Quality over Quantity: Non-market Values of Restoring Coastal Dunes in the US Pacific Northwest

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Key words: choice experiments, restoration, nonmarket valuation, willingness to pay, coastal dunes, ecosystem

JEL codes: Q51, Q57

doi:10.3368/le.040721-0036R

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Abstract

We design a choice experiment to examine public preferences for coastal dune ecosystem restoration in the US Pacific Northwest, a public good whose natural state is now rare. Respondents are asked to choose among hypothetical projects that vary by project size, restoration quality, recreation access, flooding risk, and cost. Restoration quality is defined as closeness to the natural ecosystem. We find that increasing restoration quality results in significantly higher welfare gains than increasing the size of restoration area. Maintaining recreation access is preferred, and programs with recreation restrictions yield positive willingness-to-pay only if accompanied by the highest restoration quality.

Appendix materials can be accessed online at:

https://uwpress.wisc.edu/journals/pdfs/LE-99-1-Nguyen-appA.pdf

https://uwpress.wisc.edu/journals/pdfs/LE-99-1-Nguyen-appB.pdf

1. Introduction

Decisions regarding ecosystem restoration present complex trade-offs involving ecological and budget constraints (Bennett et al. 2009; Lester et al. 2013; Needles et al. 2015; Biel et al. 2017). One such trade-off is restoration quantity versus quality: whether the focus should be on restoring a large area or on restoring a small area so that it more closely resembles its natural state. Another trade-off concerns the different potential services that can be provided by a restored ecosystem. For example, allowing certain recreational activities may negatively impact the health of a restored ecosystem but restrictions on recreational activities may negatively impact welfare associated with the restored site. While costs of restoration are often straightforward to calculate, a well-known challenge is that nonmarket benefits of ecosystem services can be difficult to estimate.

In this paper, we implement a stated-preference discrete choice experiment (DCE) to examine public preferences for ecosystem quality, quantity, and recreation access associated with the restoration of US Pacific Northwest (PNW) coastal dune ecosystems. Sandy beaches and coastal dunes make up a third of the world's coastline, play a vital role in recreation and habitat provision, and have not been immune to ecosystem degradation (Luijendijk et al. 2018). Therefore, an understanding of public preferences for this type of ecosystem is crucial for setting and carrying out targets for ocean and coastal restoration (Ingeman et al. 2019).

Although the nonmarket values of a variety of ecosystems including grasslands (Dissaynayake and Ando 2014), wetlands (Milon and Scrogin 2006; Petrolia et al. 2014), and oyster reefs, salt marsh, and mangroves (Interis and Petrolia 2016) have been studied, quantifying the trade-offs among the quality, quantity, and recreation access of a restored ecosystem remains a challenge. The quantity of restored land (Petrolia et al. 2014) and total area of kelp forest restored (Hynes et al. 2021) been shown to positively impact WTP for restoration. When evaluating trade-off between recreation and conservation, Dundas et al. (2018) find that costs from off-road vehicles (ORV) recreation management are modest and are outweighed by benefits associated with species protection. Quantitative measures such as species richness and species population density (Dissanayake and Ando 2014), the rate of wildlife population growth (Interis and Petrolia 2016), and species population and listing status (Lewis et al. 2019) have been used as proxies for restoration quality. Yet, to our knowledge, the value of how closely restored areas resemble their natural state, has not been explored. In summary, the existing literature suggests that these attributes are important for the public but does not offer clear evidence on their relative values.

Starting in the early 1900s, PNW coastal dunes have been altered at a landscape scale by the introduction of non-native beachgrasses (*Ammophila arenaria* and *A. breviligulata*) to stabilize shifting sand for development and coastal protection purposes (Seabloom and Wiedemann 1994; Hacker et al. 2012; Ruggiero et al. 2018). These changes have resulted in negative impacts to biodiversity, motivating coastal managers to restore areas of the coast (Wiedemann and Pickart 1996). Current restoration efforts emphasize dune flattening and invasive beachgrass removal (Zarnetske et al. 2010; Biel et al. 2017). Restoration can be rapid, but maintenance is required to prevent reinvasion of non-native beachgrasses, recreation may be restricted to protect native species, and there may be an increase in temporary flooding events within restored areas (Carlson et al. 1991; Zarnetske et al. 2010; Carroll 2016; Biel et al. 2017). Our study is the first to quantify the nonmarket values associated with the restoration of these unique coastal ecosystems.

