

RUNNING HEAD: Increasing Public Support for Environmental Management through  
Communication: The Case of Invasive Species

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**Abstract**

Environmental managers face major challenges related to not only how to implement projects but also how to communicate their value to the public. Management agencies often face significant opposition from people concerned with both the goals and means of management projects. The ability to effectively communicate with the public can help mitigate some of this opposition. In this study, we evaluate how to effectively communicate the benefits of environmental management. To do so, we field a survey experiment in which we present the public with an invasive species management proposal that uses a two (economic, ecological) by two (gain, loss) design to evaluate how the public responds to messages highlighting different reasons for the policy. We find that ecological messages are significantly more effective at promoting invasive species management than economic frames and that loss frames are more effective than gain frames. We also find that treatment responses differ based on a number of covariates including political party identification and overall environmental concern. These results provide important new information to policymakers and to researchers wishing to better understand how to craft messages that increase support for environmental management projects.

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## Increasing Public Support for Environmental Management through Communication: The Case of Invasive Species

### **Introduction**

Public support for environmental policies and even specific environmental management projects can play an important role in their success or failure (Beierle 1999; Eden 1996; O’Faircheallaigh 2010). In some cases, public opposition threatens to significantly delay or even derail projects, including invasive species management projects, even if they offer significant public benefits (Bertolini and Genovesi 2003). Public opposition often occurs once environmental managers already have funding identified for a project and are developing implementation strategies. However, public support is also important well before dramatic opposition campaigns. In the case of invasive species management, projects are underfunded largely because the public and policymakers do not consider it a priority. Developing better ways for private advocates and public agencies to communicate the value of the environmental management work they can increase support for such projects and ensure that they continue to be both funded and implemented.

Protection of ecological and economic resources are two of the most substantial public benefits pursued through environmental management. Though economic and ecological outcomes are not entirely independent of one another, they represent distinct goals for environmental managers. Ecological frames highlight the importance of protecting the environment for the sake of its animals and ecosystems, while economic frames focus on how environmental protection can benefit human economic production. This distinction between different types of benefits of a program are attribute frames. Both economic and ecological benefits can be presented as ways to promote gains or prevent losses, which are outcome frames.

In this paper, we present the results of a survey experiment of California residents (N=1077) to understand how the public responds to messages that vary by both attribute and outcome frames. The sample was gathered by Qualtrics using quota sampling. The factorial design of the field experiment allows us to evaluate how gain and loss frames interact with ecological and economic frames. We find that ecological messages are significantly more effective for promoting invasive species management than economic frames and that loss frames are more effective than gain frames. We also find that responses to different messages differ based on a number of individual-level covariates including political party identification and environmental concern. These results provide important new information to policymakers and to researchers wishing to better understand how people respond to environmental messages.

In the next section, we introduce how public support can impact environmental management projects and how effective communication can influence that support. Next, we present the case of invasive species management, which is the subject of our survey experiment. We then review how different types of message frames can influence public opinion and develop several hypotheses regarding the most effective ways to influence support for invasive species management. Data and methods for the field experiment are then presented, followed by results and a discussion the impacts of our findings on broader invasive species and environmental management research and consider future directions for related research.

### **Improving Environmental Communication**

Environmental managers can significantly improve communication with the public and stakeholders regarding the value of environmental management through testing which message frames resonate with the public broadly and with specific groups. Ecosystem-based management, which involves management of a full range of interactions between species, humans, and natural

processes occurring in an ecosystem (McLeod et al., 2005), can suffer when agencies are unable to communicate the importance of such programs in ways that convince the public or their elected representatives (Tanentzap et al., 2009). The public frequently misunderstands management goals, which can lead to confusion and lack of support (McNeely, 2001). One way to effectively communicate issues in ways that are more relevant and easily understandable to the public is to communicate using message frames that highlight information about an environmental management project that can connect to the public's existing concerns or beliefs (Nelson et al. 1997; Nelson and Oxley 1999). Frames influence people's opinions and interest in policy issues by connecting complex considerations, like how to best manage invasive species, to issues or values they already understand and care about (Lakoff 2010; Nelson et al. 1997). Engaging citizens through effective communication can also increase public participation in management processes, which can help build trust and collaboration between the public and management agencies and can improve the quality and legitimacy of agency decisions (Nisbet et al., 2012).

We evaluate the impacts of two distinct types of message frames on support for a specific invasive species project and political action to support the project. The first frame that we employ is an attribute frame, which highlights specific factors present in the issue being evaluated (Levin et al. 1998; Spence and Pidgeon 2010). In our case, the attribute frame being varied is the ecological or economic impacts that a particular invasive species management project will have. Our second frame is an outcome frame, which presents the highlighted attribute in terms of gains or losses and which is rooted in prospect theory (Kahneman and Tversky 1979, 1984; Levin et al. 1998; Spence and Pidgeon 2010). Expected impacts of these two different framing manipulations are discussed in detail below.

Some people have criticized use of communication strategies to influence opinions environmental projects as outside of the responsibilities of environmental managers, and that doing so is manipulative or otherwise inappropriate (e.g. Larson, 2008). For those people, the job of ecologists and government environmental agencies is to present facts and data in support of their ecosystem management and allow citizens to decide whether to support them. But this completely misses the point that “environmental frames are the (typically unconscious) conceptual structures that people have in their brain circuitry to understand environmental issues” (Lakoff 2010). There is no such thing as un-framed information. Deciding how to frame environmental management offers opportunities for both increasing public understanding of these projects and support for them.

### **The Case of Invasive Species Management**

Invasive species management provides an excellent test case for evaluating how environmental managers can improve communication with the public. First, invasive species pose tremendous ecological and economic threats. Invasive species cause major damage to ecosystem health and are a significant driver of global biodiversity loss (Sala et al. 2000) and hinder agricultural production. As a result, and like many other environmental problems, the two primary reasons for government action to address species are their impacts on economic activity and on ecosystem health. Though economic and ecological consequences of species invasion are not entirely independent of one another, they represent distinct goals for environmental managers. Second, the benefits from managing invasive species can either come in the form of preventing losses or in facilitating gains. Framed as facilitating gains, managing invasive species offers opportunities for native species to thrive or agricultural production to increase. Framed as

preventing losses, managing invasive species can prevent further destruction of native habitat or agricultural products.

