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Public Reaction to Invasive Plant Species in a Disturbed Colorado Landscape

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Invasive plant species degrade ecosystems in many ways. Controlling invasive plants is costly for government agencies, businesses, and individuals. North central Colorado is currently experiencing large-scale disturbance, and millions of acres are vulnerable to invasion because of natural and socioeconomic processes. Mountain pine beetles typically endemic to this region have reached epidemic proportions, with up to 80% tree mortality, which opens growing space for invasive plants. In socioeconomic terms, the popularity of this amenity-rich region for tourists and in-migrants has resulted in increased development, often bordering the public land that is common in the American West. Increased recreational access and the construction of new roads and infrastructure disturb ecosystems in an increasingly fragmented landscape. A survey was mailed to more than 4,000 households in a five-county region of north central Colorado to gauge public awareness and attitudes regarding invasive plant species, helping to illuminate whether the public shows a capacity to help land managers detect and respond to invasive plants before they profoundly alter the local ecosystem. Although 88% of respondents had heard or read about invasive plant species, far fewer were familiar with specific, locally targeted species, and fewer still had taken any action to control these species. The overall awareness and concern about invasive plants in the area indicated a capacity for more public participation in management.

Nomenclature: Mountain pine beetle, *Dendroctonus ponderosae* Hopkins.

Key words: Amenity-based communities, invasive plants, disturbance, invasive awareness.

The introduction and spread of nonnative, invasive plants is one of the major global environmental tribulations of today (Mack et al. 2000; Vitousek et al. 1997; Wilcove, et al. 1998). Biodiversity, the economy, and long-cherished ways of life such as ranching are threatened by plants that spread aggressively through landscapes in which they have only a short history (Duncan et al. 2004; Hirsh and Leitch 1996; Lacey et al. 1989; Pauchard et al. 2003; Pimentel et al. 2005; Zavaleta 2000). Institutional frameworks in place to address the issue of invasive species, such as state and regional laws, the Plant Protection Act, the Federal Noxious Weed Act, and the Federal Seed Act, are often marred by differing objectives, scope, species focus, and mechanisms (Meyers and Bazely 2003; Shine et al. 2005). Alternatively, knowledgeable individuals can often make lasting contributions in this arena, perhaps more so than with any other human-influenced global change (Vitousek et al. 1997).

Prevention, early detection, and rapid response are economically and ecologically the least taxing defenses against plant invasions (Anderson 2005; Baker 2001; Leung et al. 2002 Reichard 1997; Smith et al. 1999; Wittenberg and Cock 2005), and these defenses are also where individuals have opportunities to participate in reducing introductions of invasive plants. A majority of plants considered invasive in the United States have been introduced through horticultural use (Reichard 1997; Reichard and White 2001), so choices made by gardeners, who enjoy one of the leading hobbies in the United States, can make a big difference in the number of invasive plant introductions (Reichard and White 2001). Visitors to natural areas can also introduce invasive plants, in that they, the animals traveling with them (Wells and Lauenroth 2007), or their vehicles can act as vectors for dispersal (Lonsdale and Lane 1994; Reichard 1997).

When prevention fails, early detection and rapid response are necessary for protection of local flora and fauna (Dyckman 2001; Masters and Sheley 2001). An alert public can be a valuable tool in early detection of invasive introductions and notifying managers so that a response can be made before invasive populations swell (Dewey et al.

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Interpretive Summary

The high level of disturbance to the land as a result of the mountain pine beetle and development in north central Colorado has created a situation favorable for the establishment and spread of invasive plants. The potential for the public to aid in the management of invasive plant species is great, particularly in the stages of prevention, early detection, and rapid response. In a survey of households in a five-county area, we found that the public is very aware of the existence of invasive plant problems, with 88% of respondents reporting they had heard or read about invasive plants. The primary sources of plant information sought by respondents were newspapers (67.8%), word of mouth (50.3%), respondents' own observations (49.5%), and the county extension office (38.2%). Although each of these sources is significantly correlated with having heard or read about invasive plants ($P < 0.01$), the county extension office had the highest correlation with having heard or read about the specific plant species targeted in that county ($r = 3.92$, $P < 0.01$). The public showed concern about the consequences of plant invasions by directly reporting concerns and through their answers detailing why they believe that invasive plants are undesirable. The high level of awareness and concern in regard to invasive plants leads us to believe that the public shows potential to aid in management of invasive plants. Respondents did report taking steps to aid in the prevention of invasive plant introductions. Fifty-eight percent of respondents reported having checked a plant's potential for invasiveness before purchasing or planting, and others had attempted to remove or reduce invasive plants. This study has shown that the public in north central Colorado has received the message about invasive plants and their consequences but still needs better information about local problem species and motivation to further participate in management.

1995; Dewey and Anderson 2004). The public can also be an important ally to land managers by taking steps to limit the spread of already established invasive plants or volunteering to help in control and removal efforts.

Therefore, because the public has such potential to affect the number and extent of plant invasions, and public awareness of invasive plants has also led to public pressure on legislative bodies to increase funding to address the issue (DiTomaso et al. 2000), an appeal for increased public awareness and public involvement in a collaborative effort to prevent the spread of invasive plants is found in both literature (Chapin et al. 2000; DiTomaso 2000; Jenkins and Mooney 2006; Myers and Bazely 2003; Reichard 1997; Vitousek et al. 1997) and public policy (Baker 2001; Dyckman 2001). A measure of the public's awareness, attitudes, and behavior regarding the issue of invasive plants will help gauge the capacity of the public to make contributions to halt the spread of invasive plants.

Awareness, Attitudes, Action. The general public's level of awareness of the ecological and economic consequences of invasive plants is generally regarded as low (Colton and Alpert 1998). In a study of West Virginia woodland landowners, only 34% of those surveyed had heard or read about invasive plant species (Steele et al. 2006). In a study of horticultural consumers, Reichard and White (2001) found a lack of education regarding the harm nonnative plants can cause in natural areas. Although past studies suggest little awareness of invasive plants, public awareness regarding invasive plants and biological invasions is thought to be on the rise as the issue has become a more prevalent topic in the mainstream press, including popular books and news articles in print and online (D'Antonio et al. 2004; DiTomaso 2000; Reichard and White 2001).

Although research shows that awareness or knowledge do not necessarily lead to pro-environmental behavior (Kollmuss and Agyeman 2002), public education campaigns have been shown to increase participation in programs such as recycling (DeYoung 1989; Nyamwange 1996; Vining and Ebreo 1990). Even if a person has developed a general attitude of concern about the environment, this concern is also not necessarily a strong predictor of pro-environmental behavior (Bamberg 2003; Scott and Willits 1994; Vining and Ebreo 1992). However, in a review of the literature on recycling behavior, Schultz et al. (1995) detail how a specific attitude of concern toward the problem of recycling significantly correlates with positive recycling behavior.

Models of altruistic behavior have been applied to pro-environmental behavior (Guagnano 1995; Vining and Ebreo 1992). The norm activation model of Schwartz (1977) is based on the idea that people will act altruistically in situations in which they are aware of the consequences of nonaction and personally assume responsibility to take action. The influence of perceived personal costs is often also included in combination with these moral norms (Guagnano 1995; Stern et al. 1985). Vining and Ebreo (1992) and Guagnano (1995) found awareness of consequences alone can significantly influence pro-environmental behavior if the threat is perceived as serious enough.

