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ORIGINAL PAPER

# Invasive species on British Columbia's grasslands: estimating the benefits of control policies

**Adetola Ajayi · Panagiotis Tsigaris · Joel Wood · Lauchlan Fraser**

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**Abstract** Invasive species significantly impact biodiversity and ecosystem services, causing economic and ecological damage. Particularly, non-native plant invasions in grasslands impose costs on society, including biodiversity loss, habitat destruction, and altered recreational opportunities. This study attempts to measure preferences for reducing the loss of aggregate ecosystem services caused by invasive plant species in British Columbia's (B.C.) grasslands. While the study does not explicitly value reduction in individual ecosystem service benefits, it captures public preferences for policy action, which may implicitly reflect broader ecological concerns. The results of a choice experiment survey reveal a strong willingness to pay (88.6% of survey respondents) for comprehensive control policies, with a preference for widespread control in B.C.'s interior. The results indicate that respondents are willing to pay more for either biological control methods or targeted grazing compared to chemical control approaches, with a preference for major to moderate eradication of invasive species. A heterogeneity analysis reveals that environmental concern, income, education, and geographic background significantly shape preferences for policy action. We estimate that in aggregate, B.C. households are willing to pay 208 million CAD [95% CI 156 million, 251 million] annually for chemical control of invasive species on B.C.'s grasslands. For biological control methods this estimate more than doubles to 454 million CAD per year [95% CI 349 million, 559 million]. For targeted grazing control methods, the estimate is 493 million CAD per year [95% CI 396 million, 592 million]. These results indicate large potential benefits of invasive species control on B.C. grasslands. This study estimates public preferences for invasive species control policies in British Columbia's grasslands, focusing on willingness to pay for different control measures and locations.

**Keywords** Biodiversity · Ecosystem services · Grasslands · Invasive plants · Control methods · Valuation

A. Ajayi
Faculty of Science, Master of Science in Environmental Science, Kamloops, Canada

P. Tsigaris (✉) · J. Wood
Department of Economics, Bob Gaglardi School of Business and Economics, Thompson Rivers University, Kamloops, B.C., Canada
e-mail: ptsigaris@tru.ca

J. Wood
e-mail: jwood@tru.ca

L. Fraser
Department of Natural Resource Science, Faculty of Science, Thompson Rivers University, Kamloops, B.C., Canada
e-mail: lfraser@tru.ca

## Introduction

Invasive plants are non-native or alien species that, upon introduction to an ecosystem, cause or have the potential to cause economic or environmental harm, including harm to human and animal health (Convention on Biological Diversity, 2022). Invasive plants can destabilize ecosystems, increase the risk of species extinction, and cause significant economic damage (Gurevitch & Padilla 2004). According to Bengtsson (2019) and Hanisch et al. (2020), maintaining grasslands is essential for biodiversity and ecological services. Managing invasive species yields significant economic benefits by minimizing the harm inflicted upon ecosystems and human well-being (Hanley, 2019). These benefits come from protecting biodiversity, forestry, agriculture, and ecosystem health (Maestas et al. 2016). Disease spread, native species damage, and ecosystem service loss are not adequately reflected in market prices. Non-market valuation methods like stated and revealed preference approaches and production function methods are needed to accurately assess the economic benefits of invasive species management (Hanley & Roberts 2019). Economic evaluations must also consider public preferences for management methods like chemical or pesticide control methods. However, economic valuation methods face challenges such as limited public knowledge about the invasions, scientific uncertainty about the spread and impact of invasive species and the effectiveness of control measures, the irreversibility of some impacts, and the presence of positive cultural or social values associated with some invasive species (Hanley & Roberts 2019). Stated preference methods need to provide information to those surveyed to reduce these challenges.

Studies show that greater species richness in grasslands increases its economic value by improving biomass production and increasing carbon storage in both plant and soil (Hungate et al. 2017). Hungate et al., (2017) found that each additional species contributes to higher carbon storage value, but diminishing marginal returns are observed for an extra species added. Thus, preventing species loss and enhancing biodiversity in restoration projects can yield significant economic benefits to society.

Dissanayake, and Ando (2014) estimated willingness to pay (WTP) for attributes to restore grasslands using a choice experiment survey. Proximity to existing grasslands, species richness, population density, and endangered species significantly affect WTP. Households value more bird species and those endangered, prefer a higher bird density to less, and people value species richness more as bird population density decreases.

The above studies indicate that invasive plant species on grasslands could result in a loss of economic value as they can reduce native species and their richness. Already evidence indicates that various plant species of the Canadian province British Columbia's (B.C.) grasslands, many of which are endangered, make them vulnerable from invaders (Kemp & Michalk 2007).

Earlier evidence, in the southern interior of B.C., at 17 sites indicates that non-native herbaceous species on grazed grasslands ranged from 0 to 84% with an average of 35% of the total herbaceous cover, (Gayton 2004). Inadequate updated information on invasive plants' socio-economic impacts has created a significant barrier to implementing comprehensive national invasive species management programs. It is one of the main reasons for the failure of invasive species issues to feature prominently in the mainstream agenda of most countries (Convention on Biological Diversity, 2022).

Invasive plants significantly disrupt grassland ecosystems by increasing the rate of nitrogen cycling, with the effects varying depending on the specific ecosystem and climate involved (Liao et al. 2008). They affect the soil's nitrogen and carbon cycles, which can, in turn, impact the hydrological balance due to their greater water consumption compared to native plants, resulting in lower soil moisture (Lovett et al. 2010; Cavaleri & Sack 2010; Pysek et al., 2012). The alterations introduced by these invasive plants stimulate microbial activities in the soil, consequently leading to heightened nitrogen availability in the invaded soils, strengthening the invasive plants (Castro-Diez et al., 2014; Ehrenfeld et al. 2005; Liao et al. 2008). In addition to these impacts on nutrient cycles, introducing invasive plants increases nutrient concentrations in both ground and surface waters, promoting nutrient leaching (Chamier et al. 2012; Nagler et al. 2008; Ehrenfeld et al., 2003).

From a socio-economic perspective, the impacts of invasive plant species are vast and complex, influencing property values, agricultural productivity, public utilities, tourism, and outdoor recreation (Perrings et al. 2002; Baskin 2002; Pimentel et al. 2001; Shackleton et al. 2019). Simultaneously, these invasive species trigger a significant loss in biodiversity and alter climate factors, which can pose severe public health risks (Jones, 2017; Rai 2015). The control of invasive species is an increasingly important issue in society due to its detrimental impacts on ecosystems, economies, and human well-being. However, controlling invasive species often incurs high costs and can face social opposition (Martin et al., 2006; Sheremet et al. 2017). Evaluating the benefits of controlling invasive species requires a comprehensive understanding of the costs involved, the damages avoided, and the potential positive values that can be derived from the presence of these species (Donlan et al. 2015; Roberts et al. 2018). Studies measuring the benefits and costs of controlling invasive species are vital in developing effective management strategies and policies that can address the complex problem of invasive species (Hanley & Roberts, 2018; Diagne et al. 2020; Bradshaw et al. 2016).