Our survey design allows us to examine the trade-off between nonmarket values for restoration quality and quantity, and between restoration and recreation access. To depict restoration quality as a nonmarket good, we define three levels of restoration in order of quality from low to high: no restoration, moderate restoration, and full restoration, with full restoration most closely resembling the natural, pre-invasion state. The level of restoration is explicitly expressed in the biophysical appearance and characteristics of the system, instead of implied in the provision of ecosystem services, which offers a unique perspective from prior research. We find that respondents prefer larger restored areas, full restoration, and no change to recreation access, with preferences being heterogeneous. One interesting finding is that while welfare increases resulting from expanding the size of restored area are modest, substantial welfare gains are realized from increasing the quality of restoration. This finding is critical because most existing restoration programs for PNW coastal dunes do not target full restoration of all ecosystem functions, as they are designed only to recover populations of specific threatened species (Zarnetske et al. 2010; USDA 2020). More generally, the success of many restoration programs is measured by the number of acres restored, or the increases in species population, rather than how closely the restored areas resemble their natural state. Meanwhile, our results suggest that people place higher values on ecosystem services provided by restored areas that are close to their natural state. In addition, we find that while changing recreation access generally results in disutility, programs that restrict recreation may still yield positive social welfare if high restoration quality is achieved. Our results suggest restoration programs can achieve large social gains by shifting the emphasis toward a holistic approach in which restored areas resembles their natural condition.

Another unique aspect of our study is that it seeks to value coastal dunes in a state that is rare today, but that previously existed and can be quickly recreated. Although the dunes in their current state are familiar to most people in the study population, the natural state of the dunes remain unfamiliar because they are virtually nonexistent nowadays. To address this unfamiliarity, we generated customized illustrations that not only highlight certain restoration attributes but also help respondents visualize unfamiliar outcomes. The nonmarket valuation literature has shown that visual aids could help familiarize respondents with unfamiliar public goods in choice experiments (Aanesen et al. 2015; Matthews et al. 2017). Finally, the illustrations and the choice experiment framework could be used to estimate benefits of restoration scenarios that are currently rare or nonexistent.

2. Coastal dune ecosystems in the Pacific Northwest

Sandy beaches backed by coastal dunes make up about 250,000 acres or 45% of the Oregon and Washington coastline, a region containing the largest dune sheet in North America (Cooper 1958).[i] Coastal dunes in this region have experienced a dramatic transformation over the last century due to the introduction of non-native beachgrasses and the development that followed. Prior to 1900, these backshore areas were flat, open, and characterized by sparse and low native vegetation and shifting sand (Wiedemann and Pickart 1996). The dunes were home for diverse native flora and fauna. In the early 20th century, non-native American beachgrass (*Ammophila breviligulata*) and European beachgrass (*Ammophila arenaria*) were planted to stabilize dunes, aid development, and protect infrastructure (Seabloom and Weidemann 1994; Hacker et al. 2012). However, non-native beachgrasses also spread to areas without human-made infrastructure and altered the beaches and dunes where they had no protection value. Today, most PNW coastal dunes are tall, stable, and dominated by non-native beachgrasses, which are now considered invasive species, that have outcompeted native plants (Hacker et al. 2012). Native species such as the Western Snowy plover (*Charadrius alexandrinus nivosus*), the streaked horned lark (*Eremophila alpestris strigata*), and the pink sand verbena (*Abronia umbellata*) are now listed as threatened due to habitat loss and degradation caused by invasive beachgrasses. (Wiedemann and Pickart 1996; USFWS 2007; Giles and Kaye 2015).

Besides serving as habitat for native species, PNW coastal dunes also provide recreational opportunities for the public. In 2017, visitors made 10.3 million overnight trips to the Oregon coast alone, and direct spending was almost U.S. $2 billion (Longwoods Travel USA 2018). The use of ORV is allowed at designated locations, such as the Oregon Dunes National Recreation Area, where hiking is also a popular activity (Oregon Dunes Restoration Collaborative 2018). At restoration sites where native threatened and endangered species are present, visitors are only allowed to walk on the beach to minimize disturbance to the dunes (USFWS 2007). However, the majority of the dunes are open to the public for general recreational activities such as hiking, camping, and sand boarding (USFWS 2007). The 1967 Oregon's Beach Bill grants permanent public easement for access and recreation to all Oregon's beaches and the entire ocean shoreline, making beach access and recreation in Oregon a right, which is a unique feature of this coast (Oregon Legislative Assembly 1967).