Invasive species also provide an excellent case for evaluating message effectiveness because unlike many other environmental issues like climate change, invasive species management is not highly politicized. Most people do not have strongly held policy positions (Zaller, 1992), and party cues can overwhelm individuals' own policy considerations, causing them to establish policy positions based on their party identities rather than personal ideology (Cohen, 2003; Goren et al. 2009; Slothuus and De Vrees 2010). This may occur independent of explicit references to political parties, and occurs when a policy issue is psychologically connected to the values of a group the individual identifies with (Kahan 2012; Kahan et al. 2012). Whereas a number of environmental issues are the subject of significant polarization along party lines (Dunlap et al. 2001; Feygina, Jost, and Goldsmith 2010), invasive species management is not prominent in current partisan rhetoric and therefore less likely to be associated with an individual's party identification. As a result, we are able to evaluate the impacts of different message frames on support for invasive species management with greater confidence that participants are responding to the frames we present rather than partisan signals.

Species invasion is occurring at increasing frequency across the world, and is responsible for large-scale environmental change (Sala et al., 2000; Mack et al., 2000). The direct cause of species invasion is almost always human-related, frequently the result of globalization and economic trade which introduce either intentional non-native invasive species or unintentional non-native invasive species (Mack et al. 2000; Simberloff et al. 2013). As globalization and trade continue to accelerate in tandem with climate change, it is very likely that the problems posed by invasive species will become more important and have stronger impacts on ecosystems

(Hellmann et al. 2008). This is also likely to make the issue more socially and politically contentious as trade routes are expanded and biodiversity declines. While economic arguments for environmental protection are most extensively employed in reference to issues like climate change and energy production, the visibility of arguments regarding the economic value of ecosystem services and natural capital similarly frame environmental protection as an economic necessity (Costanza et al. 2017; Daily 1997). As a result, people may be familiar with both ecological and economic reasons to manage invasive species, or to address other similar environmental issues.

### **Ecological and Economic Impacts of Invasive Species**

Invasive species impact the natural environments they invade by direct predation or habitat destruction, often accelerating or magnifying natural disturbance rates. This can further enable the establishment of nonnative species through changes in the disturbance regime, competition, or changes to the physical environment (Mack et al. 2000; Kotanen 2004; Didham, Tylianakis, and Hutchison 2005; Chapin et al. 2000). As of the late 1990s, 400 of the 958 listed endangered species in the United States are primarily at risk due to species invasion (Wilcove et al. 1998). The life histories of invasive species make them particularly well suited to adapt to the impacts of climate change, and may work synergistically with climate change in a variety of ways to invade novel systems and increase their impacts in areas that are vulnerable to climate impacts. Increased human disturbance across natural landscapes and the opening of new ocean passageways also provide additional systems for species to expand into.

Invasive species also pose significant economic costs. In addition to costs associated with mitigating their ecological damage, invasive species damage private and public property and can destroy agricultural products such as crops, fisheries, and other ecosystem services that

contribute to human economic activity. Estimates of damages vary, but one suggests it would require \$120 billion annually to mitigate damages caused by invasive species worldwide (Pimentel, Zuniga, and Morrison 2005). Invasive weeds alone are estimated to cause direct costs of \$3.6-5.4 billion USD per year as of 1993 (Office of Technology Assessment, 1993).

### **Public Perceptions of Invasive Species Management**

The public's attitudes toward invasive species removal projects can play an important role in determining the success or failure of such programs. Ecologists and wildlife biologists, including government employees whose mandate includes conservation goals, may be primarily concerned with the threat invasive species pose to healthy ecosystems. While many biologists consider controlling invasive species to be essential to managing ecosystem health (e.g. Sala et al. 2000), in most cases the public is either unaware of the consequences of invasive species or unconcerned by it (Bremner and Park, 2007; Bertolino and Genovesi, 2003). In some cases, the public has actively delayed projects or even prevented projects from being implemented (Selge, Fischer, and van der Wal, 2011; Bertolino and Genovesi, 2003; Veitch and Clout 2001; Marshall et al. 2011; McNeely 2011). Although most studies indicate that the majority of the public supports some type of invasive species management (Sharp et al. 2011; Bremner and Park 2007), many people oppose invasive species eradication projects. Often, this is because the public finds killing or otherwise controlling animals distasteful or morally unacceptable (Sharp et al. 2011).

Understanding people's values as they relate to invasive species management may be essential to determining why people oppose invasive species programs and how the goals of such programs can be communicated to address concerns arising from those values. People with more ecocentric attitudes tend to prefer passive management over more direct management that may involve human intervention to eradicate invasive species (Sharp et al., 2011). This may be



counterintuitive to researchers – the ecological benefits of invasive species management would suggest those concerned about the environment would be among the most supportive. However, while ecologists tend to see the whole ecological picture when making management decisions, members of the public most concerned with ecological health may instead focus on the welfare of individual animals.

### **Using Economic and Ecological Frames to Promote Invasive Species Management**

The two primary reasons that government intervenes to protect the environment are to address potential economic and ecological consequences of environmental degradation. Messages related to the environment frequently frame ecological and economic benefits as in competition with one another (Lakoff 2010, Miller 2000). Political debate refers to economic damages associated with environmental regulation or environmental degradation caused by unfettered industry (Vezirgiannidou 2010, 2013; Bang 2010). Ecological frames highlight the importance of protecting the environment for the sake of the environment itself, including animals and ecosystems. These messages presuppose that nature has intrinsic value and that humans should protect it. Reframing environmental benefits as not just good for nature but also good for the economy challenges the assumption that pro-environmental policies harm the economy (Vezirgiannidou 2013; Hale 2010). However, in many cases protecting nature is the primary reason for environmental management, and ignoring that in favor of alternative arguments may not be most effective.

Economic arguments in favor of environmental protection can be more effective than traditional environmental arguments that focus on preservation of nature because they present co-benefits to environmental protection. Environmental policy with co-benefits results in a cleaner environment alongside, rather than in place of, economic growth (Vezirgiannidou 2013;

Hale 2010). If people automatically think about the ecological benefits of environmental protection, then use of an economic frame can broaden perceived benefits without decreasing appeal among people inclined to support environmental protection for its ecological value. This can be particularly important because economic issues are much more important and immediately concerning to most Americans than environmental issues are (Gallup 2017).

Economic frames also frequently emphasize that environmental protection offers opportunities instead of requiring sacrifices (Vezirgiannidou 2013). The language of risk, guilt, and sacrifice is typically ineffective for both eliciting positive opinions about environmental policies or motivating action in support of them, particularly among people not otherwise predisposed to support those policies (Markowitz and Shariff 2012; Bain et al. 2012). Reframing environmental issues based on their economic consequences can be highly effective for promoting environmental protection generally and invasive species management in particular. However, several additional considerations need to be addressed to determine which type of frame will be most effective for increasing support for invasive species management.