Only a few studies have explored willingness to pay to mitigate the presence of invasive species across various contextual settings. Chakir et al. (2016) employed the choice experiment methodology to assess the willingness to pay of the French population in relation to the conservation of indigenous biodiversity and the mitigation of the adverse effects produced by the invasive Asian ladybird species. The research revealed that individuals showed a willingness to incur costs to safeguard indigenous species, diminish the use of pesticides, and mitigate the negative impacts caused by Asian ladybirds on residential settings.

The study conducted by Sheremet et al. (2017) investigated the public's preferences and willingness to pay (WTP) for the control of forest diseases in the United Kingdom. The research revealed that disease management initiatives implemented in forests under public ownership and those held by charitable trusts exhibited a higher likelihood of gaining public support. The significance of incorporating public preferences and economic rewards into the management of invasive species has been emphasized by various case studies investigating the willingness to pay for invasive species control. Adams et al. (2020) employed the choice experiment methodology to ascertain the monetary value that inhabitants of Florida are ready to allocate monthly for the preservation of their urban woods in the face of invading pests. The study participants showed a willingness to contribute an average monthly amount of US $5.44 towards the implementation of a monitoring and prevention initiative targeting invasive pests. The total willingness to pay amounted to $540 million annually. The findings indicate that the participants demonstrated a heightened awareness of the program's extent, as evidenced by their active engagement in the survey and a significantly higher willingness to pay for the avoidance of forest pest invasion compared to the control group. Finally, Atallah et al. (2023) found that landowners preferred mechanical over chemical control methods, with support influenced by ecosystem services and neighboring involvement.

This study adds to the literature by examining peoples' WTP to control invasive plant species on grasslands in B.C. using a choice experiment survey. Choice experiment surveys are a well-established stated preference approach to assessing public preferences, valuing environmental services, and informing public policy (Hanley et al. 1998; Hanley and Czajkowski 2017; Krosnick et al. 2018). The survey explores the WTP for attributes such as various location of control, type of control methods, the degree of control, and additional taxes to assess public preferences for invasive plant species management on grasslands in B.C. The location attribute is supposed to capture preference for regional variation in control methods and proximity effects, while the control methods, chemical, biological, and targeted grazing, reflect different ecological impacts and public acceptability levels. The degree of control, minor, moderate, and major eradication, measures preference for intervention intensity, and the tax cost attribute determines the economic trade-offs individuals are willing to make. Our primary hypothesis is that the WTP of B.C. residents for invasive species control on grasslands is positive and increasing in the degree of control and the geographic extent of control. A secondary hypothesis is that, as seen in other studies, residents will be WTP more for non-chemical control methods. Together, answering these hypotheses and measuring the magnitude of WTP will provide insights into the public's valuation and acceptance of various control strategies, informing effective and targeted management policies.

## Methodology

### Study area

The research focuses on the grasslands in B.C., Canada's westernmost province. B.C. is characterized by diverse landscapes including rocky coastlines, forests,

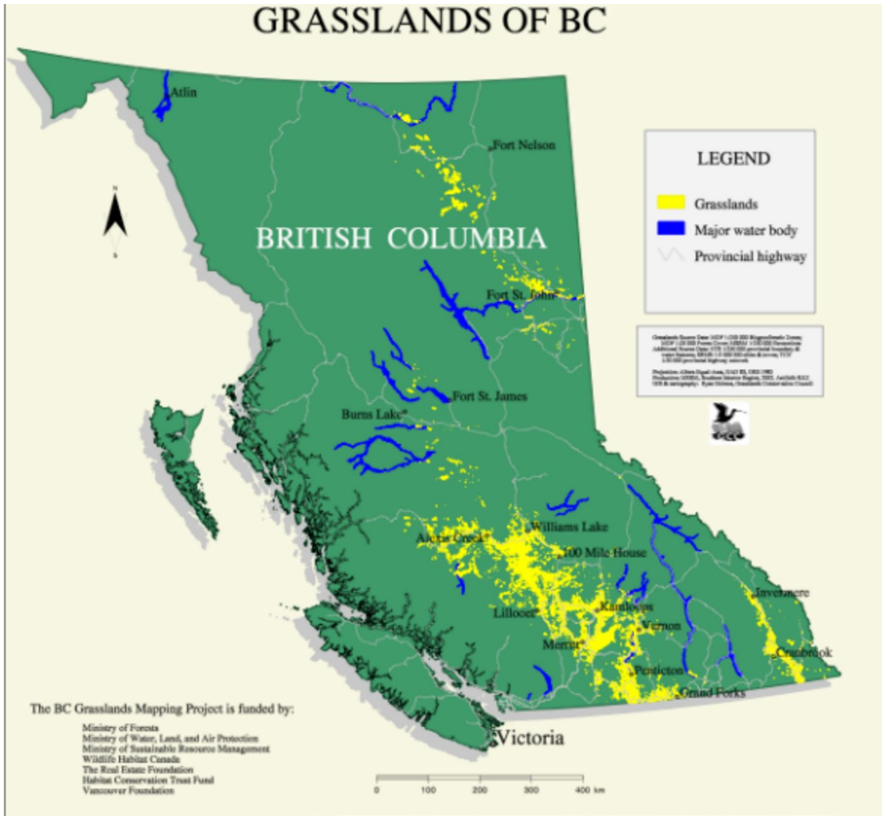


**Fig. 1** Grassland regions in British Columbia. Adapted from BC Grasslands Mapping Project: Year 3 Mid-Term Statistical Report (Grasslands Conservation Council, 2002). Reproduced with permission

mountains, and grassy plains. Grasslands occupy less than 1% of B.C., primarily east of the Coast and Cascade Mountains. Key grassland regions include East Kootenay Trench, Okanagan, Thompson-Pavilion, and others (Fig. 1).

## Experimental design

The study employed a choice experiment survey to understand preferences related to invasive species control policy. Using Ngene software, the survey design was optimized to present respondents with a manageable number of choice combinations. The survey had four parts: General knowledge about invasive plants in B.C., detailed information about the attributes, reflection on decision-making and socio-demographic details. Attributes related to invasive species control policy design were selected by extensive consultations with various stakeholders in the field, including expert and stakeholder input, discussions with researchers in ecology, environmental science, and economics, and feedback from conference presentations of the research proposal.[1] While this study

[1] Initial consultation on attribute selection took place at the Fraser Research Lab https://fraserlab.trubox.ca/, amongst faculty, post-doctoral researchers, and graduate students conducting research in ecosystem reclamation, ecology, restoration, and climate change.. Additionally, consultation took place with representatives from relevant non-profit, stakeholder organizations, including the Invasive Species Council of B.C. and the Grasslands Conservation Council of B.C. The research proposal including the attributes was presented to the Natural Science and Engineering Research Council (NSERC-IRC) Steering Committee on 12 October 2022, before the survey was fully developed and distributed and feedback was provided. The study was also presented at the Canadian Institute of Mining, Kamloops, BC, September 2023 and at the British Columbia Technical and Research Committee on Reclamation, Prince George, BC, September 2023.

was inspired by Sheremet et al. (2017), the attributes we used differ significantly, reflecting the distinct environmental and policy context of invasive species management in British Columbia. Whereas Sheremet et al. (2017) focused on forest disease management with attributes related to woodland ownership, disease control, and scientific uncertainty, our study centered on invasive plant species control, emphasizing location, control measures, degree of control, and associated costs.