There are ongoing efforts to restore coastal dunes in the PNW to enhance native biodiversity and aesthetics given adverse effects of beachgrass-induced dune stabilization. Most restoration is designed with the goal of generating habitat to recover threatened Western snowy plover populations and involve invasive beachgrass removal, dune flattening, closures that protect nesting areas but limit recreation access, and predator control (USFWS 2007, Zarnetske et al. 2010; Biel et al. 2017). Traditionally, restoration of Western snowy plover habitat does not involve intentionally restoring native plant species, but some restored areas have seen increases in native plant diversity (Zarnetske et al. 2010; Biel et al. 2017) and seeding of native pink sand verbena is carried out in some locations (Giles and Kaye 2015). In addition, restored areas may experience greater temporary flooding risk, primarily in the winter (Carroll 2016; Biel et al. 2017).

Restoration can be done rather quickly, and results can be seen within a year, but continual maintenance is required to prevent reinvasion of beachgrasses (Wiedemann and Pickart 1996; Zarnetske et al. 2010). Restoration entails tradeoffs between quantity and quality of restored areas, and between restoration and recreation. Resource managers make decisions such as where to carry out restoration, how large of an area to restore, and how much recreational access to allow within restored areas, given financial and biological constraints and tradeoffs. Therefore, in addition to physical, geological, and ecological knowledge, information on public preferences can help planners devise and carry out restoration strategies that consider not only conservation but also social benefit goals.

3. Survey design and administration

We conducted a choice experiment (CE) in this study for several reasons. First, as a stated preference method, it can be used to elicit both use and non-use values, the latter being potentially significant in our application. We hypothesize that coastal dunes may provide existence non-use values because they are considered by some to be an iconic part of the PNW with historic and cultural significance (Oregon Dunes Restoration Collaborative 2018). There may also be bequest values to preserve the ecosystems for future generations. Second, coastal dunes can be described in terms of policy-relevant attributes that are not perfectly correlated, which allows for the valuation of separate attributes. The size of a restored area is not perfectly correlated with the type of recreational activities allowed within that area: for example, a dune area may or may not allow the use of off-road-vehicles (ORV). The choice experiment format allows us to estimate WTP for these attributes separately, and to study preferences regarding trade-offs among the attributes (Lewis et al. 2019). Choice experiment responses can also be used to measure preference heterogeneity for distinct attributes (Johnston et al. 2017).

The population frame for this study is regional, consisting of households in Oregon, Washington, and Idaho. A postal survey was distributed to 4,200 households in early 2019. These households represent a random sample of the population provided by Survey Sampling International (SSI).[ii] The state-level breakdown for the sample is as follows: 2020 surveys, or 48.10% of the sample, were sent to Oregon households, 1800 surveys, or 42.86%, to Washington households, and 380 surveys, or 9.05%, to Idaho households. We over-sampled Oregon households because the majority of coastal dunes are located along the Oregon coastline. Prior to being fielded, the survey went through three formal focus groups and a pilot survey. The focus groups were conducted to test for overall comprehension and unbiasedness of the survey instruments. The goal of the pilot study was to identify any remaining issues with the survey instrument, obtain an expected response rate for the full survey, and gauge the upper bound for costs included in the CE. The survey administration process follows the Dillman method with repeated mailings, including personalized correspondence and inclusion of a US two-dollar bill as a monetary incentive to increase response rates (Dillman et al. 2007).

The survey is 16 pages long and has 29 questions, including 3 choice cards, 8 demographic questions, 1 open-ended question for additional comments, and 17 qualitative questions (See

Appendix B for an example of a full survey version). Respondents are first given background information on the Pacific Northwest sandy beaches and coastal dunes, nonnative beachgrasses (including their often-beneficial stabilizing effects), and the transformation of the dunes since the early twentieth century. Next, respondents are informed that areas of the invaded dunes can be restored and are shown various attributes and scenarios associated with restoration.