By shifting focus off of ecological benefits, frames that highlight co-benefits may decrease the perceived urgency of the issue or reduce the environment as a secondary consideration (Vezirgiannidou 2013). Most studies comparing economic and environmental frames focus specifically on climate change. But the climate change debate is hindered by pervasive but ineffective frames, most notably presenting climate change as a form of pollution. The dominance of the pollution frame has led to ongoing debate over the science of climate change rather than the benefits associated with addressing the issue (Vezirgiannidou 2013). As a result, the potential advantages of re-framing the issue in a way that highlights co-benefits are more apparent for climate change than other environmental management issues. Climate change

is also uniquely politicized among environmental issues, which makes trying to find frames that cut across typical party identifiers more important than for invasive species management.

Highlighting the ecological importance of managing invasive species or other less politicized issues is unlikely to elicit hyper-partisan responses that make people defensive and cause them to “dig in” in response to a common opposition frames. For environmental issues that have more localized consequences, less media attention, or are less politicized as compared to climate change, focusing on ecological benefits may not be as problematic.

Ecological frames may also be more effective because some people find economic arguments for environmental policies to be unpalatable or even unethical. By focusing on how protecting the environment benefits humans, less attention is paid to the intrinsic value a healthy environment. The case of managing invasive species is an excellent example of the potential negative consequences of economic framing of environmental issues. Managing vertebrate invasive species involves harming individual animals. Doing so for the specific purpose of increasing economic growth threatens to violate personal ethics (Saachi et al., 2014; Sandel 2012). However, when informed that a policy can help the ecosystem broadly people may be more willing to support the project, even if a requirement of improving the ecosystem is harming some individual animals. Willingness to accept harm to some animals when it offers overall environmental benefits has roots in dissonance theory, which suggests that individuals will attempt to minimize inconsistencies between beliefs in order to avoid psychological discomfort (Eagly and Chaiken 1993). In the case of invasive species management, being presented with information regarding how actions that harm animals may nonetheless be good for the environment broadly may help reduce the discomfort that would otherwise result from their desire to both care for the environment and individual animals.

The overall efficacy of messages highlighting economic benefits as compared to ecological benefits of an environmental issue, particularly an issue like invasive species management that is largely non-politicized, can provide important insight regarding how people respond to different types messages intended to promote environmental protection. Based on the discussion above, we propose the following hypothesis regarding the impacts of ecological and economic messages on support for invasive species management.

*H1: People will be more supportive of invasive species management when framed as providing ecological or economic benefits, as compared to a control message.*

*H2: People will be more supportive of invasive species management when framed as providing ecological benefits than when framed as providing economic benefits.*

Economic and ecological arguments in favor of invasive species management may also be received differently by certain groups of people. Conservatives are typically more responsive to messages highlighting economic benefits than ecological ones. The roots of this lie in a conservative moral system that subordinates nature to the will of people who desire to use it for their own ends and that believes in market-based systems that evaluates the environment based on their costs and benefits rather than their intrinsic value (Lakoff 2010). When conservatives are presented with environmental messages framed using moral values consistent with conservative ideology, including potential benefits to economic growth from environmental protection, they are much more supportive of these policies (Clifford and Jerit 2013; Bain et al. 2012). These same principles can be applied to invasive species management, and lead to our next hypothesis:

*H3: Among conservatives, economic frames will increase support for invasive species management more than ecological frames.*

The progressive moral system, on the other hand, is based on empathy and feelings of responsibility including toward non-human species (Lakoff 2010). Liberals are also more likely to believe in the importance of caring for and protecting other people and species (Graham,

Haidt, and Nosek 2009; Schwartz et al. 2010). As a result, liberals and environmentalists are more likely than non-environmentalists to see the environment as a moral issue (Feinberg and Willer 2012; McCright and Dunlap 2011). And these same people who believe that protecting the environment is a moral issue are also more likely to reject economic arguments for environmental protection as immoral (Saachi et al. 2014). This is true even if such arguments are not presented as a tradeoff between economic benefits and environmental benefits, but rather as a “win-win” for both. The result is that progressives and environmentalists will be more responsive to frames that highlight the ecological benefits of environmental policies, which are our next two hypotheses:

*H4: Among liberals, ecological frames will increase support for invasive species management more than economic frames.*

*H5: Among environmentalists, ecological frames will increase support for invasive species management more than economic frames.*

### **Using Gain and Loss Frames to Promote Invasive Species Management**

The benefits associated with environmental policies, including invasive species management, can either come in the form of preventing losses or in facilitating gains. This is the case regardless of whether the policy is intended to provide economic benefits, ecological benefits, or anything else. For example, removal of an invasive species can be interpreted as providing opportunities for native species to reestablish themselves and increase their numbers. This frame brings forth images of movement back toward a more natural ecological balance in a system that has been impacted by invasive species. Alternatively, removal of an invasive species may provide opportunities to prevent further destruction of native species. Rather than images of ecological gains, this frame suggests that management still stop additional degradation. These are examples of gain and loss frames, respectively.

Our comparison of how the public responds to message frames highlighting potential gains as compared to prevented losses in invasive species management is an extension of existing prospect theory research. Prospect theory (Kahneman and Tversky 1979, 1984) suggests that potential losses have a larger impact on decision-making than equivalent gains. In other words, people are loss averse – the negative effect of losing \$100 is greater than the positive effect of gaining \$100. While most prospect theory research has focused on monetary gains, loss aversion applies to other goods as well, including environmental goods (Novemsky and Kahneman 2005; Hardisty and Weber 2009). In some cases, loss aversion may be even stronger for environmental losses than for financial losses (Hardisty and Weber 2009). We should expect that loss frames will therefore be more effective than gain frames in terms of encouraging support for environmental protection. After all, if we are more sensitive to losses than gains, then the prospect of environmental losses should be more concerning than equivalent environmental gains. However, where the present research and all other research that attempts to prospect theory to frames to environmental decision-making diverges from traditional prospect theory is in who is subject to potential gains and losses. Even existing research that shows loss aversion in political decision-making (Quattrone and Tversky, 1984) does so by proposing that the election of specific candidates will have specific gains or losses for the individual decision-maker, rather than for the country as a whole.

How people respond to different gain and loss frames to promote invasive species management can tell us something about how environmental policy is perceived as risky or cautious. Absent known equivalent expected outcomes, when gain frames are presented people will tend to act cautiously and when loss frames are presented people will tend to take risks. Evaluating how people respond to gain and loss frames provides information regarding whether

they perceive action or inaction as risky. If gain frames lead to more opposition to invasive species projects while loss frames lead to more support for them then this indicates that the status quo, in which no policy exists, is perceived as more cautious than managing invasive species. However, if gain frames lead to more support for project and loss frames lead to more opposition, then the alternative is true: policy action would thus be perceived as more cautious, and inaction the riskier choice.