This resulted in the inclusion of four attributes:

1. *Location of control*:
   - Northern interior of B.C. (Sub-Boreal Interior and Northern Boreal Mountains, Boreal and Taiga Plains)
   - Central interior of B.C. (Cariboo-Chilcotin and Central Interior)
   - Southern interior of B.C. (Southern interior and Southern interior mountains)
   - Everywhere in the interior of B.C.
2. *Control measures*:
   - Chemical control method: This involves using pesticides, herbicides, fungicides, and insecticides to destroy undesired invasive plants.
   - Biological control method: This involves using natural enemies to reduce the vigour or reproductive potential of invasive plants, e.g., herbivores, plant-attacking insects, mites, and pathogens.
   - Targeted grazing method: This involves using livestock for grazing on invasive plants for control purposes, e.g., goats, cattle, and sheep.

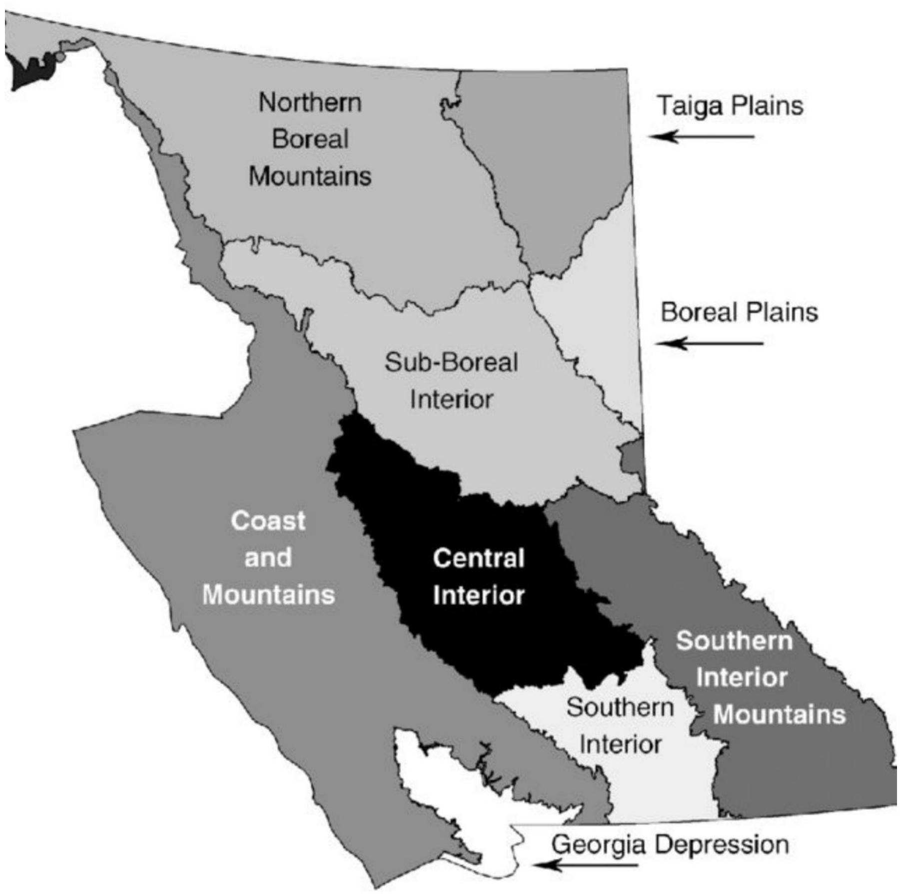


**Fig. 2** Eco-province classification map of British Columbia. Reproduced with permission from Fitterer et al. (2013), © John Wiley & Sons

3. *Degree of control* was minor, moderate, and major eradication.
4. *Additional tax costs* were set at \$25, \$50, \$75, and \$100 per year.

Each option referred to a given invasive plant control program over a 10-year period. The choice selection for each respondent consisted of five choice cards with each choice card having two options describing alternative measures comprising possible invasive plants control policy options and an opt-out option representing a status quo choice of no additional action. Each respondent received one of the blocks by randomization in the survey. The following example illustrates a choice card which was also included in the survey as an example to illustrate to respondents how to make choices (Table 1; Fig. 2):

This research is designed to assess public preferences for invasive species control policies rather than to explicitly quantify ecosystem service benefits. This decision is based on concerns about respondent comprehension, scientific uncertainty in defining precise ecosystem outcomes, and aligns with prior stated preference studies that focus on policy choices rather than direct environmental valuation (e.g., McIntosh et al. 2010; Adams et al. 2011). It is possible that preferences for regional control indirectly capture preferences for certain ecosystem services, as the northern interior is a remote area, whereas other regions offer significant provisioning and recreational opportunities. However, rather than measuring preferences for mitigating the loss of specific ecosystem services such as recreation or biodiversity, our study captures preferences for reducing the overall loss of ecosystem services caused by invasive plant species.

## Econometric methods

The choice experiment method derives from Lancaster's characteristics theory of value (Lancaster 1966). The model assumes respondents select alternatives offering the highest utility. The utility is a combination of a deterministic component and a random component. The utility function can be expanded to include socioeconomic and attitudinal variables. The model derives three utility functions. Each option, whether it's a policy or no action, generates a utility based on attributes like tax, location, type, and degree of control. The model estimates parameters showing the marginal impact of attribute changes on utility. The willingness to pay (WTP) for specific policy packages can be evaluated as well.

To measure the welfare change, we use the concept of compensating surplus (CS). CS indicates the amount a household is willing to pay to be indifferent between the current situation and a policy change. The model estimated is as follows[2]:

$$\begin{aligned} U_j = V_j + \varepsilon = {} & \beta_2 \mathrm{Tax} + \beta_3 \mathrm{North} + \beta_4 \mathrm{Central} + \beta_5 \mathrm{South} \\ & + \beta_6 \mathrm{Biol} + \beta_7 TG + \beta_8 \mathrm{Mod} + \beta_9 \mathrm{Maj} + \beta_1 \mathrm{ASC}_0 + \beta_{1,1} \mathrm{ASC}_0 \mathrm{RG} \\ & + \beta_{1,2} \mathrm{ASC}_0 UD + \beta_{1,3} \mathrm{ASC}_0 MI + \beta_{1,4} \mathrm{ASC}_0 HI + \beta_{1,5} \mathrm{ASC}_0 \mathrm{CRN} + \varepsilon \end{aligned} \tag{1}$$

