington as managing wild horses more than Utah respondents; Nevada respondents were similar to the other regions. Nevada respondents indicated Wyoming as managing wild horses less than both West and Utah respondents. Males indicated that wild horses are managed in California, Nevada, Utah,

Table 1
For each of five survey questions about the respondents' knowledge of wild, free-roaming horses on western public rangelands, the percentage of each demographic that selected the most appropriate response, as indicated by table headings. Online survey of US public living in western states, 2020.

Demographic	Horses were introduced to North America by European explorers	There are > 75 000 free-roaming horses in herd management areas	A healthy mare can birth 1 foal/yr
Region ($n = 1$ 124)			
"West"	24.9a	6.7a	35.7
"Nevada"	30.3a,b	13.1b	39.4
"Utah"	33.7b	4.8a	38.0
Gender ($n = 1$ 104)			
Female	21.7a	5.1a	38.4
Male	39.0b	12b	37.5
Income ($n = 1$ 120)			
$0-< $25K	21.4	2.9a	39.7
$25K-< $50K	32.8	5.3a,b	39.3
$50K-< $75K	31.8	5.7a,b	38.5
$75K-< $100K	34.4	18.1c	28.8
$100K-< $150K	33.1	8.3a,b,c	41.4
$150K-< $200K	22.7	12.1b,c	36.4
> $200K	28.0	20.0c	34.0
Age ($n = 1$ 115)			
18-21	30.3a	1.4a	19.0a
22-37	24.4a	5.3a,b	33.1a,b
38-53	30.0a	12.2c	41.8b,c
54-72	32.5a	11.4b,c	47.7c
> 73	64.1b	12.8b,c	64.1c

a, b, and c represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of $P < 0.05$.
"West" includes California, Colorado, Idaho, Montana, Oregon, Washington, Wyoming.

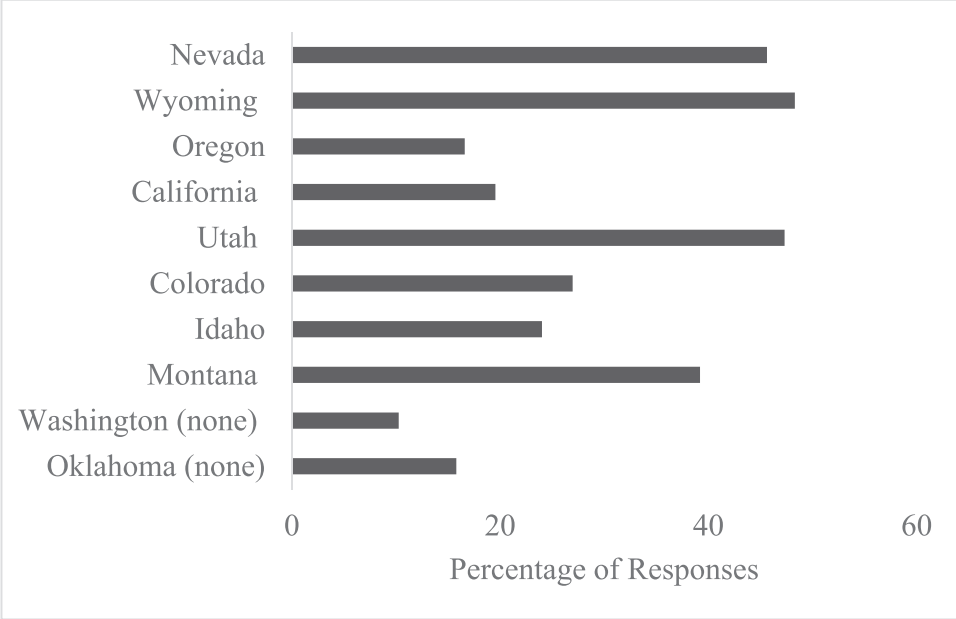

Figure 3. The percentage of respondents selecting each state in response to the question "which U. S. states manage free-roaming horses on public lands?" in a survey of western United States residents, n = 1124, 2020. States are displayed in order of greatest (Nevada) to smallest (Montana) federally managed horse populations. Respondents resided in the following states: California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming.

and Washington more frequently than females. There were no discernable trends among the differences detected among income and age brackets.