Limited existing research tests these gain and loss frames on environmental issues, and none addresses invasive species management. Climate change messaging that employs gain frames may be more effective than loss frames at increasing attitudes toward climate change mitigation efforts (Spence and Pidgeon 2010). The authors hypothesize that the reason for the greater efficacy of gain frames is that mitigation policies are perceived as the more cautious approach to addressing climate change, as compared to no climate mitigation policy. This is a particularly important result given that loss aversion typically leads to support for the political status quo (Quattrone and Tversky, 1984). Since people have more confident expectations regarding what will occur under the status quo, which usually results in small changes rather than large potential gains nor losses, prospect theory biases us toward maintaining that status quo. While the alternative choice may provide greater potential gains than the status quo, we are more sensitive to the potential losses associated with an alternative choice than potential gains, and so usually avoid it.

The primary question that needs to be addressed in terms of what to expect regarding people's reactions to gain and loss frames for environmental management projects is whether we anticipate that inaction will be perceived as the risky choice or the cautious choice. Previous evidence suggests that people perceive action regarding climate change mitigation as the more

cautious choice, and as a result tend to be more responsive to gain frames (Spence and Pidgeon 2010).

Inaction with respect to invasive species appears a priori to be the riskier choice because the result is likely to be large ecological and economic damages (Keller et al. 2008; Keller et al. 2009; Pejchar and Mooney 2009). Moreover, discussions of losses due to non-action are more common in environmental policy debates than discussions of gains – environmental advocates frequently describe what will happen if the government neglects to act. However, that threat may not be readily apparent to the public. While some species invasions in recent years have been subject to extensive media coverage, such as Asian carp in the Great Lakes and Burmese pythons in southern Florida, the sustained threats posed by invasive species are largely ignored by politicians as media when compared to other environmental issues like climate change or drinking water access. As a result, we do not anticipate that gain frames will be most effective for messaging about invasive species policies, as they are for climate change. Instead, we anticipate that people will be more likely to support the project when framed in terms of potential losses avoided, as predicted by prospect theory. This leads to our next hypothesis.

*H6: People will be more supportive of invasive species management when presented in terms of economic or ecological losses than comparable economic or ecological gains.*

We do not anticipate significant differences in treatment effects among subgroups based on outcome frames. There is evidence that conservatives and Republicans respond better to gain-framed messages than to messages that focus on the risk of environmental loss due to inaction (Markowitz and Shariff 2012; Bain et al. 2012). However, we expect that this primarily results from backlash associated with partisan media coverage rather than a natural predisposition to respond to gain frames rather than loss frames. Given the non-partisan nature of invasive species



management, we therefore do not anticipate political affiliations to substantially influence response to gain and loss frames.

## **Data and Methods**

### **Procedure**

We recruited a sample of Californians ( $N=1077$ ) using an online panel provided by Qualtrics. The sample was gathered using online quota sampling that allowed us to gather a sample of California residents that mirrored the state population based on household income and political party affiliation, and also allowed us to oversample rural residents. A review of sample demographic characteristics is available in Appendix A.

The survey experiment began by measuring a number of covariates including demographic information, political beliefs and affiliations, participants' individual values and environmental attitudes. Next, participants were randomly assigned to read one of five possible descriptions of a proposed invasive species management project in California. They were told that the California Department of Fish and Wildlife (CDFW) is considering moving forward with a proposal to manage and ultimately eradicate invasive wild pigs, and that they would like to know more about the public's opinions and support or opposition for such a project. The five descriptions include four treatment messages that use a full factorial 2 (target frame: ecological vs. economic) x 2 (outcome frame: gain vs. loss) design. A fifth control condition is also included, which provided participants with information regarding CDFW's planned implementation of the project, but excludes project goals related to ecological or economic gains and losses.

After reading the press release they were assigned to read, participants were asked whether they support or oppose the project, and how strongly they hold this position. Responses

to these questions are our primary outcome measures. Participants were then told that CDFW was in the process of taking public comment on the project, and participants were asked if interested to brief comments regarding why they supported or opposed the project. This is used as an additional outcome measure for political activism. Participants were provided debriefing information and the survey experiment was completed. Several attention checks were used throughout the survey experiment. Responses from any participant who spent less than 33% or more than 300% of mean survey response time was excluded. In addition, two separate control questions were used in which participants were asked to click a specific multiple choice option. Participants who failed either attention check question were excluded.

### **Measures**

**Message frame treatments.** Four message frames were included as treatments. The four treatment messages were intended to hold all language constant other than the expected outcomes resulting from implementation of the management program or failure to do so. Stated differently, the project attributes and goals differed in each treatment condition included the following: 1) ecological gain treatment: highlights benefits to native California ecosystems and species that would result from implementation of the pig management program; 2) ecological loss treatment: highlights further loss of native habitat and species destruction if CDFW fails to implement the management program; 3) economic gain treatment: highlights the increase in statewide economic production and government tax revenue that would result from implementation of the management program; 4) economic loss treatment: highlights the continued loss of economic production and government tax revenue that would result from failure to implement the management program. The primary difference between these four

conditions occurred at the end of each project description. The language from each is available in the appendix.

**Message frame control.** In addition to the four treatment messages described above, one message was included as control. The control message used all of the same language as the treatment messages, but did not reference expected outcomes of the wild pig management project.

**Support for invasive species management.** The primary dependent variable used in analysis is support for the wild pig management project described in each message frame. To increase the perceived importance and personal connection to the question, participants were asked “As a California resident, do you support or oppose the proposal...” Responses were initially measured as binary (support/oppose) and participants were subsequently asked about their strength of support or opposition. This offered the opportunity to use both the simpler, binary measure and an ordinal measure of strength of support, which improves statistical power for analysis.

**Political activism in support of invasive species management.** After responding to the initial support or opposition question, participants were asked whether they would be willing to write a short statement to CDFW to tell the agency why they support or oppose the proposed project. Participants were provided with an essay box in which to write their statement, and told that if they did not wish to provide a statement that they should move to the next question. The question is used as a proxy for political activism in support or opposition to the project. Responses were coded post hoc, creating a binary variable that measures whether participants wrote a statement or not. The coding criteria were that the statement must be at least one

sentence long (i.e. two word responses were coded negatively) and had to at least reference an argument in support or opposition to the project.