Where *Tax* =25, 50, 75 or \$100, North =1 if control is in northern B.C, otherwise 0, Central =1 if control is central B.C., 0 otherwise, South =1 if southern B.C. otherwise 0, with everywhere in the interior of B.C as the base case. For controls, Biol =1 if biological control otherwise 0, TG =1 if targeted grazing otherwise 0, with chemical as the base case. Mod =1 if moderate eradication otherwise zero, and Maj =1 if major eradication otherwise zero, with base case minor eradication. Hence, the base policy case is chemical spraying, minor eradication, and everywhere in the interior of B.C. The $ASC_0$ captures the difference between the alternative policy options and the do nothing/status quo option. RG is a dummy variable =1 if respondent j spent at least part of their childhood growing up in a rural area, otherwise zero, UDj =1 if respondent j has a university degree, otherwise zero, MI =0 if household's income is in the middle of the distribution, HI if household is in the high income group and CRN is concerned (i.e., 1 not concerned to 5 extremely concerned). All the socio-economic variables interact with the alternative specific constant. In a model without the socioeconomic and attitudinal variables policy is preferred to no policy if $\beta_1 < 0$, in this framework the utility a person gets from no action depends on the socio-economic and attitudinal variables as follows:

$$V_0 = \beta_1 + \beta_{1,1} RG + \beta_{1,2} UD + \beta_{1,3} MI + \beta_{1,4} HI + \beta_{1,5} CRN$$

[2] The study did not explicitly model interactions between attributes, as the selected attributes—location of control, degree of control, control method, and taxes—are conceptually independent. Additionally, interactions between attributes, such as location and control method, could lack a clear behavioral interpretation and introduce multicollinearity issues, so the study opted for a more interpretable design.

**Table 1** Sample choice card

| Attributes | Control policy 1 | Control policy 2 | |
|---|---|---|---|
| Additional tax per year for control | $100 | $50 | Opt-out option I prefer that the government takes NO action. NO additional TAXES |
| Location of control | Everywhere in the interior of B.C | Southern interior of B.C | |
| Control measure | Chemical spraying | Targeted grazing | |
| Degree of control | Moderate eradication | Major eradication | |

Hence, whether policy is preferred to no policy depends on income, education, growing up in rural areas and concerned with invasive plant species and the estimated parameters in (2). If $V_0|_{RG,UD,MI,HI,CRN}$ < 0 then policy is preferred and vice versa.

The multinomial logit model (MNL) was used first to analyze the survey data (Kuhfeld 2001). It's suitable for analyzing categorical data with multiple outcomes. However, the MNL model has limitations such as assumes linear relationships, fixed coefficients across households, also assumes the independence of Irrelevant Alternatives (IIA). To test the IIA assumption, the Hausman-McFadden is often used (Hausman and McFadden 1984). The mixed logit model (MXL) was also used to capture unobserved preference heterogeneity by allowing variable influences to vary between individuals. It offers flexibility, captures heterogeneity, does not require the IIA assumption and provides a better fit to data. However, it's computationally complex and can lead to overfitting.

## Survey overview

The survey had three sections. The first section had background information about the issue followed by awareness, concern and effectiveness questions. Section two described the hypothetical scenario, a description of the choice experiment, the attributes and their levels with a map of the different location and images of the three control policies. In addition, the participants practiced with an example of a choice card to become familiar with the environment that they were about to face. The example was not used in the research as it was only for getting some experience on the choice they were about to make. Next in the survey was the choice experiment with the five choice cards each participant obtained randomly from the eight blocks. Finally, socio-economic and demographic information was in the last section of the survey.

To reduce hypothetical bias, the survey included cheap talk scripts in Sect."Methodology", where respondents were informed that the measures to control invasive plants are costly and would be funded through increased taxes, "the measures to control the invasive plants are costly and paid for by increased taxes". Respondents were also reminded, 'Your household will have less money to spend on other things if the program goes ahead,' emphasizing the trade-offs involved in supporting the proposed program.

In March 2023, data collection was undertaken using an online comprehensive survey. An online survey company, SurveyMonkey, was contracted to recruit an opt-in, non-probability sample of B.C. residents to complete the survey. An online, opt-in sample was used for convenience and cost considerations. Recent valuation research has shown that, although probability-based samples are preferred, opt-in non-probability samples can still provide overestimated but similar valuation results (Whitehead et al. 2023, Sandstrom-Mistry, 2023, Penn et al. 2023). The primary objective of this survey was to gather insights and opinions on invasive species and grasslands in B.C. Before the main survey, a pre-test was conducted in February 2023 with a group of volunteers (a mix of university students and faculty) to estimate the time needed for completion and to identify potential issues. The survey had 1,060 participants. However, 60 participants dropped out during various stages of the survey. The demographic characteristics of the remaining sample were analyzed and compared to the general B.C. population and are displayed in Table 2. One notable observation was that the sample had a higher representation of women, at 61%, and fewer observations were from the higher income group. Z-tests of equal proportions indicate that the sample is relatively representative of geographic location and age; though it does skew slightly younger. However, there are statistically significant differences in the share of females, university education, and income groups. The sample skews female, non-university educated, and lower income than the B.C. adult population.

To assess for the possibility of non-response bias, we compared early and late respondents (50 responses in each group) on key demographic and attitudinal variables, including income, age, location, gender, education, awareness, and concern. No significant differences were found, except for location; in the central interior of B.C., early respondents represented a larger proportion than in the late respondents. This result likely reflects the smaller population size in the central interior of B.C., leading to saturation of engaged individuals among early respondents. Importantly, no significant differences in awareness or concern were observed between early and late respondents in central B.C. or other regions, suggesting that non-response bias does not substantively affect our key findings.

Survey response analysis

The survey responses to the choice experiment painted a balanced picture regarding policy alternatives. Both alternative 1 and alternative 2 were equally popular, each being chosen around 40% of the time. The responses indicated an equal preference for policy alternatives 1 and 2 (i.e., 88.6% selected at least 1 control policy). A fraction of respondents consistently chose the opt-out option across all five cards (i.e., 11.4% or 114 respondents). Those opting out from all cards had diverse motivations: a significant group felt that invasive plant management should be privately funded (55 respondents), while a small fraction considered the issue unimportant (16 respondents). Some participants opting out (30 respondents) expressed skepticism about the effectiveness of the invasive plants control measures proposed. A minority of those opting out believed the case's crucial aspects were misrepresented or argued that taxes in B.C. are already high enough, advocating against public funding for invasive plants control. A very small number of those opting out felt other provincial issues, like homelessness and security, were more urgent.

When asked to rank the four attributes in terms of importance for their choices, with 1 being the most important and 4 the least important, the public ranked type of control as the most important factor, followed by degree of eradication, then extra taxes, and last, the location of spread.