We define three levels of restoration quality. The first is the status quo which involves no restoration and results in no changes to the current ecosystems. The second is "moderate restoration" which involves flattening dunes and removing invasive beach grasses, resulting in flat and open dunes and shifting sand. The term “moderate restoration” is neutral framing corresponding to dune restoration as is currently practiced in the PNW to help improve nesting habitat for threatened species like the Western snowy plover. “Full restoration,” in addition to all activities carried out in the moderate restoration scenario, involves planting of native plants and hosts more diverse flora and fauna. Respondents are shown the visual illustrations (Figure 1) and a written description of the restoration levels. In addition, we define three levels of recreation access: same, fewer, and more. The “same” level, or status quo level, of recreation access allows most activities such as hiking, kite flying, and dog walking. The “fewer” recreational activities level only allows people to walk on wet sand or enjoy guided tour; this level minimizes disturbance for the restored dunes and species in it. The “more” recreational activities level allows all current activities plus ORV use. These levels of restoration are expressed in terms of their biophysical attributes, and we are interested in their values in and of themselves rather than values of ecosystem service endpoints like habitat provision.

While restoration, which involves dune flattening, might result in an increase in temporary flooding within restored areas, respondents are informed that restoration would occur far away from communities and thus not affect infrastructure. This is consistent with past and current restoration practice and the geography and population density of the Pacific Northwest coast given the available coastal area to restore and the scale of the proposed project. There are examples of successful restoration along the US west coast at these levels, thus uncertainty of restoration success is not a primary concern. We address relevant uncertainty in terms of coastal flooding reducing access during the winter months.

Next, respondents are asked to consider a hypothetical but plausible program of new restoration. To keep the description simple and limit the number of attributes included in the choice experiment, we fix the number of new restored areas to 10 locations spread out along the coast. The even distribution of restoration areas avoids anchoring to particular locations by respondents. Respondents are shown a map as an example but informed that the distribution of the restored areas may not follow this particular placement (Appendix Figure A1).

Prior to the choice cards is a cheap talk script that acknowledges the hypothetical nature of the stated preference questions while appealing to respondents to answer them as if they were paying real money to reduce hypothetical bias (Cummings and Taylor 1999; Morrison and Brown 2009). The cheap talk script, together with the information that this type of restoration has been successful on a smaller scale, acts to enhance consequentiality and incentive compatibility. The final section of the survey collects standard demographic data such as age, education, and income.

In each of the three choice cards, respondents are asked to select the scenario they prefer among the status quo and two restoration alternatives. The alternatives are described using five attributes: total size of restored area, level of restoration quality (or closeness to the natural state), recreational activities allowed within restored areas, average number of flooding days affecting restored areas, and cost. The status quo involves no new restoration and incurs no cost to respondents and stays constant across choice cards and across survey versions. The two alternatives involving new restoration incur a cost to respondents. The payment vehicle is described in terms of an increase in household taxes per year for the next 10 years, which is both familiar and binding, and thus helps mitigate hypothetical bias (Carson and Groves 2007). The explanation of key attributes and their levels are shown in Table 1.

In the experimental design, the choice cards were generated using D_0-optimal design principles and tested using Monte Carlo simulation prior to survey administration (Huber and Zwerina 1996). There are 20 unique survey versions, each of which contains 3 choice cards, resulting in a total of 60 unique choice sets. This allows for a panel dataset with variation to recover parameter estimates. Some combinations of attribute levels were restricted from appearing in alternatives due to their infeasibility, as per consultation with experts on the dunes system and a coastal geomorphologist.

While respondents are informed in the survey instrument that restoration might benefit threatened plant and animal species, the species are not included as attributes in the experimental design. Western Snowy plover populations are unlikely to recover if restoration is limited to Oregon and Washington and does not include California.[iii] Since our study area only includes the Oregon and Washington coast, there would be no variation in the listing status of the species, and salience of threatened species protection diminishes substantially for respondents if actions do not lead to delisting (Lew et al. 2010). Furthermore, our choice cards are already quite complex. Adding another attribute would place even greater cognitive burden on respondents, which might lead to respondents resorting to heuristics.