**Manipulation checks.** We asked participants several questions to measure whether or not the treatments had effectively influenced their thinking. First, we asked all participants whether wild pigs primarily present a problem to California because of their economic or ecological consequences. Participants could also select that they did not know. Results show a significant difference in response choice based on ecological or economic treatment frame ( $\chi^2(8) = 167.46, p < .01$ ). Participants were then asked whether the program would “prevent further declines” or “allow for increases” in native species and habitat, for those who received an ecological treatment; or whether the program would “prevent further economic damages” or “allow additional economic benefits,” for those receiving an economic treatment. Responses were combined across the economic and ecological conditions and evaluated whether people were able to successfully identify the outcome frame they received. Results indicate that responses differed by gain or loss outcome frame ( $\chi^2(1) = 14.48, p < .01$ ).

**Covariates.** A number of other factors may help explain support for invasive species management. Because we are primarily interested in the effects of the different treatments on support for the proposed invasive species management project, we measured these covariates in our survey and include them in analysis.

To measure individuals’ environmental concern, the study uses an abridged version of the New Ecological Paradigm (NEP; Dunlap et al. 2000; Stern 1999). This version of the NEP includes five questions which were then combined into a single measure of environmental concern (five items, Cronbach’s  $\alpha = .64$ ). In spite of only modest internal consistency and previous research questioning the validity of the NEP as a unidimensional measure of

environmental attitudes (Amburgey and Thoman, 2012), use of the NEP provides a well-understood means of incorporating some measure of environmental concern in analysis of survey data. As a result, all responses were included in a single measure of NEP for analysis. We also used this measure in subgroup analysis in order to determine whether people who exhibit high levels of environmental concern (i.e. “environmentalists”) responded to treatments differently than those exhibiting low levels of environmental concern (i.e. “non-environmentalists”). For subgroup analyses, environmentalists were defined as responses in the top quartile for the NEP scale used, while non-environmentalists had responses in the bottom quartile.

We also asked questions regarding participants’ concern for animals’ well-being (four items, Cronbach’s  $\alpha=.61$ ). Again in spite of relatively poor internal consistency, we maintained a single measure of concern for animals. Inclusion of this measure in our analysis provides an opportunity to distinguish people who are broadly concerned about environmental health and protection from people whose primary concern is animals’ well-being. Based on pre-test results we suspected that many people opposed to invasive species projects may be motivated by their concern over harming individual animals.

Several political variables were measured, based on the assumption that people’s opinions and attitudes regarding politics and government may influence their support for a government program like invasive species management. Political ideology was measured on a seven-point Likert scale, from “extremely liberal” (1) to “extremely conservative” (7). Party identification was measured by asking participants whether they identify as a member of a particular party including as a Democrat, Republican, Independent/Unaffiliated, or Other. Although we anticipate that invasive species management is significantly less politicized than other environmental policy issues, inclusion of these measures increases our confidence that the

variation in support for the wild pig management project is not primarily motivated by political affiliations or beliefs. These covariates also allow for subgroup analyses to identify heterogeneous treatment effects, as outlined in Hypothesis 3 and Hypothesis 4.

A number of demographic and socio-economic variables were also measured. Participants were asked for their highest level of education completed, which ranged from “Did not finish High School” to options for a number of advanced degrees. For analysis, these responses were coded into a binary variable identifying whether the participant was a college graduate (1) or non-college graduate (0). Annual household income was also measured on an ordinal scale, from “Less than \$20,000” to “Over \$150,000.” The survey matched household income quotas that were consistent with existing U.S. Census information for California residents. Information on participants’ race/ethnicity, gender, age, and whether they live in a rural or urban environment were also measured. In analysis presented below, race is included as a binary variable for non-Hispanic White (1) or non-White/Hispanic (0). Gender is presented as male (1) or female (0). Age is included as a continuous variable, and age-squared was also evaluated to control for non-linear effects.

## **Results**

### *Support for Invasive Species Management*

We began analysis by estimating the effects of treatment assignment on support for the wild pig management project. We did so by specifying a multiple logistic regression while controlling for a number of covariates. Full regression results can be found in Appendix A. Predicted probabilities of support for the pig management program for each treatment condition and for changes across two covariates that had a significant effect on support are all shown in Table 1.

Table 1: Effects of Treatments and Covariates on the Predicted Probability of Support for Wild Pig Management in California

Treatment/Covariate	Predicted Probability	$\Delta$
Treatment Condition		
Control	.644	-
Ecological Loss	.849	.205
Ecological Gain	.791	.147
Economic Loss	.751	.107
Economic Gain*	.709	.065
Animal Welfare Support		
High Support	.658	
Low Support	.815	.157
Gender		
Female	.703	
Male	.819	.116

Results are predicted probabilities at specific levels for each listed treatment or covariate, while holding other covariates at their means.  $\Delta$  of predicted probabilities for treatments is in relation to control. For animal welfare and gender, treatments are excluded from the model in order to include all observations. To estimate animal welfare, High=top decile, Low=bottom decile.

\*Economic gain treatment not significant at  $p < .05$  in logit model.

Regression results show that the ecological loss frame has the largest effect on support for invasive species management, followed by the ecological gain frame and the economic loss frame. The economic gain frame did not have a significant effect on support for the project. Only two control variables – concern for animal welfare and gender – had an effect on support for the project. People concerned about animal welfare were less supportive of the project, likely because they are concerned with caring for individual animals and therefore find the prospect of killing certain animals to be unacceptable. Men were more supportive of the project than women, which is consistent with existing invasive species opinion research (Fitzgerald et al. 2007; Brember and Park 2007).

Table 2 shows results of treatments pooled into ecological and economic treatment frames and when treatments are pooled into gain and loss frames. The pooled results indicate that attribute frames, which highlighted ecological or economic consequences of the program, had a

significant effect on whether or not people supported the invasive species management project ( $\chi^2(4) = 29.22, p < .001$ ). Additional results indicate that ecological frames were more effective than both the control frame (Kruskal-Wallis  $\chi^2(1) = 21.45, p < .001$ ), and the economic frame (K-W  $\chi^2(1) = 10.16, p = .004$ ).<sup>2</sup> Support for the wild pig management program did not differ significantly between the pooled economic frames and the control frame (K-W  $\chi^2(1) = 3.66, p = .17$ ). These results provide support for hypotheses 1, but only partial support for hypothesis 2.