## Results

The results of the econometric estimation are displayed in Table 3. The coefficient representing the marginal disutility from higher taxes is negative in

**Table 2** Socioeconomic and demographic characteristics of the respondents

| | Survey | | Census | | |
|---|---|---|---|---|---|
| Characteristics | Respondents | Proportion | B.C. population | Difference | |
| Share of females | 996 | 61.8% | 51.0% | 10.2% | *** |
| Age (years) group shares | | | | | |
| 18–34 | 997 | 31.3% | 26.0% | 5.29% | *** |
| 35–64 | 997 | 47.9% | 50.0% | – 2.10% | |
| 65 + | 997 | 20.9% | 24.0% | – 3.09% | ** |
| Grew up in rural area | 997 | 48.7% | N. A | | |
| Location of respondents | | | | | |
| Vancouver Island | 997 | 18.8% | 17.0% | 1.80% | |
| Lower Mainland | 997 | 58.6% | 61.2% | – 2.60% | * |
| Interior B.C | 997 | 21.4% | 21.3% | 0.10% | |
| University education | 997 | 36.5% | 43.7% | – 7.20% | *** |
| Household Income distribution | | | | | |
| Low income ($1-$49,999) | 923 | 48.6.% | 26.3% | 22.30% | *** |
| Middle income ($50,000–$99,999) | 994 | 37.7% | 31.9% | 5.80% | *** |
| High Income (> $100,000) | 994 | 13.7% | 41.8% | – 28.10% | *** |

***, **, and * indicate statistical significance of a Z-test of equal proportions at the 1%, 5%, and 10% significance levels. Source: Statistics Canada. 2023. (table). *Census Profile*. 2021 Census of Population. Statistics Canada Catalogue no. 98–316-X2021001. Ottawa. Released March 29, 2023. https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/index.cfm?Lang=E (accessed May 25, 2023) both models. However, in the MXL model the value is significantly lower to the MNL ($p < 0.01$).

A consistent observation across both models is the preference of households for a comprehensive policy over no policy. Furthermore, there's a clear inclination towards controlling invasive plants throughout the entirety of B.C. as opposed to regional-specific control. The Wald test indicated that there's no distinguishable preference among the southern, central, and northern regions of B.C. in the MXL.

When it comes to the methods of control, targeted grazing and biological control emerged as the top choices, overshadowing chemical spraying. The utility derived from targeted grazing stood at 1.00, which was higher than the 0.87 utility from biological control for the MXL, a difference that was statistically significant with a p-value less than 0.03.

A notable difference between the MNL and mixed model was observed in the preference for eradication levels. While the MNL model favored moderate eradication over major eradication, the mixed model showed the opposite. Major eradication was clearly preferred over moderate eradication in the mixed model.

The MXL estimation for no action was influenced by various socioeconomic variables. Even though the ASCO: No policy is positive with a coefficient 1.646 indicating no policy is preferred, the socioeconomic demographics reduce this value for respondents who grew up in rural areas, possessed a university degree,

**Table 3** Estimation of MNL and MXL models for valuation of attributes of control policies

| | Multinomial Logit Model | Mixed Logit Model |
|---|---|---|
| Extra taxes | − 0.016*** | − 0.006*** |
| | [− 0.018, − 0.014] | [− 0.008, − 0.004] |
| Northern interior | − 0.368*** | − 0.314*** |
| | [− 0.470, − 0.266] | [− 0.442, − 0.185] |
| Central interior | − 0.659*** | − 0.213*** |
| | [− 0.773, − 0.545] | [− 0.330, − 0.096] |
| Southern interior | − 0.655*** | − 0.249*** |
| | [− 0.765, − 0.544] | [− 0.391, − 0.106] |
| Biological control | 0.851*** | 0.866*** |
| | [0.753, 0.949] | [0.755, 0.977] |
| Targeted grazing | 1.268*** | 1.003*** |
| | [1.136, 1.400] | [0.865, 1.142] |
| Moderate eradication | 0.541*** | 0.309*** |
| | [0.411, 0.670] | [0.182, 0.436] |
| Major eradication | 0.399*** | 0.575*** |
| | [0.295, 0.503] | [0.445, 0.705] |
| ASC0: No policy | 0.515*** | 1.646*** |
| | [0.281, 0.749] | [1.346, 1.945] |
| ASC0*Concern | − 0.617*** | − 0.631*** |
| | [− 0.697, − 0.538] | [− 0.711, − 0.550] |
| ASC0*Rural Growing | − 0.222*** | − 0.224*** |
| | [− 0.369, − 0.075] | [− 0.373, − 0.076] |
| ASC0*University Degree | − 0.205*** | − 0.210*** |
| | [− 0.359, − 0.051] | [− 0.366, − 0.055] |
| ASC0*Middle income | − 0.148* | − 0.162** |
| | [− 0.299, 0.003] | [− 0.315, − 0.010] |
| ASC0*High income | 0.052 | 0.054 |
| | [− 0.158, 0.262] | [− 0.156, 0.264] |
| Number of observations | 14,868*** | 14,841*** |
| $\chi^2$ | 2637.82 | 1194.10 |

*** p <.01, ** p <.05, * p <.1, Robust standard errors were used to construct the 95% confidence intervals (CI). The 95% CI are reported below the estimated coefficients. The estimation was done with STATA 18 and belonged to the middle-income bracket have less utility in no policy compared to their counterparts from urban areas, without a university degree, and from either low or high-income groups. The level of concern also played a pivotal role. The more concerned the respondents were, the lower the utility they derived from inaction. For instance, respondents who did not have a university degree, grew up in an urban area and were of low income, but were extremely concerned (= 5) had a utility value of $-1.50$ ($p = 0.000$) for no action indicating preference for action. In contrast, those who weren't concerned (= 1) had a higher utility value of 1.02 ($p = 0.000$) indicating no policy is preferred. Those that were slightly concerned (= 2) they too preferred no policy to policy of these type of individuals ($p = 0.001$). Those of the high-income type but without a university degree, living in an urban area, and have no concern or slight concern have a utility level for no policy of 1.07 ($p = 0.000$) and 0.438 ($p = 0.002$) indicating preference for no policy but if the level of concern increases to extremely concern (= 5) they switch and prefer policy to no policy with a coefficient of $-0.145$ ($p = 0.000$).

The Hausman-McFadden test showed that removing specific policy options caused the results to change significantly. This suggests that the independence of irrelevant alternatives (IIA) assumption is violated, meaning that the choice between options is influenced by the presence or absence of other options (Fry et al., 1996, 1998, Allison, 2012).

To assess possible heterogeneity in preferences, we also estimated a mixed logit with model with some unrestricted random coefficients; however, we applied a likelihood ratio test and failed to reject the null hypothesis that there is a difference between the model with random coefficients and the model with fixed coefficients.[3] However, as seen with the results, the no policy constant interacts with attitudinal and socio-economic demographics, and thus heterogeneity is manifesting in ways that is operating beyond the random coefficients approach. In the next section we use the MXL model results to price the levels of the various attributes and packages.[4]

Valuation of invasive plant species control measures

Marginal willingness to pay (MWTP) values quantify the monetary worth of an attribute modification. This shows how much a British Columbian would be willing to pay for various invasive plant species control measures or packages. MWTP is the monetary value of switching from baseline attribute levels to an alternative attribute level. It is the marginal utility of the change in attribute level multiplied by the inverse of the marginal utility of income to convert the marginal utility gain or loss to monetary value. The implicit prices are derived as follows:

$$\text{MWTP for attribute modification} = -\frac{\beta_i}{\beta_2} \tag{2}$$

Where $-\boldsymbol{\beta}_2$ is the marginal utility of income and $\boldsymbol{\beta}_\mathbf{i}$ is the change in the attribute level from the baseline case. When the MWTP is negative it shows how much a British Columbian would demand in reduced taxes to be just as well off with the change that they dislike. Since an attribute level could reduce utility, the household will require an increase in income to be indifferent with the change in the attribute level from baseline. An increase in income can be achieved by a tax reduction.