4. Methods

To study respondent selections in the choice experiment, we adopt the random utility maximization (RUM) model as a behavioral framework. Given a choice set, a respondent is assumed to choose the alternative that maximizes their utility. We assume that the utility (U_{nit}) an individual n receives from alternative i on choice occasion t is:

$$U_{nit} = \boldsymbol{\beta}_n \mathbf{X}_{nit} + \gamma_n z_{nit} + \varepsilon_{nit} \tag{1}$$

where $\mathbf{X}_{nit}$ is a vector of alternative-specific attribute levels, $\boldsymbol{\beta}_n$ is a row vector of coefficients on alternative-specific characteristics, γ_n is the coefficient corresponding to the cost variable, z_{nit} represents the cost of the alternative to the respondent, and ε_{nit} is an error term and is assumed to be independently and identically distributed Extreme Value type I.

The mixed logit (MXL) model is the preferred model for this research because it accounts for individual-level preference heterogeneity and does not assume independence of irrelevant alternatives (IIA), which means that when one alternative is removed from the choice set, the relative proportion of probability of choosing the remaining alternatives remain the same. Modeling preference heterogeneity is consistent with current best practice in stated preference studies (Johnston et al. 2017). The coefficients on attributes in the MXL model are assumed to be normally distributed to allow for flexibility in modeling diverse preferences of respondents. For example, regarding the quality attribute, different respondents might prefer different levels of restoration. Following Carson and Czajkowski (2019), we exponentiate the cost parameter, thus assuming that its exponential is log-normally distributed. Utility for non-SQ alternatives is then:

$$U_{nit} = \boldsymbol{\beta}_n \mathbf{X}_{nit} - exp(\delta_n) z_{nit} + \varepsilon_{nit} \tag{2}$$

Here z_{nit} is the cost variable, and the original cost parameter γ_n is replaced by -exp(δ_n). The status quo is modeled using an alternative-specific constant (ASC) whose parameter is assumed to be normally distributed.

Let $\boldsymbol{\phi}_n = [\boldsymbol{\beta}_n\ \boldsymbol{\delta}_n]$ be a row parameter vector and $\mathbf{W}_{nit} = [\mathbf{X}_{nit}\ \mathbf{z}_{nit}]'$ be an alternative specific vector of all attributes. The density of $\boldsymbol{\phi}_n$ is then multivariate normal with mean vector $\boldsymbol{\phi}$ and covariance matrix $\boldsymbol{\Omega}$.[iv] Conditional on $\boldsymbol{\phi}_n$, the probability of observing individual n selecting alternative i given J alternatives is:

$$L_{nit}(\beta|\boldsymbol{\phi}_n) = \frac{exp(\boldsymbol{\phi}_n \mathbf{W}_{nit})}{\sum_{j=1}^{J} exp(\boldsymbol{\phi}_n \mathbf{W}_{njt})} \quad (3)$$

while the unconditional probability is:

$$P_{nit} = \int L_{nit}(b) f(b; \phi, \Omega) db \quad (4)$$

Since there is no closed-form solution for the integral in Equation (4), we calculate choice probabilities using simulation. This is done via a quasi-Monte Carlo approach, where values are sampled from the support of $f(b; \phi, \Omega)$ through inverting Halton sequences. Taking the average of evaluations for Halton sequences of length R gives: $\hat{P}_{nit} = \frac{1}{R}\sum_{r=1}^{R} L_{nit}(b)$ (Hensher and Greene 2003). We also account for the panel structure of the data by restricting the random parameter to be the same within one respondent while allowing it to vary across respondents.

On a choice occasion, restoration alternatives A and B may be considered closer substitutes than the status quo. A model with an alternative-specific constant (ASC) may be a good fit because it captures the difference in substitutability among alternatives. Here we include an ASC for the status quo to represent this difference in utility between selecting either of the two restoration alternatives and selecting the status quo.

In the MXL model, coefficients are indexed n, which means they are constant across choice occasions for an individual but vary across individuals. The main effects specification is:

$$V_{nit} = -\exp(\delta_n)\, Cost_{nit} + \beta_{n1} Size_{nit} + \beta_{n2} Flood_{nit} + \beta_{n3} Full_{nit} + \beta_{n4} FewerRec_{nit} + \beta_{n5} MoreRec_{nit} + \varepsilon_{nit} \quad (5)$$