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

A majority of the respondents (41.7%) correctly indicated that killing a WFR horse is considered a felony. However, more than a third (35.3%) of the respondents indicated that they did not know the answer to this question. Alternately, 15.7% of the respondents indicated that the penalty was a $250 fine; 3.1% indicated nothing would happen and 4.2% indicated that the culprit would get an official warning. There were no regional differences in the selection that this action is a felony ($\chi^2 = 11.655$, df = 8, $n = 1$ 120, $P = 0.167$, $\lambda = 0.048$). While the χ^2 test indicated differences between genders ($\chi^2 = 16.732$, df = 4, $n = 1$ 104, $P = 0.002$, $\lambda = 0.017$), and among income brackets ($\chi^2 = 46.177$, df = 24, n = 1120, P = 0.004, $\lambda = 0.048$), Bonferroni tests did not indicate a difference in the selection for the correct response within these demographics (Table 4). Conversely, there were differences in the proportion of respondents that selected "felony" among age groups ($\chi^2 = 65.360$, df = 16, $n = 1$ 115, $P = 0.000$, $\lambda = 0.026$), although there was no clear trend (see Table 4).

Table 2
Chi-square tests of association among region, gender, income, and age and which states were selected in response to the question "Which of the following western US states have wild, free-roaming horses managed on public lands?" in an online survey of the US public living in western states, 2020. All states, except for Oklahoma and Washington, have wild, free-roaming horses managed on federal public lands. *P* values < 0.05 indicate significant χ^2 associations; however, Tau estimates of association strength (i.e., PRE) were < 0.10 for all tests of association, which is considered weak.

State	Region ($n = 1$ 124)		Gender ($n = 1$ 104)		Income ($n = 1$ 120)		Age ($n = 1$ 115)	
	χ^2	*P* value (df = 2)	χ^2	*P* value (df = 1)		*P* value (df = 6)	χ^2	*P* value (df = 4)
California	12.416	0.002	8.926	0.003	6.606	0.359	7.882	0.096
Colorado	2.786	0.248	0.014	0.904	7.820	0.252	3.184	0.527
Idaho	11.175	0.004	0.026	0.873	9.109	0.168	9.317	0.054
I don't know	2.783	0.249	3.599	0.058	25.688	0.00	16.390	0.003
Montana	6.783	0.034	1.173	0.279	22.581	0.001	12.686	0.013
Nevada	84.730	0.000	15.504	0.00	21.170	0.002	60.283	0.00
Oklahoma	0.733	0.693	0.004	0.953	7.193	0.303	5.482	0.241
Oregon	2.062	0.357	0.114	0.735	6.190	0.402	6.170	0.187
Utah	33.409	0.000	5.575	0.018	19.868	0.003	22.744	0.00
Washington	10.906	0.004	7.737	0.005	9.576	0.144	3.988	0.408
Wyoming	21.946	0.000	0.251	0.617	36.223	0.000	14.603	0.006

Table 3
Percentage of respondents from each region, sex, income, and age that selected a state in response to the questions "Which of the following western US states have wild horses managed on public lands?" in an online survey of the western US public, 2020. Superscripts represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of $P < 0.05$. Those states not listed exhibited no differences within any demographic.

Region ($n = 1$ 124)	California	Idaho	Montana	Nevada	Utah	Washington	Wyoming	I don't know
"West"	24.7a	20.1a	39.7a,b	31.9a	42.9a	14.2a	50.4a	21.7
"Nevada"	19.6a,b	22.0a	34.3b	64.3b	39.7a	9.7a,b	38.9b	23.1
"Utah"	14.4b	29.9b	43.6a	40.6c	59.4b	7.0b	55.6a	26.7
Gender ($n = 1$ 104)								
Female	16.2a	23.7	40.4	40.1a	43.9a	7.8a	48.8	26.1
Male	23.4b	24.1	37.3	51.9b	51.0b	12.9b	47.3	21.2
Income ($n = 1$ 120)								
\$0–< \$25K	14.6	20.5	33.5a,b	38.5a	38.1a	7.5	41.0a,b,c,d	34.7a
\$25K–< \$50K	19.3	26.6	48.0c	49.6a,b	48.4a,b	7.4	56.6e	20.1b
\$50K–< \$75K	22.4	22.4	40.1a,b,c	41.1a,b	52.1a,b	10.4	51.6c,d,e	21.4b
\$75K–< \$100K	18.8	26.9	37.5a,b,c	49.4a,b	51.3a,b	12.5	48.1b,d,e	16.9b
\$100K–< \$150K	21.3	29.0	44.4b,c	55.6b	55.0b	14.2	56.8e	20.1b
\$150K–< \$200K	24.2	15.2	22.7a	31.8a	45.5a,b	15.2	25.8a	25.8a,b
> \$200K	14.6	20.5	33.5a,b,c	38.5a,b	38.1a,b	7.5	41.0a,b,c,d	34.7a,b
Age ($n = 1$ 115)								
< 21	19.0	21.1	33.1	34.5a	39.4a	8.5	39.4a	35.9a
22-37	22.9	21.4	37.9	36.9a	42.5a	10.7	50.1a,b	22.1b
38-53	19.7	25.0	36.5	46.1a	50.0a	10.5	44.1a,b	22.7b
54-72	13.9	26.6	46.8	61.2b	53.2a,b	8.4	54.4b	22.8a,b
> 73	23.1	41.0	53.8	79.5b	74.4b	17.9	64.1a,b	10.3b