Table 2: Effects of Pooled Treatments on Support for Wild Pig Management

Treatment (Pooled)	ATE	95% CI	N
Ecological Treatments	.168	.133, .203	432
Economic Treatments	.074	.049, .099	427
Gain Treatments	.083	.057, .109	433
Loss Treatments	.160	.126, .195	426

Outcome frames, which highlighted the potential gains or avoided losses that would result from implementing the program, also had a significant effect on participants' support of the project ( $\chi^2(2) = 19.52, p < .001$ ). Support for the wild management project was significantly greater among people who received the loss frames than in the control frame (Kruskal-Wallis  $\chi^2(1) = 19.21, p < .001$ ), and was also significantly greater as compared to those who received gain frames (K-W  $\chi^2(1) = 6.95, p = .03$ ). These results support hypothesis 6. Participants who received one of the two gain frames appeared to be significantly more likely to support wild pig management than those receiving the control frame, but after Bonferroni correction the difference was not significant (K-W  $\chi^2(1) = 4.64, p = .09$ ).

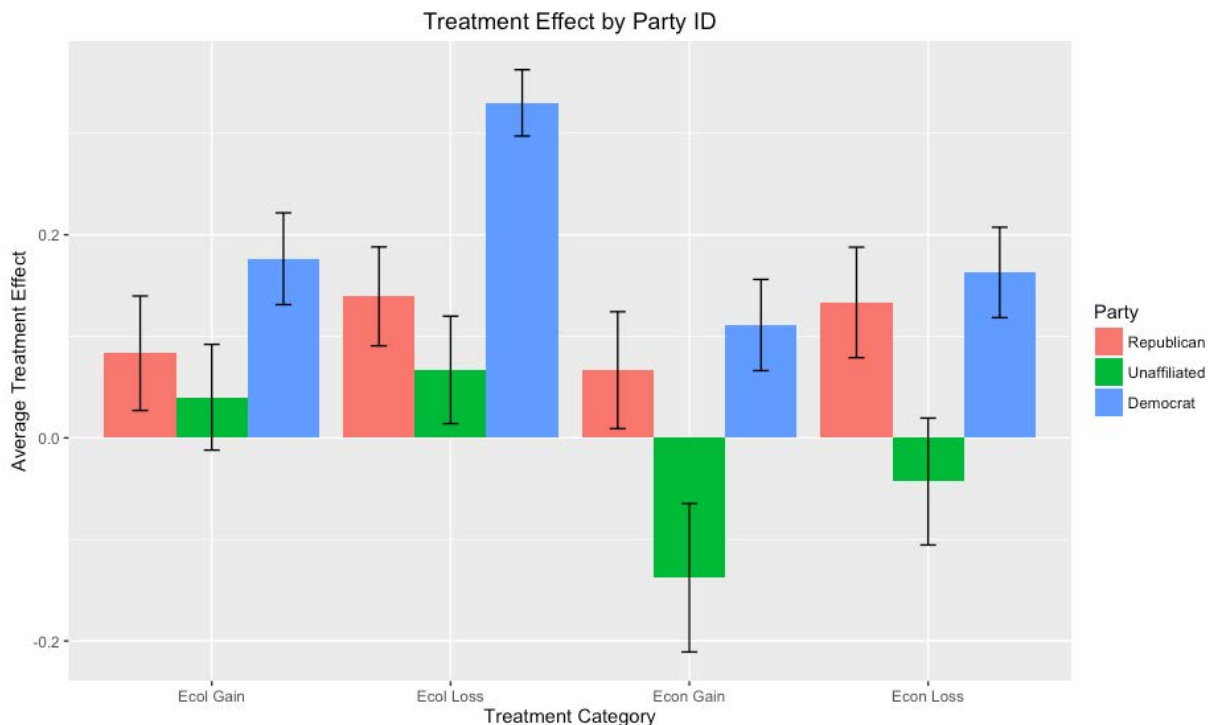
<sup>2</sup> When referencing comparisons of effects of different treatments to one another, we use a Bonferroni correction to  $p < .05$ . When  $p$ -values are reported, they are Bonferroni-adjusted.



Collectively, results indicate that people who received ecological frames and those who received loss frames were more supportive of wild pig management than participants in the control and in the control. Those participants who received economic and gain frames, however, were no more likely to support the project than those who received the control.

### *Treatment-by-Covariate Heterogeneous Effects*

We expected that messages would be interpreted differently by certain participants, and so investigated potential heterogeneous treatment effects. We began by evaluating how treatments influenced support for the management project among different political party identifiers. Figure 1 shows treatment effects among self-identified Democrats, Republicans, and Independents.



Among Democrats, assignment to different messages did have a significant effect on support for wild pig management ( $\chi^2(4) = 27.93, p < .001$ ). Treatment effects among Democrats mirror the main findings above, with ecological loss treatments having the largest effect on

project support followed by ecological gain and economic gain treatments. Treatment assignment did not have significant effects on Republicans' ( $\chi^2(4) = 4.18, p=.38$ ) or Independents' ( $\chi^2(4) = 6.10, p=.19$ ) support for the project. It is worth noting that asymmetric statistical power may play a role in these non-significant findings, since the sample was mirrored a California population that is nearly 50% Democratic. However, average treatment effects among Republicans and Independents were not as large as those among Democrats, which suggests that this is not an issue of power.

Next, we pooled treatments to evaluate the effects of different types of messages among different groups. Table 3 summarizes heterogeneous average treatment effects (ATEs) of pooled ecological and economic treatments by party identification and environmental concern.

Table 3: Heterogeneous Treatment Effects for Pooled Ecological and Economic Treatments

Subgroup	ATE	95% CI	N
Ecological Treatments (Pooled)			
Democrat	.253	.192, .314	253
Republican	.113	.058, .168	127
Independent	.035	-.001, .071	100
Environmentalist	.176	.109, .243	124
Non-Environmentalist	.230	.158, .302	131
Economic Treatments (Pooled)			
Democrat	.136	.090, .182	214
Republican	.099	.044, .154	115
Independent	-.113	-.180, -.046	85
Environmentalist	-.002	-.009, .005	146
Non-Environmentalist	.161	.092, .230	108

Democrats are significantly more responsive to the ecological treatments than either Republicans or Independents, while Democrats and Republicans are both significantly more responsive to economic treatments than Independents are. Ecological treatments had large

average treatment effects for both environmentalist and non-environmentalists. Surprisingly, mean effects of ecological treatments were actually larger among non-environmentalists. Democrats are also significantly more responsive to ecological treatments than they are to economic treatments, supporting hypothesis 4.