The following section describes the current situation in north central Colorado to demonstrate that potential invasion by nonnative plants can have serious consequences.

North Central Colorado. Interactions between people and the natural landscape in north central Colorado make public awareness and involvement important to resource management. The most recent critical ecosystem process in this amenity-rich region is the large-scale forest disturbance caused by the mountain pine beetle (MPB; *Dendroctonus ponderosae* Hopkins), a native insect that has killed millions of trees across 2 million acres (809,371 ha) in the area (Smith 2009). Although this beetle outbreak has affected many Colorado counties, the forests of Eagle, Grand, Jackson, Routt, and Summit counties have been particularly decimated with a high proportion of infested forest (Hackett 2007), which prompted these counties to be chosen for the study area.

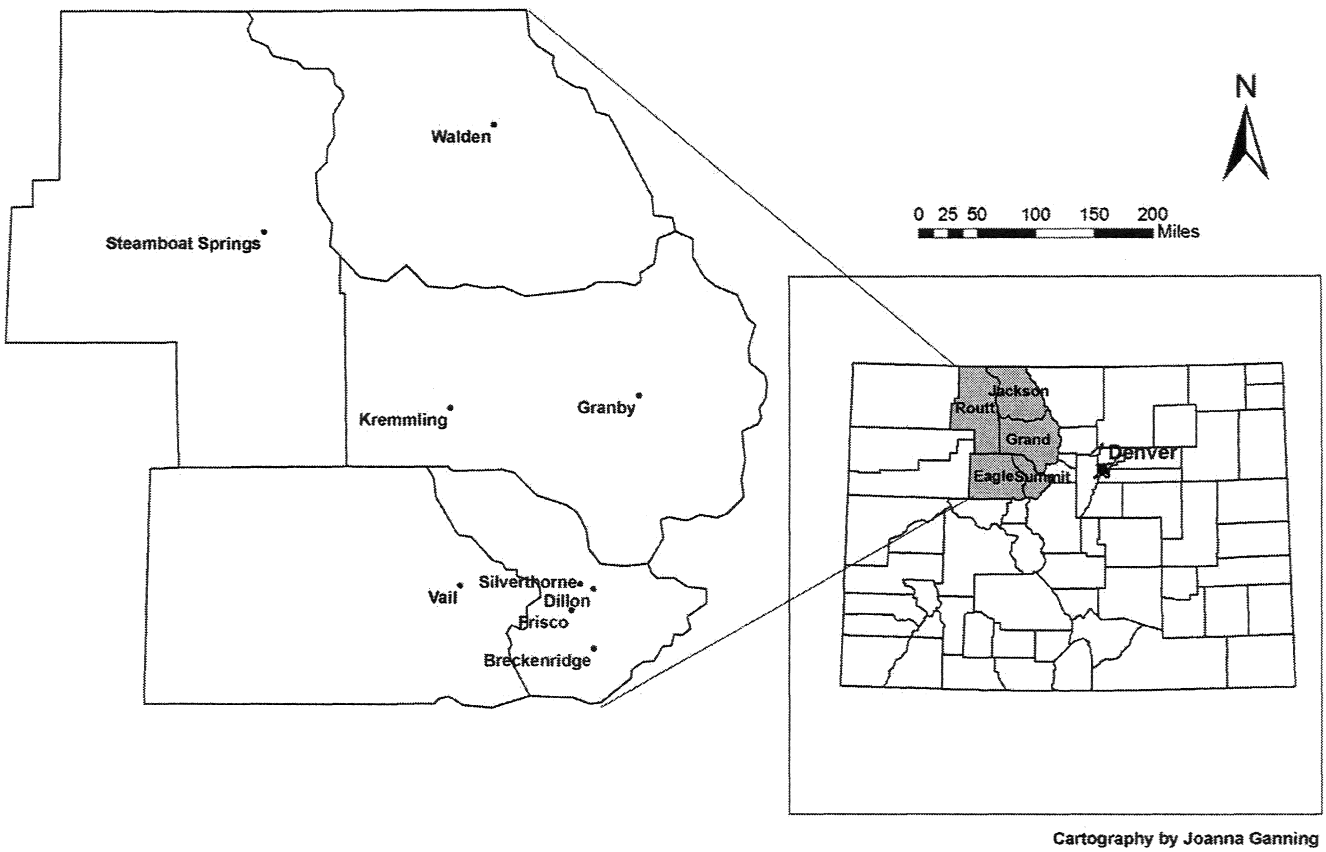

Figure 1. Map of Colorado study area.

Disturbance, defined by White and Pickett (1985:7) as "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment," is a factor that can increase susceptibility to invasive plant establishment (Hobbs 1989, 1991, 2000; Hobbs and Huenneke 1992; With 2004). North central Colorado (Figure 1) has experienced ecological and socioeconomic changes at a rapid rate, resulting in profound landscape disturbance. Recent large-scale forest disturbance by MPB and land use development have combined to create optimal conditions for the spread of invasive plants.

The killing of large stands of pine trees by beetles affects herbaceous growth and fire hazards. Although severe fire is not inevitable following a beetle outbreak (Bebi et al. 2003; Kulakowski et al. 2003), large numbers of beetle-killed trees increase fuel loading (McCullough et al. 1998) and can contribute to wildfires during periods of warm, dry, and windy weather (Parker and Stipe 1993). Fire mitigation techniques such as fuel removal disturb the soil and can facilitate invasion (Harrod and Reichard 2002; Keeley et al. 2003). In the event of a fire, there is an increase in light and soil nutrient availability, creating ideal establishment conditions for plant species not usually found in forests because of species composition and canopy cover (Keeley et al. 2003).

McCambridge et al. (1982) reported finding increased growth of forbs, sedges, and grasses in areas killed by beetles because of newly created canopy openings. The next generation of native Colorado trees could potentially succeed native herbaceous plants in these openings, but the presence of invasive plants in or near beetle-killed openings can alter traditional pathways of succession when they out-compete native species for resources and exploit vacant niches (Brooks et al. 2004; Walker and Smith 1997).

In addition to disturbances resulting from MPB outbreaks, landscapes have been fragmented and disturbed by development. North central Colorado, like much of the western United States, has experienced rapid population growth as people are attracted to its environmental amenities (Johnson and Beale 2002; Shumway and Otterstrom 2001). Research has shown that counties hosting environmental amenities such as national forests and wilderness areas (found in the five counties in the study area) tend to have significantly higher rates of population growth, income growth, and employment growth than

counties that do not (Johnson and Beale 2002; Lorah and Southwick 2003; McGranahan 1999). Of the five counties in the study area, all but Jackson experienced population growth from 2000 to 2006. Land use patterns emerging from this growth require new roads, which have been shown to be a vector of invasive plant species (D'Antonio et al. 2004; Myers and Bazely 2003; Parendes and Jones 2000; Pauchard and Alaback 2004; Tyser and Worley 1992). Not only do these developments increase the chance of plant invasions, but the consequences of the lack of land management experience by new ranch landowners can include the introduction and spread of invasive plants (Maestes et al. 2001, 2002; Travis 2007).