"West" includes California, Colorado, Idaho, Montana, Oregon, Washington, and Wyoming. All listed states, except for Washington, managed wild horses on federal public lands.

Table 4
For each of five survey questions about the respondents' knowledge of wild, free-roaming horse management on western federally managed public rangelands, the percentage of each demographic that selected the most appropriate response, as indicated by the table headings. a, b, and c represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of $P < 0.05$. Online survey of western US public, $n = 1$ 124, 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 ($n = 1$ 124)					
West	46.4	38.1a	26.8a	24.1	21.7
Nevada	39.1	41.0a	36.2b	31.1	26.3
Utah	39.6	52.9b	29.4a,b	25.7	23.3
Gender ($n = 1$ 104)					
Female	41.0	43.3	25.1a	24.4	18.4a
Male	42.5	44.6	36.9b	29.5	29.3b
Income ($n = 1$ 120)					
\$0–< \$25K	38.1	41.8	23.0a	19.2a	12.1a
\$25K-< \$50K	39.3	41.8	32.0a,b	26.6a,b	25.4b,c
\$50K-< \$75K	48.4	46.9	25.5a	23.4a,b	24.0c
\$75K-< \$100K	41.3	46.9	33.8a,b	30.0a,b	26.9b,c
\$100K-< \$150K	40.2	47.3	34.9a,b	32.5b	24.9b,c
\$150K-< \$200K	40.9	43.9	50.0b	39.4b	43.9b
> \$200K	52.0	34.0	34.0a,b	34.0a,b	30.0b,c
Age ($n = 1$ 115)					
18-21	29.6a	44.4a,b	14.8a	14.8a	13.4a
22-37	44.0b	39.9b	30.5b	25.4a,b	22.4a,b
38-53	48.0b	52.0a	31.3b	29.6b,c	27.6b
54-72	39.2a,b	41.4a,b	35.0b	30.0b,c	24.9a,b
> 73	30.8a,b	35.9a,b	64.1c	48.7c	41.0b

The US government is authorized to use which tools to manage free-roaming horse population numbers in horse management areas?

More than a third of the respondents (37.5%) indicated that they were unaware of the legal options available to federal agencies to manage WFR horse populations in herd management areas. Of the four legal options provided, with the ability to select more than one option, most respondents (44%) selected adoption and sales of horses held in federal holding facilities. Only 30.8% of respondents indicated that removal of WFR horses from public lands to a holding facility was a legal population control method. Lessor known methods were sterilization (27.0%) and euthanasia (23.8%). We examined the frequency of selection for each option individually to detect associations with our demographics. On the basis of T values, no demographics had a strong influence on predicting the selection of any one management option. Chi-square test results indicated associations between demographic variables and the proportion of the respondents selecting each management method, discussed in the following sections.

Removal from public lands to holding facilities. Chi-square test results indicated associations among region of residence and the percentage of respondents selecting removal from public lands to federal holding facilities as a legal management option ($\chi^2 = 8.144$, df = 2, $n = 1$ 120, $P = 0.017$, $T = 0.007$). More Nevada respondents selected removal to holding facilities than West and Utah respondents (see Table 4). Differences were also detected between genders ($\chi^2 = 17.988$, df = 1, $n = 1$ 104, $P = 0.000$, $T = 0.016$). Males selected this option more frequently than females (see Table 4). Additionally, there were some associations among income classes and removal to holding facilities ($\chi^2 = 22.654$, df = 6, $n = 1$ 120, $P = 0.001$, $T = 0.021$). Respondents earning ≤ $25K and those earning $50K–$75K selected this option less frequently than those earning $150K–$200K; other income brackets were similar (see Table 4). Finally, as age increased, the percentage of respondents selecting removal to holding facilities as a legal option increased ($\chi^2 = 39.802$, df = 4, $n = 1$ 115, $P = 0.000$, $T = 0.035$; see Table 4).