Table 4 shows the MWTP per unit change per household per year. Households want a reduction in taxes when location is regional relative to everywhere in the interior of B.C., since the implicit prices are negative and significant. For control in the northern B.C., a household from the public would require a \$49 per year reduction in taxes while for the southern interior a minimum reduction in taxes would need to be \$39 to bring their utility to the same level as it

[3] The MNL model is estimated using maximum likelihood estimation and converged after 4 iterations, while the mixed logit model uses the Hammersley point set for Monte Carlo integration, a quasi-random sequence of draws, to estimate parameters and converged after 12 iterations. Even if fixed coefficients cannot be rejected in favour of random coefficients, the numerical integration involved in estimating the mixed logit can introduce differences compared to the maximum likelihood estimation used in MNL.

[4] The MXL model had a simulated log likelihood of -4,647.80 that is much higher than the maximum likelihood estimation of the MNL model of -8,477.24 and thus we use the MXL model to compute the implicit prices and the value of the different packages.

would be if the control was everywhere in the interior of B.C. and for Central a reduction of taxes in the order of $33 per year would be needed. The relatively larger negative WTP in the Northern interior most likely has to do with the remoteness and proximity. The other areas provide significantly more recreational and provisioning services due to their weather while the Northern interior does not. For type of control, biological control is worth an extra tax of $136 per household per year relative to chemical spraying and $157 per household per year for targeted grazing relative to chemical spraying. As for degree of control, people prefer major eradication to moderate eradication than minor eradication and are willing to pay up to $48 per year per household for moderate eradication and $90 for major eradication relative to minor eradication. Households place a very high value on targeted grazing relative to biological control in all the regions.

The results for the MXL model with socioeconomic variables assessed at their sample means with households that are slightly concerned = 2, at the sample mean 2.9 and those that are extremely concerned = 5. The assessment is made for moderate eradication. For those concerned = 2.9, the highest valued package is everywhere in B.C. using either biological control priced at $251 or targeted grazing at $273 per household per year in extra taxes. Chemical spraying is also valued but significantly lower at $115 per household per year with control location everywhere

**Table 4** MXL Implicit prices of attributes of control policies

| Mixed logit model | | | |
|---|---|---|---|
| | WTP per unit change | | [95% conf interval] |
| Location (base level: Everywhere in B.C.) | | | |
| Northern interior | − 49 | *** | (− 25, − 73) |
| Central interior | − 33 | *** | (− 12, − 54) |
| Southern interior | − 39 | *** | (− 15, − 62) |
| Type of control (base level: Chemical spraying) | | | |
| Biological control | 136 | *** | (90,182) |
| Targeted grazing | 157 | *** | (113,202) |
| Degree of control (base case: Minor eradication) | | | |
| Moderate eradication | 48 | *** | (29,68) |
| Major eradication | 90 | *** | (53,127) |

*** p <.01, ** p<.05, * p <.1. Robust standard errors were used to construct the 95% confidence intervals (CI)

in B.C. Thus, targeted grazing and biological control are preferred to chemical control (Table 5).

## Discussion

Invasive species pose a significant threat to the environment and the economy, causing considerable damage across different sectors. Invasive species cost the Canadian economy a total of US$ 34.5 billion from 1960 to 2017, and for North America such invasive species cost at least US$ 1.26 trillion over the same period (Crystal-Ornelas et al. 2021). Furthermore, the costs of invasive species over time in North America is trending upwards from US$2.13 billion per year in the 1960 s to at least US$26.26 billion per year in the 2010 s (Crystal-Ornelas et al. 2021). Earlier estimated damages and control costs in the US was $120 billion per year using replacement, control costs and lost productivity (Pimentel et al. 2005). However, such fixed-price models overestimate the financial impact by failing to account for behavioral adjustments (McDermott et al. 2013). Endogenous price models lower the cost estimates. For example, the annual cost of the Ohio emerald ash borer was estimated at $70 million, using a computational general equilibrium model with endogenous prices, compared to $400–$900 million estimated using fixed-price models (McDermott et al. 2013). People adapt through price signals and income adjustments, after the emerald ash borer destroyed ash trees, reducing damages.

While proactive management strategies, such as early detection and rapid response are needed, the true economic costs are often underestimated due to data limitations and insufficient research efforts, especially in regions beyond North America and Europe (Bradshaw et al. 2016). Paini et al., (2016) examined the global threat to agriculture from invasive species and found that for Canada the overall threat was classified as very high and the impact of crop invasions estimated at $9.3 billion USD.

A study focusing on invasive plants in Florida's public conservation forestlands demonstrates that even at lower spending levels, invasive species management programs can generate substantial net benefits (Lee et al. 2009). This study emphasizes a front-loaded investment strategy as it ultimately yields the greatest long-term net benefits (Lee et al. 2009). Beyond invasive plant species, invasive borer insects

**Table 5** Mixed logit willingness to pay per year per household for control policies:

| Location of control | Type of control | Slightly concerned = 2 WTP | Slightly concerned = 2 95% CI | Concerned = 2.9 WTP | Concerned = 2.9 95% CI | Extremely concern = 5 WTP | Extremely concern = 5 95% CI |
|---|---|---|---|---|---|---|---|
| Everywhere in interior B.C | Chemical | 26* | (− 4,56) | 115*** | (88,142) | 324*** | (240,407) |
| | Biological | 162*** | (127,196) | 252*** | (193,309) | 460*** | (337,582) |
| | Targeted grazing | 184*** | (153,214) | 273*** | (219,327) | 482*** | (362,600) |
| Northern interior | Chemical | 23 | (− 63,16) | 66*** | (39,92) | 274*** | (201,347) |
| | Biological | 113*** | (86,139) | 202*** | (155,248) | 411*** | (300,521) |
| | Targeted grazing | 135*** | (110,158) | 224*** | (180,266) | 432*** | (335,539) |
| Central interior | Chemical | 8 | (− 43,27) | 82*** | (58,104) | 290*** | (216,364) |
| | Biological | 129*** | (102,155) | 218*** | (170,266) | 427*** | (313,539) |
| | Targeted grazing | 150*** | (126,174) | 240*** | (195,284) | 448*** | (393,557) |
| Southern interior | Chemical | 13 | (− 54,19) | 76*** | (54,97) | 254*** | (209,360) |
| | Biological | 123*** | (91,154) | 212*** | (160,264) | 421*** | (305,536) |
| | Targeted grazing | 145*** | (114,174) | 234*** | (185,283) | 443*** | (330,555) |

*** p <.01, ** p<.05, * p <.1. Robust standard errors were used to construct the 95% confidence intervals (CI). the packages are evaluated at the sample means for middle income, high income, university education and growing up in the rural area. When population values were used except for rural results changed very marginally

like the emerald ash borer caused substantial economic damage (Aukema et al. 2011). Another study examines the economic impacts of a potential zebra mussel invasion of Lake Okeechobee, Florida, using a probabilistic bio-economic simulation model. The results of the study indicate that, without any management intervention, zebra mussels would have a significant negative economic impact, costing an estimated $244.1 million over 20 years. However, the study also found that public investment in both prevention and eradication of zebra mussels would lead to a net economic gain of $188.7 million over the same period. All the above studies highlight the economic advantage of proactive and aggressive intervention in invasive species control. Overall, the sources emphasize the urgent need to address the escalating threat of invasive species, urging increased investment in research, prevention, and control measures to mitigate their economic burden and protect valuable ecosystems.