There are 1.25 million acres (505,900 ha) of farmland in the five-county study area, and just as new owners of former ranchlands have to prudently manage their lands to minimize plant invasions, so do the traditional ranch operators and others in the agriculture industry. The grazing selection of livestock has played a role in the expansion of invasive plants in the western United States (DiTomaso 2000), as has the spread of contaminated crop seed (Baker 1986; Mack 2001). Agriculture is also heavily affected by invasive plants. The proliferation of less desirable plants increases management costs for ranchers and farmers, reduces quality of livestock, increases erosion, and reduces utility of the land (Beck 1994; DiTomaso 2000).

Much like agriculture, recreation has an effect on, and conversely is affected by, invasive plant species. Recreation is a key economic driver in north central Colorado, with year-round tourism based on outdoor activities (Riebsame et al. 1996). Increased visits by humans to natural areas have been shown to increase the richness of invasive plants (Lonsdale 1999; Usher 1988). Colorado Rocky Mountain trail systems are conduits for invasive plant movement (Beck 1994; Benninger-Truax et al. 1992; Wells and Lauenroth 2007) because the seeds of plants can hitch rides on clothing or animals (Beck 1994).

Invasive plants can reduce the value of recreational lands and cause problems for human and animal health (DiTomaso 2000). Knapweeds (*Centaurea* spp.), leafy spurge (*Euphorbia esula* L.), and thistles [*Cirsium arvense* (L.) Scop and *Carduus nutans* L.] irritate the skin (Beck 1994; Duncan et al. 2004). Forage lands for wildlife are diminished by invasive plants (Beck 1994; DiTomaso 2000). Consequently, populations of elk, bison, and deer may become less available for hunting, wildlife watching, and photography. The reduction of plant diversity associated with invasive plants (DiTomaso 2000) might affect the natural quality and scenery that brought people to the area to begin with. Rapid environmental change in the study area suggests a need for public awareness and concern in regard to invasive plant problems so that prevention, early detection, and rapid response can be utilized. In this paper, we empirically assessed awareness, attitudes, and action in this highly disturbed region to determine the likelihood of participation in prevention of, and rapid response to, invasive plants.

Hypotheses. This study sought to measure the level of public awareness regarding invasive plants, the level of concern and personal norms regarding invasive plant problems, and the amount of action taken to address the invasive plant issue. The hypotheses presented below were derived from the literature and background investigation of the study area.

Awareness

1. The level of public awareness of invasive plant species is expected to be higher than in previous studies. Although the literature suggests awareness will be low (Colton and Alpert 1998; Reichard and White 2001; Steele et al. 2006), factors could cause higher levels of awareness in north central Colorado. A review of media coverage revealed more than 100 newspaper articles detailing the threats of invasive plants had been printed in the study area in 15 mo preceding the mailing of the questionnaire. Also, all five counties in the study area have county weed boards charged by the Colorado Noxious Weed Act with preventing further damage from invasive plants through management plans, including education. Municipalities within the counties are also active in invasive plant management.
2. The public's awareness of invasive plants targeted by county weed boards is expected to be positively correlated with a general awareness of invasive plant species.
3. Forest management or agricultural production employment experience are expected to correlate positively with awareness of invasive plant species because these respondents will have experience in industries directly affected by and affecting invasive species.
4. Homeownership is expected to correlate positively with awareness of invasive plant species because homeowners are required by law to remove state-declared noxious weeds from their lands.
5. Having used the newspaper for information on plants is expected to be positively correlated with awareness of invasive plant species. The high number of invasive plant–themed newspaper articles published in the area combined with high readership levels suggests that much of the public will have been exposed to invasive plant information through this medium.

Attitudes

6. The public in north central Colorado is expected to consider invasive plant species to be a serious problem. One factor influencing expected concern is the amplification of the risk of invasive species in reporting by the media (Kasperson et al. 1988; Pidgeon et al.

2003). Invasive plant species are also likely to be a concern for respondents because of their negative effects on human health (e.g., skin dermatitis, allergens, or tumor-promoting compounds), livestock production, and wildlife and plant communities (Duncan et al. 2004).

Action

7. Actions to prevent or manage invasive plants are expected to be positively correlated with awareness of invasive plants.
8. Actions to prevent or manage invasive plants are expected to be positively correlated with concern about invasive plants.

We found no literature examines these relationships in the context of invasive plant species. However, as stated previously, public education campaigns have been shown to increase action on other environmental issues (DeYoung 1989; Nyamwange 1996; Vining and Ebreo 1990), as has an attitude of concern about a specific environmental problem (Schultz et al. 1995).

Materials and Methods

To gather data and evaluate the preceding hypotheses, a four-page questionnaire on invasive plant species was included in a 16-page questionnaire titled "Mountain Pine Beetles and Invasive Plant Species" and mailed to a sample of 4,027 households in nine north central Colorado communities in spring 2007. These communities were Breckenridge, Dillon, Frisco, Granby, Kremmling, Silverthorne, Steamboat Springs, Vail, and the Walden area. All communities were located within the following counties: Eagle, Grand, Jackson, Routt, and Summit. Households were identified by a purchased database[1] from USADATA and area phonebooks. A total of 1,346 surveys were returned, yielding a response rate of 39% after accounting for 569 undeliverable surveys. Further details of survey administration are described in Qin and Flint (2010).

Questionnaire Development. The public's awareness of invasive plants was investigated through several measures. Questions adapted from a survey of woodland landowners by Steele et al. (2006) were modified to address the general public. These questions addressed awareness and attitudes in regard to invasive plants. General awareness of invasive plants by the public was measured by asking whether respondents had ever heard or read information about invasive plant species in their area (Steele et al. 2006). Knowledge of the terms "biodiversity," "biological invasion," and "native species," previously investigated by Colton and Alpert (1998), were examined by requesting that respondents "Please indicate your knowledge of the following terms," using a Likert scale of 1 (never heard of) to 5 (understand/comprehend). We also included the terms "invasive plant" and "noxious weed." "Invasive plant" species were the topic of the survey, and the term is widely used by land managers and in the literature. "Noxious weed" is a term commonly used in Colorado and is defined in the Colorado Noxious Weed Act as a plant that meets one or more of the following criteria:

> "... aggressively invades or is detrimental to economic crops or native plant communities; is poisonous to livestock; is a carrier of detrimental insects, diseases, or parasites; the direct or indirect effect of the presence of this plant is detrimental to the environmentally sound management of natural or agricultural ecosystems." (Colorado Noxious Weed Act 996, Section 103.)

The introduction to the invasive plant species portion of the questionnaire contained the following statement, "The United States National Arboretum defines an invasive plant as a plant that *has the ability to thrive and spread aggressively outside of its natural range.* The plants are often referred to as *noxious weeds.*" The U.S. National Arboretum definition was chosen because it is concise and comes from a more neutral source than other agencies active in Colorado, such as the U.S. Forest Service or National Park Service.