Adoption and sale of horses from holding facilities. Chi-square test results indicated associations between respondents' region of residence ($\chi^2 = 18.767$, df = 2, $n = 1$ 120, $P = 0.00$, $T = 0.017$) and age ($\chi^2 = 12.158$, df = 4, $n = 1$ 115, $P = 0.016$, $T = 0.011$) and percentage of respondents indicating the adoption and sale of horses in federal facilities as a legal management option. Utah respondents selected adoption and sale of horses more often than West or Nevada respondents (see Table 4). Additionally, respondents age 38–53 selected adoption and sale of horses more often than respondents age 18–21, 54–72, 22–37, and ≥ 73 (see Table 4). There were no associations between genders ($\chi^2 = 0.174$, df = 1, $n = 1$ 104, $P = 0.676$, $T = 0.000$) or among income classes ($\chi^2 = 4.948$, df = 6, $n = 1$ 120, $P = 0.551$, $T = 0.004$).

Sterilization, Neutering, Castration. Chi-square test results indicated significant associations between respondents' income ($\chi^2 = 18.303$, df = 6, $n = 1$ 120, $P = 0.006$, $T = 0.016$) and age ($\chi^2 = 22.006$, df = 4, $n = 1$ 115, $P = 0.000$, $T = 0.020$) and the selection of sterilization, neutering, and castration as a legal management option. Respondents earning ≤ $25K selected this legal option less often than respondents earning $100K–$150K and $150K–$200K; other income brackets were similar to these three (see Table 4). Respondents age 18–21 selected sterilization, neutering, and castration as a legal management option less often than respondents aged ≥ 73; other age brackets were similar to these (see Table 4). There were no associations among regions ($\chi^2 = 5.024$, df = 2, $n = 1$ 120, $P = 0.081$, $T = 0.005$) or between genders ($\chi^2 = 3.688$, df = 1, $n = 1$ 104, $P = 0.055$, $T = 0.003$).

Lethal animal control (euthanasia). Chi-square test results indicated statistically significant associations between identifying euthanasia as a control option and gender ($\chi^2 = 18.198$, df = 1, $n = 1$ 104, $P = 0.000$, $T = 0.016$), income ($\chi^2 = 35.868$, df = 6, $n = 1$ 120, $P = 0.000$, $T = 0.031$), and age ($\chi^2 = 18.247$, df = 4, $n = 1$ 115, $P = 0.001$, $T = 0.016$). There were no associations among region of residence and the selection of euthanasia ($\chi^2 = 2.201$, df = 2, $n = 1$ 120, $P = 0.333$, $T = 0.002$). Males selected euthanasia as a legal management option more frequently than females (see Table 4). Respondents who reported earning ≤ $25K selected this option least often compared with higher income groups (see Table 4). Respondents age 18–21 selected euthanasia less often than respondents aged 38–53 and ≥ 73 (see Table 4).

I Don't Know. Chi-square test results indicated statistically significant associations between income ($\chi^2 = 23.015$, df = 6, $n = 1$ 120, $P = 0.001$, $T = 0.02$), gender ($\chi^2 = 13.762$, df = 41, $n = 1$ 104, $P = 0.000$, $T = 0.012$), and age ($\chi^2 = 18.186$, df = 4, $n = 1$ 115, $P = 0.001$, $T = 0.015$ and selecting "I don't know"). There were no associations among region of residence and this selection ($\chi^2 = 3.594$, df = 2, $n = 1$ 120, $P = 0.166$, $T = 0.003$). Post-hoc tests indicated those respondents earning ≤ $25K selected "I don't know" (48.1%) more often than respondents earning $75K to ≤ $100K (30.0%) and $150K to ≤ $200K (22.7%). Other income brackets were similar (33.7–40.0%). Fewer males (31.9%) selected "I don't know" compared with females (42.7%). Finally, there was a generally decreasing trend among age classes. Respondents age 18–21 selected "I don't know" more often (48.6%) than respondents age 38–53 (34.5%) and ≥ 73 (15.4%). Other age classes were similar to these three: 22–37 (38.7%), 54–72 (35.9%).

Which of the following is a common predator of free-roaming horses on western public lands?

Very few respondents (6%) correctly answered that there are no common native predators of wild horses in North America. The majority of the respondents (53.7%) selected cougars *(Puma concolor),* a species that can sometimes depredate horses in areas where they both occur (Andreasen et al. 2021). Wolves *(Canis lupus),* a species whose distribution rarely overlaps with horses, were selected by 32.2% of the respondents. Nearly a quarter of the respondents (24.5%) selected "I don't know." A similar percentage of respondents selected grizzly bear (*Ursus arctos horribilis,* 17.0%) and black bear (*Ursus americanus,* 18.2%). While there were several associations among demographic parameters and the responses to this question, no one demographic exhibited predictive ability, as evidenced by Tau values of 0.000–0.093 (Table 5). Next, we provide details regarding those associations indicated by χ^2 analysis, between demographics and the possible response selections; all other possible associations of $P > 0.05$ (Table 6).