where $Cost$ represents the cost of the alternative (zero if it is the status quo) and is measured in hundreds of dollars, $Size$ is the total size of restored areas, measured in 10,000 acres, $Flood$ is the average number of flooding days within restored areas, $Full$ is a dummy variable equal to 1 if the alternative involves full restoration, $FewerRec$ is a dummy variable equal to 1 if fewer recreational activities are allowed within restored areas, $MoreRec$ is a dummy variable equal to 1 if more recreational activities are allowed within restored areas. As an alternative specification, we also include pairwise interactions between the size of restored areas and levels of restoration, and size of restored areas and level of recreation access. A significant and positive coefficient on an interaction term suggests that respondents have higher marginal utility for increases in one attribute (for example, size of restored areas) when the other attribute (for example, level of restoration) is at a high level. Vice versa, a significant and negative coefficient suggests that marginal utility is lower for increases in one attribute when the other is high.

5. Results

5.1. Summary statistics

Out of 4,200 surveys distributed from the 20 versions, a total of 1,157 respondents answered at least one choice question, resulting in an adjusted response rate of 28.4% and 3,373 choice responses. Compared to the PNW population, on average respondents to this survey tend to be older, more likely to be male, and more likely to hold a bachelor's degree or above (Table 2). Since we oversampled Oregon, the population means and medians are weighted accordingly.

The median household income and average household size in the sample are similar to the population (American Community Survey 2019).

Responses to the qualitative questions in the survey also help check for respondents' consistency and give additional information beside their choices. Three quarters of respondents either strongly agree or somewhat agree that they had enough information to make an informed choice. Considering that only 20% of respondents are aware of beachgrasses as a non-native, invasive species at the beginning of the survey, this is an indication that most respondents believe they received the information needed to evaluate restoration alternatives in the survey instruments. Over half of respondents consider the full restoration outcome, shown with more diverse plants, as the most visually appealing. Meanwhile, a fifth of respondents consider the moderate restoration outcome with mainly flat sand dunes without many plants as the most visually appealing. On the topic of recreation, while over 80% of respondents engage in general recreation on the PNW coast, 21% have ridden an ORV on beaches and dunes. Under 20% of respondent feel mostly positive or somewhat positive about beach and dune ORV use. Taken together, there is significant qualitative evidence of viewpoint heterogeneity in respondents' attitude toward restoration in general and different attributes in particular. Regarding responses to the choice questions, 34% were for the status quo, 42% were for alternative A, and 24% were for alternative B.

5.2. Estimation results

Table 3 presents estimation results for multinomial logit and MXL models with main effects and interaction effects specifications.[v] As shown in the increase in converged log-likelihood, the mixed logit model provides a better fit than the multinomial logit model. A likelihood ratio test confirms that the mixed logit model is the more appropriate choice. Most of the standard deviation parameter estimates in the mixed logit estimation are statistically significant at the 1% level. This further suggests strong preference heterogeneity in the sample, which agrees with the evidence from qualitative questions. In addition, a likelihood ratio test between the mixed logit main effects and interaction effects model shows that the addition of interaction effects does not significantly improve the goodness-of-fit to the data, an expected result as our experimental design was set up to test main effects without interactions. Therefore, our preferred model is the mixed logit main effects model.[vi]

We are interested in the sign and significance of the mean and standard deviation parameter estimates for each attribute. On average, respondents' utility increases with full restoration, which involves both invasive species removal and native species planting, compared to moderate restoration. Utility decreases with changing the level of recreation within restored areas, whether to allow more activities such as ORV use or to restrict activities such as walking dogs and flying kites, which can disturb rare native species. The logged cost parameter mean is significantly different from zero at the 1% level. The parameter mean corresponding to variable size is positive and significant. We fail to reject the null hypothesis that the mean parameter and standard deviation parameter for flooding are jointly different from zero. Full restoration is statistically significant and positive at the 1% level, which suggests that respondents prefer full restoration to moderate restoration. This is consistent with the qualitative responses, where the majority of respondents find the full restoration scenario more visually appealing than moderate restoration and the status quo. All standard deviation parameters, except that on the flooding attribute, are significant at 5% level. This evidence indicates substantial preference heterogeneity. While some respondents have different preferences, on average, respondents prefer higher restoration level, greater size of restored areas, and the same level of recreation access.