This analysis does not provide support for hypothesis 3, that conservatives will be more responsive to economic messages than ecological ones. Ecological messages had larger average treatment effects among both Republicans and non-environmentalists than economic messages did. Economic treatments also had positive average effects for non-environmentalists, though there was no significant average effect of economic treatments among environmentalists. This supports hypothesis 5, and suggests that people concerned about nature are not just more responsive messaging that highlights the benefits to nature itself of environmental policies, but that they will also reject economic messages. Somewhat surprisingly, none of the four pooled treatments had any significant effect on support among Independents, even as each pooled treatment condition had positive increased support for the project among both Democrats and Republicans.

Table 4 shows average treatment effects among the same subgroups for pooled gain and loss treatments. Analysis of pooled gain and loss treatments tell much the same story that ecological and economic treatments do.

Table 4: Heterogeneous Treatment Effects for Pooled Gain and Loss Treatments

Subgroup	ATE	95% CI	N
Loss Treatments (Pooled)			
Democrat	.243	.184, .303	199
Republican	.113	.058, .168	127
Independent	.035	-.001, .071	100
Enviromentalist	.115	.061, .169	134
Non-Environmentalism	.250	.171, .329	115
Gain Treatments (Pooled)			
Democrat	.142	.094, .189	208
Republican	.137	.076, .198	122
Independent	-.024	-.055, -.007	92
Enviromentalist	.045	.010, .080	136
Non-Environmentalism	.196	.126, .266	126

Democrats are significantly more responsive to loss frames than either Republicans or Independents are, while both Democrats and Republicans are more responsive to gain frames than Independents are. As with ecological and economic treatments, non-environmentalists are more responsive to both gain and loss than environmentalists are.

#### *Political Activism in Support and Opposition to Invasive Species Management*

We next evaluated the effects of treatments and covariates on political action to support and to oppose the project, which was measured by asking participants to write a letter to the California Department of Fish and Wildlife (CDFW). Results of the regression can be seen in the Appendix A. Among participants who supported the project, no treatments or covariates had any significant effect on their willingness to write a letter. Given the strong effects of treatments on stated support for the project, this finding was surprising. None of the treatments had significant effects on willingness to write a letter in opposition to the project either, although the economic loss treatment has a marginal negative effect. However, a number of covariates did have

significant effect. Environmental concern increased participants' likelihood of writing an opposition letter, indicating that stronger environmentalists who oppose the project are more likely to take the step of trying to do something to prevent it. Older people were also more likely to write the letter, which we suspect is related to older people being more politically engaged generally.

### **Discussion**

This study provides evidence regarding the efficacy of different message frames related to an extremely important environmental problem that nonetheless remains relatively apolitical. The broadly apolitical nature of invasive species management means that there are greater opportunities for environmental managers to communicate their goals in ways that connect to broader, related frames but are not completely washed out by partisan signaling. Our results can therefore provide practical information to environmental managers seeking to communicate their goals, but also provides new information regarding how people think about and respond to messages regarding these kinds of environmental issues, which are the focus of substantial government environmental management resources.

This survey experiment also shows that for environmental policy issues which like invasive species management are hyper-partisan, ecological messages are more effective than economic frames. This contradicts previous research regarding framing environmental issues and the ever-increasing polarization of environmental discourse. And while the sample is of California residents, our analysis suggests that the Democratic and liberal political leanings of the state do not explain the efficacy of the ecological frames. We believe that the lack of a prevailing political rhetoric for invasive species management means people are less likely to respond to mentions of the environment or protecting nature by reverting to the party line, since

there really is no party line. As a result, identifying other reasons for pro-environmental government policies (i.e. co-benefits) like economic growth or national security is neither necessary nor as effective as focusing on environmental benefits themselves.

The survey experiment also shows that loss aversion influences the public's support for environmental policies and can be used to improve environmental messaging. In addition, government action on issues like invasive species management is perceived as the riskier approach as compared to non-action, even while the majority of people in our survey experiment supported government action. Previous literature has suggested that gain frames are more effective for motivating environmental concern and activism because non-action is perceived as riskier (Spence and Pidgeon 2010) – doing nothing to address climate change, for example, could easily be perceived as the riskiest choice among policy options. However, in most cases people perceive the status quo to be the more cautious decision, which in the case of a new environmental policy proposal would mean non-action. We show that for invasive species management this is the case, as indicated by the greater efficacy of loss-framed messages as compared to gain-framed messages.

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## Appendix A: Additional Tables

Table 1: Sample Demographics

Statistic	Percent
Age	
18-25 yrs	16.5%
26-35 yrs	23.8%
36-50 yrs	22.0%
51-65 yrs	25.1%
>65 yrs	16.1%
Gender	
Male	36.2%
Female	63.8%
Household Income	
<\$40,000	35.7%
\$40,000-75,000	25.1%
\$75,000-150,000	24.9%
>\$150,000	14.4%
Education	
HS Grad or Less	13.8%
Some College	40.6%
Bachelor's Degree	30.6%
Advanced Degree	15.1%
Race	
Non-Hispanic White	56.2%
Hispanic	20.1%
Asian	17.3%
Black	5.9%
American Indian	3.7%
Household Location	
Rural	24.1%
Urban/Suburban	75.9%
Party ID	
Democrat	47.8%
Republican	28%
Independent	24.1%

Table 2: Logistic Regressions for Support for Project and Political Activism

	Stated Support for Project (1)	Action to Support Project (2)	Action to Oppose Project (3)
<b>Treatments</b>			
Ecological Gain	0.737*** (0.252)	0.182 (0.368)	-0.037 (0.461)
Ecological Loss	1.137*** (0.268)	0.350 (0.352)	-0.359 (0.515)
Economic Gain	0.298 (0.234)	0.282 (0.370)	-0.422 (0.426)
Economic Loss	0.511** (0.249)	0.301 (0.368)	-0.846* (0.477)
<b>Attitudes</b>			
NEP	0.098 (0.104)	0.118 (0.136)	0.421** (0.192)
Animal Welfare	-0.348*** (0.115)	-0.140 (0.152)	-0.210 (0.216)
<b>Political Variables</b>			
Democrat	-0.194 (0.196)	-0.031 (0.264)	0.244 (0.376)
Ideology	-0.079 (0.060)	0.034 (0.078)	0.109 (0.117)
<b>Demographics</b>			
College Degree	0.188 (0.181)	0.090 (0.234)	-0.219 (0.334)
HH Income	-0.024 (0.044)	0.009 (0.057)	0.013 (0.079)
Nonwhite	0.166 (0.179)	-0.132 (0.234)	0.293 (0.342)
Male	0.649*** (0.184)	-0.010 (0.221)	0.550 (0.351)
Age	0.004 (0.005)	0.006 (0.007)	0.025** (0.011)
Rural	-0.069 (0.197)	0.443* (0.243)	0.275 (0.363)
Constant	1.350* (0.692)	-2.243** (0.922)	-2.915** (1.333)
Observations	850	630	220
Log Likelihood	-457.387	-287.845	-132.048
Akaike Inf. Crit.	944.774	605.689	294.096

Action rates are only among people who indicated support or opposition to the project.