Chi-square analyses did not indicate significant differences among regions and the selection of "cougar" or "none." However, males selected "none" more often than females. There were differences among income classes in the frequency of selecting cougar as a common native predator of wild horses. Those in the $0 to < $25K income bracket selected "cougar" less than (44.8%) respondents in the $25K to < $50K income bracket (59.4%; see Table 6); all other income brackets' selection of this species was similar to these two (see Table 6). There was no influence of age on the proportion of respondents selecting either "none" or "cougar" in response to the question (see Table 6).

What is your primary source of factual information?

Approximately 60% of the respondents selected "Internet search for university, government, or organization's website about the subject" as their primary source of information. Facebook searches

Table 5
Chi-square tests of association among region, gender, income, and age, and which species were selected in response to the question "Which of the following is a common predator of wild, free-roaming horses on western public lands?" in a national online survey of the US public living in western states, 2020. 'None of the Above' is the most appropriate response. *P* values < 0.05 indicate significant associations; however, Tau estimates of association strength (i.e., PRE) were < 0.10 for all tests of association, which is considered weak.

	Region ($n = 1\ 124$)		Gender ($n = 1\ 104$)		Income ($n = 1\ 120$)		Age ($n = 1\ 115$)	
	χ^2	*P* value (df = 2)	χ^2	*P* value (df = 1)	χ^2	*P* value (df = 6)	χ^2	*P* value (df = 4)
Black bear *(Ursus americanus)*	0.144	0.930	14.888	0.000	17.503	0.008	14.646	0.005
Gray wolf *(Canis lupis)*	6.124	0.047	2.798	0.094	3.912	0.689	11.852	0.018
Grizzly bear *(Ursus arctos horribilis)*	2.839	0.242	13.985	0.000	19.789	0.003	20.543	0.000
Cougar *(Puma concolor)*	1.419	0.492	2.024	0.155	15.268	0.018	5.769	0.217
None of the above	0.309	0.857	4.292	0.038	3.197	0.784	2.459	0.652
I don't know	2.298	0.317	14.154	0.000	24.154	0.000	4.051	0.399

Table 6
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 an online survey of western US residents, 2020. a and b represent differences with a demographic based on Bonferroni post-hoc tests, at the significance level of $P < 0.05$.

Demographic	No common predators	Cougar *(Puma concolor)*
Region ($n = 1\ 124$)		
West	5.4	51.2
Nevada	6.2	54.4
Utah	5.3	55.3
Sex ($n = 1\ 104$)		
Female	4.3a	51.7
Male	7.1b	56.0
Income ($n = 1\ 120$)		
$0-< $25K	5.4	44.8a
$25K-< $50K	4.9	59.4b
$50K-< $75K	4.7	55.7a,b
$75K-< $100K	8.1	48.8a,b
$100K-< $150K	5.3	59.2a,b
$150K-<$200K	7.6	57.6a,b
> $200K	4.0	52.0a,b
Age ($n = 1\ 115$)		
18-21	6.3	46.5
22-37	4.8	52.7
38-53	5.3	57.9
54-72	6.3	54.4
> 73	10.3	59.0

for groups or agencies, a general Internet search, friends and neighbors, and online journal articles were selected as the primary source for information by 6–12% of the participants (Fig. 4). Gender had no influence on a respondent's primary source for information ($\chi^2 = 9.278$, df = 6, $P = 0.159$, $\lambda = 0.598$); similarly, region had no influence on a respondent's primary source for information ($\chi^2 = 18.632$, df = 12, $P = 0.98$, $\lambda = 0.159$). There were differences found within the χ^2 tests for income ($\chi^2 = 48.03$, df = 30, $P = 0.02$, $\lambda = 0.309$) and age ($\chi^2 = 87.468$, df = 24, $P < 0.001$, $\lambda = 0.078$); however, there were no discernable trends and λ values indicated little influence of the PRE.