To inquire whether respondents had heard or read about, encountered, or attempted to reduce or remove invasive plant species targeted for management locally, species were chosen from the noxious weed lists of the five counties. The plants chosen for inquiry were those targeted for management by at least three of the five study area county weed boards. Most of these plants are classified as List B, meaning they inhabit isolated populations within Colorado and are subject to management techniques, including eradication, containment, or suppression to stop their spread. One of the plants, yellow starthistle (*Centaurea solstitialis* L.), is classified as List A, meaning it is not well established in the state, but it poses a threat and should be eradicated to protect the state as a whole.

We inquired where respondents sought information about plant issues and plant-related concerns to help managers in the area make better decisions in providing invasive plant information to the public. Respondents were asked to mark any sources they had used. Results were intended to provide managers with insight into which sources were most sought after and which were most positively correlated with invasive awareness.

We addressed the public's attitudes and potential to take action regarding invasive plant species through a Schwartz (1977) norm activation model to observe whether the public held norms that could lead to altruistic anti-invasive species behavior. The measure was constructed by modifying a five-point Likert scale design used by

Table 1. Comparison of survey respondent characteristic data with census data.

	Demographic characteristics (2007 survey, %/census %)				
Community	Race, white	4-yr College degree	Advanced degree	Homeownership rate	Gender, male
Breckenridge	94.9/97.3	44.9/42.5	24.7/13.0	88.5/35.6	51.9/64.8
Dillon	93.3/91.6	40.5/35.1	34.7/15.3	90.2/54.3	56.2/60.5
Frisco	97.5/96.7	41.5/44.1	30.9/16.4	91.3/55.3	58.5/57.0
Granby	94.2/97.4	30.3/16.0	20.6/7.6	87.9/63.6	51.5/50.6
Kremmling	95.2/90.3	26.8/15.2	7.9/5.2	89.7/68.2	56.0/50.6
Silverthorne	96.0/80.6	34.7/24.8	29.5/8.9	93.8/52.9	61.4/57.0
Steamboat	96.9/96.7	40.9/36.9	28.0/15.3	91.1/62.0	63.4/55.0
Vail	96.8/94.5	50.0/44.9	21.8/16.0	90.2/52.7	54.5/58.1
Walden/Jackson	95.9/94.2	23.2/13.0	11.1/6.8	85.2/67.9	51.8/50.0

Guagnano (1995), with choices ranging from strongly disagree to strongly agree. Questions gauged respondents' awareness of the consequences of invasive plants by measuring agreement with the statements that "Over the next several decades the spread of invasive plant species will result in the loss of many of Colorado's native plant species," "The effects of invasive plant species on ecosystems are worse than we realize," and "Claims that invasive plant species are severely degrading the environment are exaggerated." Ascription of personal responsibility was measured through agreement with the statements, "It is my personal responsibility to protect against the spread of invasive plants even if other people seem to be unconcerned," and "It is my responsibility to help protect environmental quality for everyone in Colorado." Finally, perceived personal costs were measured through agreement with the statements, "Attempting to remove or reduce invasive plants will be expensive and/or time consuming for me," and "Laws aimed at requiring the removal of invasive plants limit my personal freedom."

Construction of a concern index made up of three variables measuring awareness of consequences and the question asking the public if they felt concerned about invasive plants was supported by factor analysis using varimax rotation, which revealed a common factor among these variables (Cronbach's Alpha reliability score of 0.759). The concern index variable was evaluated for its effect on action to remove or reduce invasive plants.

We believed that more specific information on what characteristics make plants weedy or undesirable in the opinion of the public could aid managers in education efforts to show that invasive plants do indeed cause harm. To measure respondents' opinions, they were given several statements and asked whether these statements reflected their views of undesirable plants. The statement choices included that plants look bad, they crowd out plants that I like for beauty and/or wildlife value, they crowd out plants that I collect, they reduce the value of timber stands, they interfere with agricultural practices, and they make it difficult to walk or ride vehicles through. We also presented respondents the opportunity to provide their own reasons for finding plants undesirable.

Results

Sociodemographic Characteristics. The majority of questionnaires returned came from primary homeowners; only 8.1% were second homeowners, and 10.4% did not own their home. Respondents reported living in their communities an average of almost 20 yr, but with standard deviation (SD) > 15, so newcomers and long-time residents were represented. Half of respondents lived within town or city limits (49.9%), and a third lived within 8 km (5 miles) of the limit (32.4%), leaving 17.7% living more than 8 km from town. Twenty-nine percent lived on property of more than 0.40 ha (1 acre) in size. The average respondent age was 52 yr. Fifty-five percent of respondents were male, and overall, respondents were predominately white (95.6%). The majority of respondents had some post-college education, and 58.8% had a 4-yr or more advanced degree. More than two-thirds (64.5%) of those responding earned more than \$50,000 yr^{-1}. Validation of the sample by comparison with census data can be found in Table 1, with a cautionary note that 2000 census data might not accurately portray these rapidly changing amenity-oriented communities.

Our sample of survey respondents overrepresents those with a 4-yr degree or advanced degree, as well as homeowners. The transient nature of these amenity-based communities made it difficult to capture respondents who were not homeowners. We cannot be sure of the effect of this response bias on the results of the survey. However, a survey of second homeowners in the region indicated second homeowners and residents shared similar values regarding community amenities and recreation (Venturoni et al. 2005). Our sample did come close to reflecting census indicators on race and gender, with the exception of an over-representation of white respondents in Silverthorne.

Table 2. Community differences in public awareness of invasive plant species.

Variable (*N*)	Have heard or read about invasive plants (%) (1,310)	Average % of presented county-targeted plants residents have heard or read about (907)
Breckenridge (157)	89.2	50.4
Dillon (118)	93.2	55.7
Frisco (125)	91.2	42.6
Silverthorne(177)	94.4	51.1
Granby (155)	80.0	43.7
Kremmling (124)	88.7	62.3
Steamboat Springs (131)	89.3	57.9
Vail (124)	84.7	34.6
Jackson County (199)	83.4	55.9
F value		6.14***
Chi-square	26.17***	

***Values are statistically significant at $P < 0.001$.

Awareness. Eighty-eight percent of respondents had heard or read about invasive plant species in their area in general, supporting our first hypothesis. This awareness was higher than found among West Virginia woodland landowners and higher than we expected. Respondents also reported they were knowledgeable of the invasive plant related terms biodiversity ($\bar{x}$ = 3.46, SD = 1.33), biological invasion ($\bar{x}$ = 3.43, SD = 1.20), native species ($\bar{x}$ = 4.30, SD = 0.91), noxious weed ($\bar{x}$ = 4.23, SD = 0.93), and invasive species ($\bar{x}$ = 4.08, SD = 1.04).

However, when we measured how many respondents had heard or read about specific invasive plants targeted for management in their own counties, awareness dropped considerably. The disparity can be seen in Table 2. Canada thistle was the species most often heard or read about by respondents in all communities where it is targeted, from a high of 97.5% of respondents in Kremmling to 81.2% of respondents in Vail. The least familiar target species was different in every community. Even though Dalmatian toadflax [*Linaria dalmatica* (L.) P. Mill.] was the target species least heard or read about in Kremmling, 59.0% of respondents in that community were aware of it, demonstrating the strength of Kremmling respondents' awareness of targeted species. In contrast, only 17.9% of respondents in Frisco had heard of or read about yellow starthistle, that community's least familiar target species.