People demonstrate a willingness to pay for the protection of natural ecosystems and are willing to contribute financially to mitigate the negative impacts of invasive species, even when complete eradication is not feasible (McIntosh et al. 2010; Adams et al. 2011). Based on a national survey of U.S. households, McIntosh et al. (2010) found that respondents are willing to pay to delay the impacts of aquatic invasive species. Conservative aggregate WTP values of $3.97 billion to delay low-impact invasions for one year, $5.55 billion for a one-year delay, and $25.4 billion for a ten-year delay. These valuations to control the aquatic invasive species far exceeded the $394 million annual investment for all aquatic and terrestrial invasive species for deterrence, early recognition and swift response by the US Federal Government. Similarly, a survey of 1436 Florida residents focused on the aggregate willingness to pay to control invasive plants in upland state parks (Adams et al. 2011). The authors used the per-visit willingness to pay values derived from their choice experiment and combined this information with annual park attendance data to calculate the statewide value of controlling invasive plants in parks. They estimated that all park visitors would be willing to pay $89.4 million per year to reduce the level of invasive plants in the parks. This valuation also far exceeds the current levels of funding of US$32 million annually.

This research also reveals preference heterogeneity related to environmental concern, income, education, and geographic background. Respondents with strong environmental concerns, particularly those in the middle-income category and urban backgrounds, showed a strong preference for invasive species control measures. Middle-income respondents exhibited greater support for control measures increasing as environmental concern levels rise. Those with university degrees prefer biological control methods over chemical approaches, aligning with previous literature on stated preferences for environmental policies. Additionally, respondents growing up in rural areas demonstrated stronger support for control measures relative to those growing up in urban areas. These findings indicate attitudinal and demographic factors play a role in shaping public support for invasive species control. Given that key coefficients remained statistically significant and stable across model specifications, we do not find strong statistical evidence supporting additional interactions or unrestricted random coefficients beyond those already included in the analysis.

A key consideration in the study design was the decision to focus on control measures rather than explicitly including ecosystem service benefits as attributes. While this approach limits the ability to directly assess use versus non-use values, it ensures that respondents evaluate realistic policy trade-offs without the added complexity of valuing uncertain ecological outcomes. The regional control attribute may serve as a proxy for ecosystem service concerns, but our findings primarily capture willingness to pay for invasive species control rather than explicit ecological benefits. Future research could refine this approach by incorporating attributes that measure specific ecosystem service improvements or by using follow-up questions to distinguish between different types of value.

Furthermore, the results of this research indicate that people are concerned about invasive species and are WTP for control programs, thus reinforcing the results od the prior literature discussed above. For measuring the aggregate annual benefits of the three control methods in this study, we examine a package that controls the invasion everywhere in the interior of B.C. with moderate eradication since these two attributes were ranked the highest. Also, the control dummy variables, growing up in a rural area, having a university degree and, middle income were kept at the sample means. Finally, there is a need to account for the fact that 11.4% of respondents opted out from all five choice cards and hence are not willing to pay for invasive species control. As of the 2021 Census, there are 2,041,830 households in B.C. (Statistics Canada, 2023) and if 11.4% would be opting out if all 2 million households were surveyed and assuming the same proportion would be opting out then just over 1.8 million households would be willing to pay for invasive species control measures. The aggregate annual benefits from a control policy of chemical spraying to British Columbians is estimated as 208 million CAD per year (i.e., \$115 per household per year times 1.809061 million households) with a 95% confidence interval of 159 million to 257 million. For a biological control policy, the aggregate benefits are 454 million CAD per year [95% CI 349 million, 559 million]. And a targeted grazing control policy is valued at 494 million CAD per year [95% CI 396 million, 592 million]. In aggregate, British Columbians are willing to pay substantially more to avoid the use of chemical control methods.

These aggregate valuations of control policies are significantly more than the spending of 12 million CAD annually by the B.C. government on invasive species management, which includes training, detection, and public awareness (B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2021). Furthermore, our results suggest that the public perceives invasive species control as a high-priority issue and highlights the benefits of increased investment in effective management strategies. Importantly, the aggregate valuations presented here represent a conservative estimate due to the underrepresentation of high-income households in our sample. Since environmental protection is typically a normal good, higher-income households are likely to value control measures more than other groups, suggesting that the true economic value of these policies may be even higher.

Overall, these findings align with the broader literature on invasive species management, reinforcing the economic case for proactive, well-funded control measures. The results highlight both the willingness of the public to fund these initiatives and the significant benefits of investing in strategies that mitigate the economic and ecological impacts of invasive species.

## Effectiveness of controlling invasive plant species

All studies discussed above suggest that the benefits of controlling invasive species exceeds the cost of controls but what does the public think about the effectiveness of such programs? The research also tried to find out people's opinions about the effectiveness of the B.C. Ministry of Forests in bringing the problem of invasive plants to the awareness of the B.C. public (Invasive Species Council of British Columbia, 2024).

How effective is the B.C. Ministry of Forests (responsible for the stewardship of Crown land) in making the public aware of the problem of invasive plant species and why it is occurring?

The public perceives the B.C. Ministry of Forests as somewhat ineffective in managing invasive plant species. On a Likert scale from 1 (strongly ineffective) to 5 (strongly effective), the effectiveness in raising awareness scored an average of 2.54, in motivating public action 2.40, and in monitoring invasions 3.09. Non-governmental agencies scored an average of 2.91 for preventing the spread of invasive plants on grasslands. Notably, a significant portion of respondents were unsure about the ministry's effectiveness, particularly in monitoring (29.1%) and NGO efforts (33.6%), indicating gaps in communication or visibility of actions. (Table 6).

There are many reasons why controls may not be seen as effective and hence the above perceptions by the responders. While the primary focus of invasive species management is often to reduce or eliminate populations of invasive species, this does not always lead to effectiveness as recovery of ecosystems may not happen. A review of 151 studies showed that 31% ecological recovery did not occur or had negative outcomes, such as increases in other invasive species (Prior et al. 2018). They found that recovery was less likely in areas with human disturbances and areas with many other invaders. Also, management strategies were more successful for animal populations than for plants or ecosystem processes. And ecological recovery outcomes were not influenced by the extent of removal of invaders (eradication vs. suppression). A study in South Africa indicated that a lot of funds we spent on invasive alien plant control yet there were issues with the effectiveness of its interventions (van Wilgen et al. 2022). Although there were localized successes in South Africa from 1998 to 2020, plant invasions continued to grow, showing a need to prioritize areas to control. Barbier et al., (2013) suggests mandatory screening and banning of high-risk plants as an effective method to control relative to the less popular annual license fee. An annual license fee could fund research, screening, education, and eradication, but it faces challenges due to the scientific complexity of estimating damages and limited stakeholder support. Springborn et al. (2011) findings suggest that increased effectiveness can be achieved by a thorough risk assessment evaluation before allowing imports into a region. Effectiveness should also integrate ecological impacts with economic feasibility and social acceptability when prioritizing conservation efforts (Roberts et al 2018). Overall, the literature effectiveness in invasive species management strategies is complex and needs the integration of broader ecological goals and to anticipate unintended consequence.