Discussion

Our study was designed to document baseline knowledge of the public residing in the western United States relative to WFR horse populations managed on federal public lands. Our study results demonstrate that residents of the western United States lack knowledge surrounding WFR horse origins, location, ecology, and management, based on the responses of our survey participants. These findings are similar to Kellert's (1984) study, which reported a general lack of environmental literacy among the general US public. Similarly, research in Scotland indicated there was little understanding of wildlife population management (Bremner and Park 2007). This lack of knowledge could lead to the public being susceptible to false information or supporting proposed changes to management policy that they do not understand. Increased knowledge of a contentious management issue may lead to increased understanding, influencing the ability of disparate groups to achieve consensus and make informed decisions (Riley and Gregory 2012).

As early as the 1980s, the National Research Council (National Research Council 1982) expressed the need for increased public outreach education concerning WFR horse management on public lands. Public education is especially relevant because federally funded management activities, such as horse roundups, fertility control, and emergency feeding/watering, for example, all require a public review period as specified by the National Environmental Policy Act (Public Law 91-190, 1970) and often end up reported in news and social media outlets. Improved understanding of the public's knowledge of management situations or actions can help federal agencies anticipate and avoid conflicts (Leong et al. 2012).

We did not define "public lands" in the question asking where "wild horses" (not exclusively federally designated WFR horses) were being managed, because we expected that most respondents might not be able to differentiate among regional, state, or federal public lands. We simply wanted their responses concerning where they "know" or "think" "wild horses" are being managed. Ideally, the percentage of respondents selecting a state would be in proportion to the number of federally managed WFR horses within that state, as a relative comparison of the public's knowledge about that state. For example, Nevada has the largest WFR horse population, and accordingly, the most "wild horses" regardless of federal designation; thus, we expected respondents to select Nevada more often than any other state. In contrast, Washington has no WFR horses, but several Tribes manage "wild horses" on their lands. Therefore, it was expected that only a small proportion of respondents would indicate Washington as managing "wild horses." While more respondents in Utah and Nevada, as compared with the broader West, demonstrated greater awareness of horse populations managed within their respective states, overall, our study sample largely did not correctly associate wild horses with those states that have the largest WFR horse populations. Similarly, Casey et al. (2005) found that residents in the southwestern United States were unaware of cougars located within that region, even in places where cougars were common. Furthermore, Hiroyasu et al. (2019) found that only 25% of Californians knew that grizzly bears do not occur in the wild in California.

Social media has contributed to the "fame" of several WFR horse herds, including the Pryor Mountain herd in Wyoming and Montana (http://www.pryormustangs.org). The popularity of such herds could contribute to a misconception of where the majority of WFR horses are located in the western United States. Additionally, these popular herds could also lead to misconceptions about WFR horses in general. Such misconceptions include 1) all WFR horses have distinct ancestry, 2) WFR horses are only found in the locations of popularized herds, 3) WFR horses are collaboratively managed on lands especially reserved for them, or 4) WFR horses need protection from extinction due to their localized distribution, just

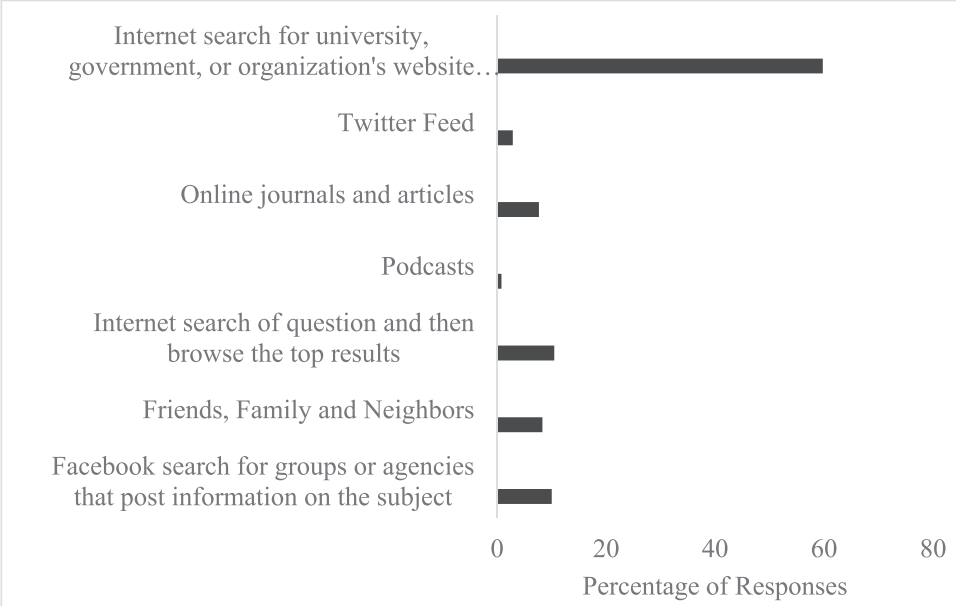

Figure 4. The percentage of respondents selecting their primary source for information, from a series of selections, in a survey of western U. S. states manage wild, free-roaming horses on federal public lands?" in a survey of western United States residents, n = 1124, 2020. Respondents resided in the following states: California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming.

to name a few possible erroneous conclusions. In turn, these misconceptions could influence the public's support for management policies and decisions under the jurisdiction of the Bureau of Land Management and Forest Service.