A test of the bivariate relationship between those who had heard or read about invasive plants in their area in general and those that had heard or read about targeted species revealed a significant positive correlation (r[900] = 0.343, $P < 0.001$), supporting our second hypothesis that general awareness and awareness of county-targeted species are positively correlated.

Table 3. Bivariate correlations among awareness and demographic variables.

Variable	County aware index (*r*)	General awareness (*r*)
General awareness	0.343**	
Forest management employment	0.158**	0.031
Agricultural production employment	0.195**	0.021
Homeownership	0.061	0.083**

**Values are statistically significant at $P < 0.01$.

In our third hypothesis, forest management employment experience and agricultural production employment experience were predicted to be positively correlated with awareness of invasive plants. This hypothesis was supported for targeted species awareness, but occupational experience had little effect on having heard or read about invasive plants in general. The correlations between these occupations and awareness of county-targeted plants were not particularly high, but they were both significant. We believe that we can confidently say our third hypothesis has been supported because of the high level of significance combined with the likelihood that these respondents had been exposed to invasive plants or invasive plant information at higher rates than the general public.

Our fourth hypothesis predicted homeownership would correlate positively with awareness, and this hypothesis was supported for having heard or read about invasive plants in general, albeit with a low correlation value and probably because of the overall high level of reported awareness. Variance might be more accounted for by the large population of survey respondents than any actual difference in groups. The relationship between county-targeted species and homeownership was not significant. The results of these relationships can be found in Table 3.

In our examination of plant information sources sought by the respondents, the newspaper was the most common source (67.8%), and it had a significantly positive correlation (r = 0.170, $P < 0.01$) with having heard or read about invasive plant species in general. A nonsignificant negative correlation (r = −0.019) with having heard or read about county-targeted plant species confirmed that our fifth hypothesis was also supported for general awareness, but not awareness of targeted species. The next most common source of plant information (50.3%), word of mouth, was also significantly positively correlated with awareness of invasive plants in general (r = 0.108, $P < 0.01$), but not with awareness of county-targeted species (r = −0.042). "My own observations" were also used by

Table 4. Plant issue information sources—use and correlations with awareness.

Source	Respondents reporting use (%)	Have heard or read about invasive plants (r)	Have heard or read about county-targeted invasive plant (r)
Newspaper	67.8	0.170**	−0.019
Word of mouth	50.3	0.108**	−0.042
My own observations	49.5	0.154**	0.183**
County Extension office	38.2	0.213**	0.372**
County government	27.8	0.180**	0.272**
U.S. Forest Service	26.7	0.110**	0.179**
Radio	23.2	0.057*	−0.061
Environmental organizations	19.6	0.127**	0.147**
Local garden club	18.9	0.043	0.090**
Town/municipal government	18.3	0.099**	0.025
Colorado Weed Management Association	18.0	0.162**	0.343**
Colorado State Forest Service	17.9	0.107**	0.226**
Department of Agriculture	17.3	0.127**	0.279**
Public meetings	16.3	0.089**	0.125**
Bureau of Land Management	15.4	0.114**	0.195**
Colorado Department of Natural Resources	7.6	0.080**	0.225**
N	1,347	1,316	908

* Value is statistically significant at $P < 0.05$.

** Values are statistically significant at $P < 0.01$.

about half of the respondents and were significantly positively correlated with general awareness of invasive plants ($r = 0.154$, $P < 0.01$) and awareness of county-targeted species ($r = 0.183$, $P < 0.01$). The fourth most sought information source (38.2%), the County Extension office, had the highest positive correlation with awareness of invasive plants in general ($r = 0.213$, $P < 0.01$) and awareness of county-targeted plants ($r = 0.372$, $P < 0.01$). The results for all sources can be seen in Table 4.

Attitudes. Respondents generally agreed they were concerned about invasive plants in Colorado ($\bar{x} = 4.00$, SD = 1.00) when asked directly if they were concerned. Respondents also showed concern through their agreement or disagreement with the statements measuring moral norms in our version of the Schwartz norm activation model. Responses indicated an awareness of the consequences of invasive plant species, including damage to the ecosystem ($\bar{x} = 3.71$, SD = 0.97) and loss of native plants specifically ($\bar{x} = 3.72$, SD = 0 .98). An assumption of responsibility was also present in respondents, in that they agreed they were personally responsible both for protecting the environmental quality for everyone in Colorado ($\bar{x} = 3.82$, SD = 1.04) and protecting against the spread of invasive plants, even if others are unconcerned ($\bar{x} = 3.66$, SD = 1.05). With regard to personal costs, respondents were not very concerned about a loss of personal freedom through laws requiring removal of invasive plants ($\bar{x} = 2.53$, SD = 1.25), but there was more concern about the time and cost involved in removing invasive plants ($\bar{x} = 3.17$, SD = 1.06).

Finally, respondents demonstrated a concern about invasive plant species compared with other forest risk concerns as a result of the MPB outbreak (Table 5). Invasive plant species was the fourth highest perceived risk because of MPB in the aggregate data, following forest fire, loss of scenic/aesthetic quality, and increased erosion and runoff. Taking the results of our measures of concern as a whole, we believe our sixth hypothesis is supported, and the public in north central Colorado do consider invasive plants to be a serious problem.

The top reason respondents found plants to be weedy or undesirable was because they crowd out plants desired for beauty or wildlife (69.7% of all respondents). Respondents were also concerned with how some plants interfere with agricultural practices (42.3%) and with aesthetic values of invasive plants, in that 41.8% of all respondents reported that these plants "look bad."

Respondents were encouraged to specify "other" reasons for finding plants weedy or undesirable, and several themes emerged from the write-in answers. These themes included harm to native species and qualities of invasiveness such as aggressive propagation ($n = 83$), the increased use of water by invasive plants ($n = 21$), harm to wildlife and livestock grazing ($n = 19$), and harm to humans from armed plants (e.g., thistles) or allergies ($n = 18$). These themes further

Table 5. Concern about forest risks as a result of mountain pine beetle outbreak.

Forest risk	Mean[a]	Standard deviation
Forest fire	4.46	0.904
Loss of scenic/aesthetic quality	4.23	1.00
Increased erosion and runoff	3.82	1.00
Invasive plant species	3.75	1.08
Decline in wildlife habitat	3.72	1.14
Effect on property values	3.68	1.21
Falling trees	3.65	1.12
Loss of forests as an economic resource	3.59	1.23
Loss of tourism and recreation opportunities	3.55	1.21
Loss of community identity tied to the forest	3.53	1.19
Effect on livestock grazing	2.68	1.30

[a]Mean is on a Likert scale from 1 (not concerned) to 5 (extremely concerned).

illustrate the public's awareness of the consequences of invasive plant species, and quotes like "grow very fast and everywhere," "crowd out native plants," and "use too much water" were common. Another theme that emerged from the open-ended option was that respondents found plants to be undesirable because they were told these plants were undesirable by sources such as the U.S. Department of Agriculture (USDA), the county, or the newspaper (n = 28).