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

## Appendix B: Treatment Language

### Ecological Gain Message:

#### **Program to Eliminate Invasive Wild Pigs in California For Immediate Release**

February 8, 2017

California Department of Fish and Wildlife

Wild pigs or feral pigs (*Sus scrofa*) were first brought to California by Spanish settlers in the 1700s. Since then, and with many more introduction events, wild pigs have colonized almost every county in the state. Wild pigs are habitat generalists and occupy a variety of habitats, including native California grasslands, oak woodlands, and along creeks and streams.

Control measures have typically been limited to hunting pigs on both public and private lands, requiring the purchase of one tag per animal hunted. The California Department of Fish and Wildlife (CDFW) does not have an active management plan for invasive wild pigs. However, populations have become more and more established across the state, making control through hunting difficult. As of 2017, wild pigs present a major threat to native habitats and the food supply and survival of native California species.

As a result, CDFW is proposing a more rigorous approach to addressing the problem of invasive pigs. The proposal involves a program to trap and cull wild pig populations in every county in the state, with the ultimate goal of eliminating the entire wild pig population across the state.

The Department has identified **major ecological benefits associated with implementation of the program:**

- Increased populations of important native and endangered California species such as coastal elk that still exist and the native plants and reptiles that are eaten by wild pigs.
- Increased oak survival, aiding in efforts to preserve iconic habitat that is home to many native species.
- In total, successful implementation of the project will provide major benefits for nearly three dozen native California species that rely on the same food sources and live in the same habitats as the wild pigs.

CDFW is asking Californians' for their support and input on the project before planned early-stage implementation in Spring 2017.

**Ecological Loss Message:****Press Release: Program to Eliminate Invasive Wild Pigs in California  
For Immediate Release**

February 8, 2017

California Department of Fish and Wildlife

Wild pigs or feral pigs (*Sus scrofa*) were first brought to California by Spanish settlers in the 1700s. Since then, and with many more introduction events, wild pigs have colonized almost every county in the state. Wild pigs are habitat generalists and occupy a variety of habitats, including native California grasslands, oak woodlands, and along creeks and streams.

Control measures have typically been limited to hunting pigs on both public and private lands, requiring the purchase of one tag per animal hunted. The California Department of Fish and Wildlife (CDFW) does not have an active management plan for invasive wild pigs. However, populations have become more and more established across the state, making control through hunting difficult. As of 2016, wild pigs present a major threat to native habitats and the food supply and survival of native California species.

As a result, CDFW is proposing a more rigorous approach to addressing the problem of invasive pigs. The proposal involves a program to trap and cull wild pig populations in every county in the state, with the ultimate goal of eliminating the entire wild pig population across the state.

The Department has identified **major ecological losses if the program is not implemented:**

- Continued decline in population numbers of important native and endangered California species such as coastal elk that still exist and the native plants and reptiles that are eaten by wild pigs.
- Increased oak death, leading to continued destruction of iconic habitat that is home to many native species.
- In total, the failure to implement the program could lead to further decline of three dozen native California species that rely on the same food sources and live in the same habitats as the wild pigs.

CDFW is asking Californians' for their support and input on the project before planned early-stage implementation in Spring 2017.

## **Economic Gain Message:**

### **Press Release: Program to Eliminate Invasive Wild Pigs in California For Immediate Release**

February 8, 2017

California Department of Fish and Wildlife

Wild pigs or feral pigs (*Sus scrofa*) were first brought to California by Spanish settlers in the 1700s. Since then, and with many more introduction events, wild pigs have colonized almost every county in the state. Wild pigs are habitat generalists and occupy a variety of habitats, including native California grasslands, oak woodlands, and along creeks and streams.

Control measures have typically been limited to hunting pigs on both public and private lands, requiring the purchase of one tag per animal hunted. The California Department of Fish and Wildlife (CDFW) does not have an active management plan for invasive wild pigs. However, populations have become more and more established across the state, making control through hunting difficult. As of 2016, wild pigs present a major financial burden to farmers and ranchers across the state.

As a result, CDFW is proposing a more rigorous approach to addressing the problem of invasive pigs. The proposal involves a program to trap and cull wild pig populations in every county in the state, with the ultimate goal of eliminating the entire wild pig population across the state.

The Department has identified **major economic benefits associated with implementation of the program:**

- \$1.5 billion annual increase in value of agricultural sales statewide by eliminating the major damages to private farmland.
- Over \$12 million increase in annual state revenue from the sale of hunting tags for other animals like deer and elk by reducing competition with pigs.
- In total, successful implementation of the project will mean \$15 billion increased state GDP and \$120 million increase in state revenue over the next ten years.

CDFW is asking Californians' for their support and input on the project before planned early-stage implementation in Spring 2017.

## **Economic Loss Message:**

### **Press Release: Program to Eliminate Invasive Wild Pigs in California For Immediate Release**

February 8, 2017

California Department of Fish and Wildlife

Wild pigs or feral pigs (*Sus scrofa*) were first brought to California by Spanish settlers in the 1700s. Since then, and with many more introduction events, wild pigs have colonized almost every county in the state. Wild pigs are habitat generalists and occupy a variety of habitats, including native California grasslands, oak woodlands, and along creeks and streams.

Control measures have typically been limited to hunting pigs on both public and private lands, requiring the purchase of one tag per animal hunted. The California Department of Fish and Wildlife (CDFW) does not have an active management plan for invasive wild pigs. However, populations have become more and more established across the state, making control through hunting difficult. As of 2017, wild pigs present a major financial burden to farmers and ranchers across the state.

As a result, CDFW is proposing a more rigorous approach to addressing the problem of invasive pigs. The proposal involves a program to trap and cull wild pig populations in every county in the state, with the ultimate goal of eliminating the entire wild pig population across the state.

The Department has identified **major economic losses if the program is not implemented:**

- \$1.5 billion annual loss in value of agricultural sales statewide due to continued damage to farm and rangeland.
- \$12 million annual state revenue lost from potential sale of hunting tags for other animals like deer and elk that are out-competed by pigs.
- In total, failure to implement the project will mean \$15 billion lost state GDP and \$120 million lost state revenue over the next ten years.

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**Control Message:****Press Release: Program to Eliminate Invasive Wild Pigs in California  
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