WFR Horse Ecology

Similar to our study, Garrott (2018) found that less than 10% of their respondents knew that WFR horses are not native to the United States. This pervasive lack of public knowledge can be problematic for WFR horse managers and policy makers because it can lead to confusion and disinformation concerning the negative ecological impacts of unmanaged WFR horse population numbers on public lands. In turn, this can influence the level of public support for federally funding the management of WFR horse populations on public lands. While knowledge is only one factor influencing public support, it is a significant factor (Tisdell and Wilson 2004). Prior studies suggest that public knowledge of a wildlife species can influence public support for conservation actions affecting that species (Bremner and Park 2007; van der Ploeg et al. 2011; Cruz-Martinez et al. 2020). For example, in a study of Australian megafauna, Drijfhout et al. (2020) determined that the knowledge of the native status of species such as brumbies *(Equus caballus),* koalas *(Phascolarctos cinereus),* and kangaroos (*Macropus* spp.) influenced support for the management of these species. Thus, to improve public support of WFR horse management programs and policies, future outreach programs should educate the public on the origin of WFR horse populations in the United States.

Much of the struggle with WFR horse population management in the US centers around natality and mortality. For example, our survey indicated that 62% of the respondents lacked knowledge concerning the reproductive capacity of WFR mares. Nearly all of our respondents (94%) indicated that they were unaware that there are no natural common predators of WFR horses in the United States. In fact, more than half of our respondents indicated that cougars are common predators of WFR horses. Even though some depredation can occur as a result of cougars, this is largely due to a lack of other available natural prey (Beier et al. 1995; Sikich and Foley 2015); few cougar populations are large enough to actually impact WFR horse populations (Turner et al. 1992; Greger and Romney 1999). Nevertheless, the popular misconception that large natural predators, such as cougars, bears, and wolves, effectively control WFR horse populations, rather than starvation and poor health due to limited resources, can undermine public support for strategic policy interventions to effectively control WFR horse populations (Baker and Rubenstein 2018). Future research should explore associations between the public's knowledge of WFR horse ecology and their support for legal management actions to maintain healthy horse herds.

WFR Horse Management

The legality of a proposed management action could influence public support for that action. Unfortunately, the majority of our respondents were unaware of legal options available to manage WFR horse population numbers on public lands. Adoption and sale of WFR horses removed from the range by BLM is a long-standing federally funded population control mechanism, yet barely half of the respondents indicated this as a legal option. The BLM and USFS rely on the gathering and removal of horses from HMAs when their numbers exceed the carrying capacity of HMAs; however, only 31% of our respondents were aware that WFR horses were managed in such holding facilities. Since the start of the WFR program in 1971 when 1 560 animals were privately adopted, the numbers of adoptions increased over the years, peaking in 2005 with 8 159 adoptions, but since then adoptions have decreased to 2 895 animals in 2022 (Bureau of Land Management 2022). Factors contributing to declining adoptions include lack of demand, which is likely associated with the high costs over time (25–30 yr) of caring for these animals (Balchunas et al. 2016). More Utah respondents were aware of adoption and sales of WFR horses held in federal facilities compared with the other two regions, whereas more Nevada respondents were aware of the relocation of WFR horses from rangelands to federal holding facilities. On the basis of the location of federal holding and adoption facilities, respondents' proximity to these facilities did not appear to factor into their level of awareness.

We included euthanasia as a population control option in our survey choice set since the WFRHBA authorized this option initially, even though later legislation defunded or banned this option (Garrott 2018). Few respondents indicated this as a legal option for management. As WFR horse populations continue to increase, discussions increasingly surround the reintroduction of euthanasia to control herd numbers. The nuances concerning public support of euthanasia as a humane tool for animals in distress versus as a tool for population control would be valuable information for herd managers and policy makers.

Our study indicates that participants are primarily using Internet searches to gather information on a subject; however, this implies that the respondent knows about the topic, such as WFR horses, and which agencies are the leaders in providing information on the subject. We suggest that wildlife managers and biologists partner with professional educators to determine strategies to engage new stakeholders and increase the overall knowledge level regarding WFR horses.