Action. The first measure of action in relation to invasive plant species involved the prevention stage of addressing the invasive plant problem. Fifty-eight percent of all respondents reported aiding in preventing the spread of invasive plants by checking plants' potential for invasiveness before purchase or planting. Bivariate analysis revealed those who were more aware of the targeted invasive species in their county were more likely to have checked a plant's potential for invasiveness (r [899] = 0.418, P < 0.001), as were those who were more concerned about invasive plants (r [1,295] = 0.225, P < 0.001).

Action was also measured by asking respondents if they had attempted to remove or reduce invasive plant species they had encountered. Whereas 57.5% of all respondents had attempted to remove Canada thistle, the percentage of the respondents taking action on other species was much less. We created an index variable titled "county action" to relate action in regard to the specifically targeted species of the county in which a respondent lived. Awareness of county-listed invasive plants (r [907] = 0.570, P < 0.001), and the concern index (r [906] = 0.328, P < 0.001) were both positively correlated with taking action to remove or reduce invasive plants. Multiple regression was conducted to determine the power of awareness and concern to predict action to remove or reduce invasive plants. The adjusted R^2 (= 0.346) indicates that 34.6% of the variance in action to remove or reduce invasive plants is explained by this model, supporting our seventh and eighth hypotheses that awareness and concern have an influence on action to address invasive plant problems. The beta weight of the county awareness index (β = 0.519) suggests this variable contributed more to action to remove or reduce than concern (β = 0.155).

Discussion

We sought to measure the north central Colorado public's awareness, attitudes, and action regarding invasive plant species to determine whether they might be prepared to act to prevent the spread of invasive plants in highly disturbed landscapes. The public of north central Colorado showed considerable awareness and concern regarding invasive plants, and many people have taken action to prevent the spread of these plant species and remove the ones that have already established. An unanticipated high of 88% of the public in north central Colorado surveyed in 2007 had heard or read about invasive plant species compared with just 34% of woodland land owners in West Virginia (Steele et al. 2006). We believe the high-profile nature of natural resource issues in this region has contributed to the high level of invasive plant awareness, and that awareness should not be considered high or low on a national scale. Levels of the public's invasive plant awareness are most likely as diverse as the regions they inhabit.

For the public's knowledge of invasive plants to be useful in aiding management at the local level, the public needs to be aware of the plants that are currently or potentially creating problems locally. Although the general level of awareness in our survey was high across all communities, respondents were less familiar with the species targeted for county management. The significant correlation between general awareness of invasive plants and awareness of targeted species could mean that much of the public's exposure to information about invasive plants in general is through efforts to increase knowledge of targeted species. Ideally, the correlation between general awareness and awareness of targeted species would be even higher, suggesting that when the public receives information about invasive plants, they are getting and retaining information that is useful locally.

Currently, the information resources most used by citizens are not helping them recognize the invasive plants that are a problem in their area. Government agencies and others supplying invasive plant information to the public should evaluate efforts to communicate information about locally problematic invasive plants through newspapers or radio. Citizens seeking information from sources such as

county extension or weed management associations likely had some previous knowledge of plant issues, leading to a higher correlation between use of these sources and awareness. Because many respondents sought plant information through social networks, the number of citizens with employment experience in agriculture or forestry in this area and their potential to spread information is important to realize. Future studies should consider a measure of the use of online tools for obtaining invasive plant information. If they have not already done so, invasive plant managers might also want to consider using the current popularity of social networking on the Internet to educate the public.

The surveyed public did report an understanding of general and specific subjects important for understanding the invasive plant problem, including knowledge of terms Colton and Alpert (1998) found lacking in their California study. Term recognition, however, must be interpreted with caution because of the possibility of social response bias. Colton and Alpert (1998) reported a lack of awareness of the consequences of invasive plant species, but many respondents in our study demonstrated that they were aware of how invasive plants can displace native flora and fauna, disrupt agriculture, and hoard valuable water resources. Respondents also demonstrated feeling personally responsible for preventing these negative consequences. Therefore, through interpretation of the Schwartz norm-activation model, we expect much of the public in this area to be willing to help prevent the spread of invasive plant species.

This willingness, however, would be weighed against concern about the personal cost of time and money to act on the invasive plant issue before any decision to take action. As a reaction to cost concerns, a message advocating the benefits of prevention, early detection, and rapid response, and the time and cost savings of employing this strategy, might be beneficial. We found that cost-share programs for invasive plant control were being advertised in the area, but did not investigate whether the target audience was being reached. More investigation should be done to determine specific limitations of public action to manage invasive plants. The majority of respondents were already taking part in one low-cost form of prevention, in that they had checked a plant's potential for invasiveness before purchase or planting (58%).

Knowledge of locally targeted species was shown to have the biggest influence on whether a respondent had acted to manage existing invasive plants. Of the many possible explanations for this relationship, it is probably a combination of factors. One is simply that awareness of the locally problematic species would have been necessary to have worked to remove or reduce them. A second is that after learning to identify a specific invasive plant, respondents' sensitivity to the plants in the landscape resulted in more recognition of the extent of the effect of the plant, and therefore increased the desire to act. For homeowners, the ability to identify a targeted plant could have led to action to be compliant with local or state laws.

Public awareness of locally problematic invasive plants will be increasingly important as disturbance from MPB and increased development opens more sites and pathways for invasion. Natural resource managers can cautiously move beyond attempting to create awareness and saliency of the invasive plant problem in general and shift to a more focused approach. For example, homeowners can be targeted for increased knowledge of plants that are sometimes planted for their beauty but can spread aggressively beyond intentions. Recreationists can be targeted for education about recently introduced invasive plants that might be spread through trail systems.

The potential for the public to take action has been revealed, and increasing knowledge of specific plants among specific groups is one step natural resource managers will have to take to capitalize on that potential. More thorough studies on stakeholders' abilities, limitations, and desire to help, as well as an examination of the current state of invasive plant educational campaigns and who they are reaching, would be useful in garnering even more awareness, concern, and action in regard to invasive plants.

Sources of Materials

[1] Database of contact information for households in Breckenridge, Dillon, Frisco, Granby, Kremmling, Silverthorne, Steamboat Springs, Vail, Walden, Coalmont, Cowdery and Rand, USADATA, New York, NY, United States.

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Literature Cited

Anderson, L.W.J. 2005. California's reaction to *Caulerpa taxifolia*: a model for invasive species rapid response. Biol. Invasions 7: 1003–1016.

Baker, B. 2001. National management plan maps strategy for controlling invasive species. Bioscience 51:92.

Baker, H. G. 1986. Patterns of plant invasion in North America. Pages 44–57 *in* H. A. Mooney and J. A. Drake, eds. Ecology of Biological Invasions in North America and Hawaii. New York: Springer-Verlag.

Bamberg, S. 2003. How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. J. Environ. Psychol. 23:21–32.

Bebi, P., D. Kulakowski, and T. T. Veblen. 2003. Interactions between fire and spruce beetles in a subalpine Rocky Mountain forest landscape. Ecology 84:362–371.