## Limitations

The study faces several limitations beyond the fact that the survey setting is a hypothetical scenario

**Table 6** Effectiveness from the public's perspective

| | N | Average | Std error | 95% CI | Not sure |
|---|---|---|---|---|---|
| How effective is the B.C. Ministry of Forests (responsible for the stewardship of Crown land) in making the public aware of the problem of invasive plant species and why it is occurring? | 853 | 2.54 | 0.037 | (2.47,2.61) | 15.9% |
| How effective is the B.C. Ministry of Forests in motivating the public to do their part to prevent further spread? | 868 | 2.40 | 0.039 | (2.32,2.48) | 14.0% |
| How effective is the B.C. Ministry of Forests in monitoring non-native plant invasion? | 758 | 3.09 | 0.038 | (3.01,3.16) | 29.1% |
| How effective are non-governmental agencies in doing their part to prevent the further spread of invasive plants on grasslands? | 730 | 2.91 | 0.043 | (2.82,2.99) | 33.6% |

N represents the total number of people that answered the question, while "Not sure" is a percentage of the total respondents. Likert scale of 1 to 6 was used, ranging from 1 "Strongly ineffective" to 5 "Strongly effective" and 6 "Not sure

(Bertrand and Mullainathan 2001). A notable limitation is the exclusion of specific ecosystem services from the attributes in the discrete choice experiment, which may have limited our ability to fully capture the public's valuation perspectives. We did not ask responders on what kinds of benefits are most badly affected by the invasive species and could have had as levels the following: recreation, biodiversity, visual appearance of landscape, and carbon storage as per the Sheremet et al. (2017) study. However, we thought that adding this attribute would not be appropriate due to the limited public knowledge about the invasions from many British Columbians especially those in the lower mainland, and scientific uncertainty about the impact of invasive species on various ecosystem services of the grassland's biome. Furthermore, we did not create an attribute with different impacts of invasive species in different regions. We were interested in capturing preference for control in the different regions and proximity effects. Choice of preference for different types of chemical methods such as pesticides, herbicides, fungicides, and insecticides were not added as an attribute and their levels.

While we incorporated cheap talk to reduce hypothetical bias, we acknowledge that this alone may not fully mitigate overstatement of WTP (Schwarz, 1999; Loomis 2014; Johnston et al. 2017). More robust methods, such as consequentiality scripts that explicitly link survey responses to policy outcomes or mechanisms involving real financial stakes, could further enhance the reliability of WTP estimates. The study also did not allow for interactions between attributes, potentially limiting the depth of our analysis regarding public understanding of invasive species impacts. In addition, the survey was administered using an online, opt-in, non-probability sample, which has been shown to potentially overestimate WTP (Whitehead et al. 2023; Sandstrom-Mistry et al. 2023). Future work should explore new methods (e.g., Lloyd-Smith 2024) for aggregating WTP estimates from non-representative, opt-in samples.

We further acknowledge that the use of qualitative descriptors (e.g., "minor," "moderate," "major" eradication) to represent the degree of invasive plant species control introduces ambiguity and may affect the content validity of our stated preference design. Johnston et al. (2012, 2017) caution against the use of imprecise terms unless they are clearly defined and readily understood by respondents. Ideally, measurable ecological outcomes such as changes in invasive plant cover, area treated, or restoration of native grasslands would be used to characterize control efforts. However, the use of quantitative indicators would introduce complexity to the choice experiment due to the varying size and ecological characteristics of the regions across British Columbia, and baseline conditions remain scientifically uncertain. To avoid placing excessive cognitive demands on respondents, we opted for simplified qualitative descriptions. This trade-off made the survey more accessible but limits the precision of the ecological and economic interpretation. Future research may improve content validity by linking these qualitative levels to ecological monitoring data as it becomes available.

Despite the above limitations, our study provides the first estimates of the B.C. public's willingness to pay for invasive species control on grasslands. Results suggest that public support exceeds current government expenditures, pointing to a potential funding gap. While this comparison should not be interpreted as a benefit–cost analysis, it offers a useful benchmark for informing future policy analysis.

## Concluding remarks

This study examines British Columbians' attitudes and perceptions of the problem of invasive plant species on grasslands in B.C. using a choice experiment. The research explores how much people are willing to pay or accept a reduction in taxes for compensation on a level of an attribute that they dislike, for various control policy attributes such as location of control, type of control method, and degree of control for invasive plant species on B.C.'s grasslands in terms of extra taxes. Results from a survey of 1,000 respondents across B.C. indicate serious concerns and a positive willingness to pay to control the problem. Results also indicate that respondents prefer control everywhere in the interior of B.C. relative to control only in specific sub-regions of the interior. The results also indicate that respondents prefer moderate and major eradication over minor eradication. Furthermore, respondents are willing to pay significantly more to use either biological control methods or targeting grazing than chemical spraying. Estimates of the aggregate annual benefits indicate that British Columbians are willing to pay 208 million per year for moderate or major eradication of invasive plant species in grasslands everywhere in the interior of B.C. using chemical spraying. Using biological methods or targeted grazing the valuation more than doubles to 454 million CAD and 494 million CAD respectively. These are estimates of the aggregate benefits from various control packages. These estimates of the benefits can inform future work on the cost–benefit analysis of invasive species control policy in British Columbia (and elsewhere using Benefit Transfer Methods). A cost–benefit analysis would need to not only measure the benefits of invasive species control (this study) but also measure the costs and productivity of the control measures.

Considering the study's findings and the broader literature on invasive plant species, we recognize that economic valuation information alone may not be sufficient to drive substantive changes in policy. As suggested by Williams et al. (2023), addressing the broader implications of invasive species requires a coordinated, collective action approach. It is a public-good social dilemma where individual actions are necessary but not sufficient to solve larger environmental issues without collaborative efforts. Future research should thus not only continue to refine economic valuation methods but also could help bridge the gap between economic valuation and actual policy implementation. This approach ensuring that the insights gained from studies like ours effectively contribute to global efforts in environmental management and sustainability.

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**Data availability** In line with the commitment to support replicable and transparent research, all data supporting the findings of this study are available on the Open Science Framework (OSF). The datasets were fully anonymized to ensure privacy and ethical compliance. The primary dataset used for empirical analysis can be accessed directly via the following OSF link: Tsigaris, P. (2024). Invasive species on British Columbia's grasslands, estimating the benefits of control policies, [Data set]. Open Science Framework. https://doi.org/. Each dataset and file repository include detailed descriptions and metadata to aid in their use and replication of the study's methodology.

**Declarations**

**Conflict of interest** The authors have no competing interests or conflict of interest to declare that are relevant to the content of this article.

**Ethical approval** Approval for the study was secured from Thompson Rivers University's Research Ethics Board with a certificate of approval number 103138 issued on 21 st July 2022.

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