Influence of demographics

Within our study, respondents' demographic characteristics (region, age, gender, income) did not appear to correlate to the extent of their knowledge of WFR horses. While some differences existed between knowledge indicators and demographic characteristics, their magnitude was not sufficient to indicate predictive power (i.e., the ability to correctly "guess" a response; Tau $>$ 0.20) for responses to any one knowledge question. Our study findings prohibit predictive assumptions concerning public knowledge about WFR horses based on where they live within the western United States, their gender, age, or income. Although our data indicated that demographics were not helpful in predicting knowledge, our survey results illustrate several trends. For example, respondents earning comparatively the least ($\leq$ \$25K) and the youngest (18–21) were the least knowledgeable about each of the legal options available to manage WFR horse herds. 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 (Dietz et al. 2007; Cordano et al. 2010; Holian and Kahn 2015). If increasing public knowledge can increase public support for pertinent environmental policy and conservation actions (Riley and Gregory 2012), an effective strategy might prioritize educational outreach that specifically targets low-income and younger constituents (often the same population).

Using market panels to conduct online research surveys is a quick tool to gather a large number of responses. However, it is nonrandom and thus could be subject to bias via uneven sampling among the factors. For example, future research should consider an even sampling intensity among each state, rather than a region compared with a state. We strived to alleviate this concern through a survey sample that was proportionally similar to the US Census. Alternately, future survey efforts might purposefully target lower-income and younger constituents, given that these demographic classes have been demonstrated to be the least knowledgeable about natural resources, to gain more insight into their understanding of WFR horse management. Furthermore, Newman et al. (2021) reported that several online market panels (Qualtrics was not tested in this group) have participants that have higher levels of education and a lower proportion of nonwhite groups than the general population—two demographics on which we did not collect information. Similarly, Hollier et al. (2016) found that online participants were generally more knowledgeable about an online health campaign than telephone survey participants. If the same conclusion holds for natural resources studies, this could have implications for additional studies of the knowledge public land management.

Implications

We had hypothesized that western US residents would be somewhat knowledgeable about horse ecology and herd management on western public lands, based on their proximity to WFR horses and public lands. However, similar to other surveys concerning public knowledge of other animal species, our survey revealed that western US residents have little knowledge of WFR horse ecology or population management. Prior research suggests that higher-income residents are more likely to support environmental conservation policies that conceptually include WFR horse management to sustain the ecological health of the nation's public rangelands (Manfredo et al. 2021). This would include actions such as reducing WFR herd numbers that exceed an area's carrying capacity or conflict with sensitive plant and wildlife species on public lands. However, if their concern for horse health is combined with a lack of knowledge specific to WFR horse ecology and population control, this demographic may inadvertently oppose environmental management policy and action that they do not fully comprehend.

Our study illustrates that one cannot assume that a segment of the US public has knowledge of their natural environment, based solely on where they reside. Put simply, western US land and wildlife managers cannot assume their constituents possess even the most basic knowledge concerning WFR horses nor have close interaction with their natural environment. Factual information regarding the origin, location, and challenges posed by WFR horse herd numbers should be provided before, or coincident with, public announcements and reports concerning herd management actions. Such educational outreach will help inform public opinions about associated WFR horse herd management actions.

Often, managers refer to possible differences between urban and rural public opinions. However, one must consider $>$ 50% of the population of every state included in this survey lives in an urban area, as defined by the US Census Bureau (Iowa State University 2023). Thus, to assess public knowledge about WFR horses in the western United States, discerning between rural or urban respondents may not necessarily add value to the results reported here. This is not to say that differences between these groups do not exist. Although we used similar sample sizes with similar confidence intervals, our data did not have equal survey intensity in each western state, which might have influenced our results for regional comparisons, given the differences in each state's population distribution.

While this study focused on assessing public baseline knowledge about WFR horses, we also asked questions to assess public opinion of federal herd management and management agencies. Future analyses will estimate the extent to which public knowledge is associated with support of management programs. In 2021, for example, BLM expended $>$ \$74 million caring for WFR horses held in "off-range" corrals and pastures; this is compared with \$14.5 million from the BLM to support their horse adoption program and \$5.6 million to support herd roundups and fertility control. Future management decisions would likely benefit from assessing public support for these individual herd management programs when the associated costs for each are also provided. Our study indicated that much of the public uses the Internet to find information on government, university, or an organization's website. Therefore, while using social media platforms may serve to reach younger generations, these platforms should be backed by informative, easily accessible informational websites.

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Supplementary materials

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