Beck, G. K. 1994. How do weeds affect us all? Pages 3–4 *in* 1994 Leafy Spurge Symposium. Bozeman, MT: United States Department of Agriculture—Agricultural Research Service.

Benninger-Truax, M., J. L. Vankat, and R. L. Schaefer. 1992. Trail corridors as habitat and conduits for movement of plant species in Rocky Mountain National Park, Colorado, USA. Landsc. Ecol. 6: 269–278.

Brooks, M. L., C. M. D'Antonio, D. M. Richardson, J. B. Grace, J. E. Keeley, J. M. DiTomaso, R. J. Hobbs, M. Pellant, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. Bioscience 54: 677–688.

Chapin, F. S., III, E. S. Zavaleta, and V. T. Eviner, et al. 2000. Consequences of changing biodiversity. Nature 405:234–242.

Colorado Noxious Weed Act. 1996. Colorado Revised Statutes. Title 35, Article 5.5, Section 103.

Colton, T. F. and P. Alpert. 1998. Lack of public awareness of biological invasions by plants. Nat. Area J 18:262–266.

D'Antonio, C. M., N. E. Jackson, C. C. Horvitz, and R. Hedberg. 2004. Invasive plants in wildland ecosystems: merging the study of invasion processes with management needs. Front. Ecol. Environ. 2: 513–521.

Dewey, S. A. and K. A. Andersen. 2004. Strategies for early detection: using the wildfire model. Weed Technol. 18(Invasive Weed Symposium):1396–1399.

Dewey, S. A., M. J. Jenkins, and R. C. Tonioli. 1995. Wildfire suppression: a paradigm for noxious weed management. Weed Technol. 9:621–627.

DeYoung, R. 1989. Exploring the difference between recyclers and non-recyclers: the role of informaton. J. Environ. Syst. 18:341–351.

DiTomaso, J. M. 2000. Invasive weeds in rangelands: species, impacts, and management. Weed Sci. 48:255–265.

DiTomaso, J. M., G. B. Kyser, S. B. Orloff, and S. F. Enloe. 2000. Integrated strategies offer site-specific control of yellow starthistle. Calif. Agric. 54:30–36.

Duncan, C. A., J. J. Jachetta, and M. L. Brown, et al. 2004. Assessing the economic, environmental, and societal losses from invasive plants on rangeland and wildlands. Weed Technol. 18(Invasive Weed Symposium):1411–1416.

Dyckman, L. J. 2001. Invasive Species: Obstacles Hinder Federal Rapid Response to Growing Threat. Washington, DC: United States General Accounting Office GAO-01-724.

Guagnano, G. 1995. Locus of control, altruism and agentic disposition. Popul. Environ. 17:63–77.

Hackett, J. 2007. Colorado's mountain pine beetle infestation offers important lessons about managing future forests. Colo, Conservator 23(2):8–9.

Harrod, R. J. and S. H. Reichard. 2001. Fire and invasive species within the temperate and boreal coniferous forests of western North America. Pages 95–101 *in* K.E.M. Galley and T. P. Wilson, eds. Proceedings of the Invasive Species Workshop: The Role of Fire in the Control and Spread of Invasive Species. Tallahassee, FL: Tall Timbers Research Station, Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication 11.

Hirsch, S. A. and J. A. Leitch. 1996. The Impact of Knapweed on Montana's Economy. North Dakota State University Agricultural Economic Report 355. 23 p.

Hobbs, R. J. 1989. The nature and effects of disturbance relative to invasion. Pages 389–405 *in* J. A. Drake, H. A. Mooney, F. di Castri, R. H. Groves, F. J. Kruger, M. Rejmanek, and M. Williamson, eds. Biological Invasions: A global Perspective. Chichester, UK: Wiley.

Hobbs, R. J. 1991. Disturbance as a precursor to weed invasion in native vegetation. Plant Prot. Q. 6(3):99–104.

Hobbs, R. J. 2000. Land-use changes and invasions. Pages 55–93 *in* H. A. Mooney and R. J. Hobbs, eds. Invasive Species in a Changing World. Washington, DC: Island Press.

Hobbs, R. J. and L. F. Huenneke. 1992. Disturbance, diversity, and invasion: implications for conservation. Conserv. Biol. 6:324–337.

Jenkins, P. and H. Mooney. 2006. The United States, China, and invasive species: present status and future prospects. Biol. Invasions 8: 1589–1593.

Johnson, K. M. and C. L. Beale. 2002. Nonmetro recreation counties: their identification and rapid growth. Rural Am. 17:12–19.

Kasperson, R. E., O. Renn, P. Slovic, H. S. Brown, J. Emel, R. Goble, J. X. Kasperson, and S. Ratick. 1988. The social amplification of risk: a conceptual framework. Risk Anal. 8(2):177–187.

Keeley, J. E., D. Lubin, and C. J. Fotheringham. 2003. Fire and grazing impacts on plant diversity and alien plant invasions in the southern Sierra Nevada. Ecol. Appl. 13:1355–1374.

Kollmuss, A. and J. Agyeman. 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ. Educ. Res. 8:239–260.

Kulakowski, D., T. T. Veblen, and P. Bebi. 2003. Effects of fire and spruce beetle outbreak legacies on the disturbance regime of a subalpine forest in Colorado. J. Biogeogr. 30:1445–1456.

Lacey, J. R., C. B. Marlow, and J. R. Lane. 1989. Influence of spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield. Weed Technol. 3:627–631.

Leung, B., D. M. Lodge, D. Finnoff, J. F. Shogren, M. A. Lewis, and G. Lamberti. 2002. An ounce of prevention or a pound of cure: bioeconomic risk analysis of invasive species. Proc. R. Soc. Lond. 269: 2407–2413.

Lonsdale, W. M. 1999. Global patterns of plant invasions and the concept of invasibility. Ecology 80:1522–1536.

Lonsdale, W. M. and A. M. Lane. 1994. Tourist vehicles as vectors of weed seeds in Kakadu National Park, northern Australia. Biol. Conserv. 69:277–283.

Lorah, P. and R. Southwick. 2003. Environmental protection, population change, and economic development in the rural western United States. Popul. Environ. 24:255–272.

Mack, R. N. 2001. Motivations and consequences of the human dispersal of plants. Pages 23–34 *in* J. A. McNeely, ed. The great reshuffling: human dimensions in invasive alien species. Gland, Switzerland and Cambridge, UK: IUCN, Biodiversity Policy Coordination Divison.

Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout, and F. A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecol. Appl. 10:689–710.

Maestas, J. D., R. L. Knight, and W. C. Gilgert. 2001. Biodiversity and land-use change in the American mountain west. Geogr. Rev. 91: 509–524.

Maestas, J. D., R. L. Knight, and W. C. Gilgert. 2002. Cows, condos, or neither: what's best for rangeland ecosystems? Rangelands 24: 36–42.

Masters, R. A. and R. L. Sheley. 2001. Principles and practices for managing rangeland invasive plants. J. Range Manage. 54:502–517.