The more recreation dummy coefficient is negative and significant at the 1% level, which signals that allowing more recreational activities, including the use of ORV, decreases utility on average. In our preferred model, the dummy coefficient for less recreation access is also negative and significant, suggesting that respondents prefer to keep recreation within restored areas the same compared with the alternatives. There is also evidence of preference heterogeneity associated with changes to status quo recreation access. There are several possible explanations for this preference heterogeneity. One is that a subset of respondents cares about the preservation of the investment in restored natural capital. ORV use, which is part of more recreation access, could disturb native species and reduce species diversity. Another reason is that the majority of respondents simply do not like having ORV where they visit, and responses from those disliking ORV outweigh those who like ORV. Non-ORV users' preference for ORV-free areas due to reasons such as noise and air quality is consistent with findings in the literature (Mansfield et al. 2008). On the other hand, the fewer recreational activities option only allows visitors to walk near restored areas or as part of guided tours, without the ability to engage in activities such as dog walking, camping, or picnicking. This management option is consistent with Endangered Species Act habitat protections when threatened and endangered species are present at restoration sites (USFWS 2007). It is possible that respondents view this option as too restrictive. These results are also consistent with the qualitative responses.

The variable indicating temporary flooding in restored areas is not significant. A plausible explanation for this is that increased flooding in restored areas does not impact infrastructure and may only generate costs to coastal residents living near the dunes (i.e., frequent visitors). Noncoastal residents are not directly impacted by floods in the way coastal residents are because flooding of restored dunes is temporary and occurs only a few days in the winter, when the public rarely visits. Coastal residents may see this rise in temporary flooding of the dunes if they choose to visit the dunes in the winter. While the possible disutility caused by increased flooding is localized, quality restoration that accompanies the flooding benefits a much broader population. We thus are able to identify how preferences for attributes that affect only local areas differ from those to the broader region.

In our preferred model, the status quo dummy coefficient, which equals 1 if the alternative is the status quo and 0 if the alternative involves active restoration, is negative and significant. This suggests that all else being equal, respondents are, on average, more likely to select a restoration alternative than the status quo, or respondents prefer restoration independent of all the attribute changes. Although the status quo bias, which is the phenomenon where respondents are more likely to select the status quo than other alternatives, is well-documented in the literature (Adamowicz et al. 1998, Interis and Petrolia 2016), there has also been evidence showing bias against the status quo (Petrolia et al. 2014). In this analysis, the status quo dummy being negative and significant provides evidence that supports respondent bias against the status quo on average, though the large and significant standard deviation parameter suggests there is considerable heterogeneity across the sample.

5.3. Robustness checks

As a robustness check, we inspect responses to qualitative questions to identify anomalies and protest votes of the respondents. We define a protest vote as one that satisfies all the following conditions. First, the protest votes belong to respondents who always select the status quo on all choice occasions. In addition, they strongly agree that they do not trust the government to restore PNW coastal dunes and do not believe the government should fund restoration (Appendix Table A1). Out of all completed surveys in the current sample, we identify 60 protest respondents. We estimate the model again without the protest votes. The results are the same qualitatively in terms of sign and significance. The standard deviation parameter for size of restored areas increases and that for days of flooding decreases. Alternative criteria are used to identify 111 protest respondents, and the results remain the same qualitatively while the model fit improves without the protest respondents.

As a further robustness check, we identify choice responses with no confidence in their responses to the choice questions. After each choice question, we ask respondents to state their confidence for their answer. We define no confidence as responding “Not at all Confident” to this question. Out of 3,373 choice responses, 60 choice responses fall into this category. We estimate the model without choice responses in which respondents are not confident, and the results remain robust. The log-likelihood in estimation without protest respondents and without no-confidence are higher than the estimation with all observations (Appendix Table A2).

In addition, we examine whether attribute non-attendance (ANA) to the payment vehicle is a concern. While it may be difficult to distinguish between non-attendance and non-importance in the restoration attributes, it is unlikely that respondents would not pay attention to increases in taxes, thus ignoring the cost variable could be a sign of hypothetical bias (Hess et al. 2013). We do this by looking at the reported non-attendance by respondents as well as inferred non-attendance from the choice data. Following the choice cards is a question asking how often respondents consider each of the attributes in their decisions. Over 90% of respondents reported taking into account cost when making their choices.