McCambridge, W. F., F. G. Hawksworth, C. B. Edminster, and J. G. Laut. 1982. Ponderosa Pine Mortality Resulting from a Mountain Pine Beetle Outbreak. Fort Collins, CO: U.S. Department of Agriculture Forest Service Rocky Mountain Forest and Range Experiment Station RM-235.

McCullough, D. G., R. A. Werner, and D. Neumann. 1998. Fire and insects in northern and boreal forest ecosystems of North America. Annu. Rev. Entomol. 43:107–127.

McGranahan, D. 1999. Natural amenities drive rural population change. Washington D.C.: Food and Rural Economics Division, Economic Research Service, U.S. Department of Agriculture AER781.

Myers, J. H. and D. Bazely. 2003. Ecology and Control of Introduced Plants. Cambridge, UK: Cambridge University Press.

Nyamwange, M. 1996. Public perception of strategies for increasing participation in recycling programs. J. Environ. Educ. 27:19–22.

Parendes, L. A. and J. A. Jones. 2000. Role of light availability and dispersal in exotic plant invasion along roads and streams in the H. J. Andrews Experimental Forest, Oregon. Conserv. Biol. 14:64–75.
Parker, D. L. and L. E. Stipe. 1993. A Sequence of Destruction: Mountain Pine Beetle and Wildfire. Washington DC: U.S. Department of Agriculture Forest Service Southwestern Region.
Pauchard, A. and P. B. Alaback. 2004. Influence of elevation, land use, and landscape context on patterns of alien plant invasions along roadsides in protected areas of south-central Chile. Conserv. Biol. 18: 238–248.
Pauchard, A., P. A. Alaback, and E. G. Edlund. 2003. Plant invasions in protected areas at multiple scales: *Linaria vulgaris* (Scrophulariaceae) in the west Yellowstone area. West. N. Am. Nat. 63:416.
Pidgeon, N. F., R. E. Kasperson, and P. Slovic. 2003. The social amplification of risk. Cambridge University Press: Cambridge: Cambridge University Press. 448 p.
Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecol. Econ. 52:273–288.
Qin, H. and C. G. Flint. 2010. Capturing community context of human response to forest disturbance by insects: a multi-method assessment. Hum. Ecol. Published Online First: 25 May. DOI: 10.1007/s10745-010-9334-2.
Reichard, S. H. 1997. Prevention of invasive plant introduction on national and local levels. Pages 215–227 *in* J. O. Luken and J. W. Theiret, eds. Assessment and Management of Plant Invasions. New York: Springer.
Reichard, S. H. and P. White. 2001. Horticulture as a pathway of invasive plant introductions in the United States. Bioscience 51:103.
Riebsame, W. E., H. Gosnell, and D. M. Theobald. 1996. Land use and landscape change in the Colorado mountains I: theory, scale, and pattern. Mt. Res. Dev. 16:395–405.
Schultz, W. P., S. Oskamp, and T. Mainieri. 1995. Who recycles and when? A review of personal and situational factors. J. Environ. Psychol. 15:105–121.
Schwartz, S. H. 1977. Normative influences on altruism. Pages 221–279 *in* L. Berkowitz, ed. Advances in Experimental Social Psychology. New York: Academic Press.
Scott, D. and F. K. Willits. 1994. Environmental attitudes and behavior: a Pennsylvania survey. Environ. Behav. 26:239–260.
Shine, C., N. Williams, and F. Burhenne-Guilmin. 2005. Legal and institutional frameworks for invasive alien species. Pages 233–284 *in* H. A. Mooney, R. N. Mack, J. A. McNeely, L. E. Neville, P. J. Schei, and J. K. Waage, eds. Invasive Alien Species. Washington, DC: Island Press.
Shumway, J. M. and S. M. Otterstrom. 2001. Spatial patterns of migration and income change in the mountain west: the dominance of service-based, amenity-rich counties. Professional Geogr. 53: 492–502.
Smith, C. S., W. M. Lonsdale, and J. Fortune. 1999. When to ignore advice: invasion predictions and decision theory. Biol. Invasions 1: 89–96.
Smith, J. 2009. Colorado pine beetle infestation swells to almost 2 million acres. Rocky Mountain News [Internet]. [cited 2010 June 17]. Available from: http://www.rockymountainnews.com/news/2009/jan/17/colorado-pine-beetle-infestation-swells-to-2/
Steele, J., R. S. Chandran, W. N. Grafton, C. D. Huebner, and D. W. McGill. 2006. Awareness and management of invasive plants among West Virginia woodland owners. J. For. 104:248–253.
Stern, P. C., T. Dietz, and J. S. Black. 1985. Support for environmental protection: the role of moral norms. Popul. Environ. 8:204–222.
Travis, W. R. 2007. New Geographies of the American West. Washington, DC: Island Press. 291 p.
Tyser, R. W. and C. A. Worley. 1992. Alien flora in grasslands adjacent to road and trail corridors in Glacier National Park, Montana (U.S.A.). Conserv. Biol. 6:253–262.
Usher, M. B. 1988. Biological invasions of nature reserves: a search for generalisations. Biol. Conserv. 44:119–135.
Venturoni, L., P. Long, and R. R. Perdue. 2005. The economic and social impacts of second homes in four mountain resort counties of Colorado, prepared for Annual Meeting of the Association of American Geographers. Denver, CO: Association of American Geographers.
Vining, J. and A. Ebreo. 1990. What makes a recycler? A comparison of recyclers and nonrecyclers. Environ. Behav. 22:55–73.
Vining, J. and A. Ebreo. 1992. Predicting recycling behavior from global and specific environmental attitudes and changes in recycling opportunities. J. Appl. Soc. Psychol. 22:1580–1607.
Vitousek, P. M., C. D. D'Antonio, L. L. Loope, M. Rejmanek, and M. Westbrooks. 1997. Introduced species: a significant component of human caused global change. N. Z. J. Ecol. 21:1.
Walker, L. R. and S. D. Smith. 1997. Impacts of invasive plants on community and ecosystem properties. Pages 69–86 *in* J. O. Luken and J. W. Theiret, eds. Assessment and Management of Plant Invasions. New York: Springer.
Wells, F. H. and W. K. Lauenroth. 2007. The potential for horses to disperse alien plants along recreational trails. Range. Ecol. Manag. 60: 574–577.
White, P. S. and S.T.A. Pickett. 1985. Natural disturbance and patch dynamics: an introduction. Pages 3–13 *in* S.T.A. Pickett and P. S. White, eds. The Ecology of Natural Disturbance and Patch Dynamics. New York: Academic Press.
Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607.
With, K. A. 2004. Assessing the risk of invasive spread in fragmented landscapes. Risk Anal. 24:803–815.
Wittenberg, R. and M.J.W. Cock. 2005. Best practices for the prevention and management of invasive alien species. Pages 209–232 *in* H. A. Mooney, R. N. Mack, J. A. McNeely, L. E. Neville, P. J. Schei, and J. K. Waage, eds. Invasive Alien Species: A New Synthesis. Washington, DC: Island Press.
Zavaleta, E. S. 2000. Valuing ecosystem services lost due to *Tamarix* invasion in the United States. Pages 261–302 *in* H. A. Mooney and R. J. Hobbs, eds. Invasive Species in a Changing World. Washington, DC: Island Press.

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