We also address payment vehicle non-attendance using an equality-constrained latent class (ECLC) model (Scarpa et al. 2012; Koetse 2017; Lew 2019). This approach involves estimating a latent class model consisting of two classes. Coefficients for all restoration attributes are constrained to be equal across the two classes, the cost coefficient in the first class is estimated using the model and that in the second class is restricted to zero to model cost ANA. We find that the signs and significance levels of variables in the two models are the same. As expected, while we find limited evidence of cost ANA, the MXL main effects model has higher explanatory power (Appendix Table A2). Therefore, the MXL main effects model remains our preferred model for welfare analysis.

5.4. Welfare analysis

We used the Krinsky-Robb (1986) approach to estimate the mean and standard deviation of the WTP distribution and conduct welfare analysis. The Krinsky-Robb method involves taking 1,000 draws from the distribution of each estimated parameter to generate an empirical distribution for WTP functions of specific scenarios, each involving a set of attribute levels. Figure 3 presents changes in WTP from changing one attribute in hypothetical restoration programs, holding other attributes constant. Gain in welfare from increasing total size of all restored areas is assumed to be linear as adding nonlinear size variables does not improve the model's fit. The greatest gain in welfare is obtained by moving from moderate to full restoration, which is $46 for 10,000 acres. Conditional on moderate restoration and the same level of recreation access, the median household WTP for an additional 1,000 acres is just over $1, while the median household WTP is over $40 for any size of fully restored areas. The other major increase in WTP from changing one attribute stems from recreation on fully restored areas. For

10,000 acres of fully restored areas, WTP rises by $39 if recreation is not restricted compared to if there were restrictions on recreation.

Table 4 presents median annual household WTP estimates for restoration scenarios with positive WTP. WTP is framed as per household per year for the next 10 years, so we report estimates of annual WTP over that duration from the start of a restoration program. The scenarios differ in restoration level, total size of restored areas, and level of recreational access. Median WTP increases with size and level of recreation access. Since WTP differences for different numbers of flooding days are close to zero, we only present scenarios with an average of 10 flooding days per year. Conditional on level of restoration and recreation, the larger the size of total restored areas, the higher the WTP. Conditional on size of total restored areas, the programs with the highest WTP involve full restoration and the same level of recreation, followed by programs with full restoration and restricted recreation, and moderate restoration and the same level of recreation.

The high value respondents attach on average to full restoration compared to moderate restoration is evident from the estimates. Most current restoration projects are designed with the goal of increasing Western snowy plover population numbers, resulting in restoration that most closely resembles the moderate alternative. Our findings suggest that the value generated by future restoration programs may be higher if investment is made in attempting to restore the native ecosystem. At the same time, respondents also view changing the level of recreational access negatively. This could be partly explained by the Oregon Beach Bill which grants the public permanent access to the Oregon coast, which suggests that restrictions on recreation would not be viewed as favorable. Furthermore, hypothetical programs that allows ORV use all have negative median household WTP, which is consistent with previous findings that show people not likely to recreate near ORV (Mansfield et al. 2008). Allowing fewer recreational activities also reduces WTP considerably. Interestingly, programs with full restoration and fewer recreational activities have higher median WTP than moderate restoration and same level of recreation, conditional on the size of restored areas. Restoring habitat for rare species often requires restricting recreational access. Here, the results show that even with restrictions on recreation, the benefits from restoration still outweigh the loss resulting from curtailing recreation.

We use median WTP figures and aggregate over the population in the Pacific Northwest to estimate nonmarket values of restoring coastal dunes. For the lower bound estimation, we follow Loomis (1987) and assume that the proportion of survey recipients who did not respond have a WTP of zero, and scale that up to the population. This is a conservative estimate because it is possible that those who did not respond have a positive WTP for restoration but chose to not respond for other reasons. The response rate for non-Oregon households, which includes Washington and Idaho households, is 26% and that for Oregon households is 30%. The total number of non-Oregon households is 3,615,568 and Oregon households is 1,624,953. Table 5 presents the lower bound annual WTP aggregation for some restoration programs.

Among the programs that yield positive WTP, the most modest gain, $5 million, occurs for 3,000 acres of moderate restoration, the same level of recreation, and an average of 5 days of flooding. This benefit increases to a high of $25 million when the acreage is increased to 15,000 acres. The program that yields the highest total WTP, at $93 million, involves 15,000 acres of full restoration, the same level of recreation, and an average of 10 days of flooding. In this scenario, an additional 1,000 acres increases nonmarket benefits by $2 million. For 15,000 acres of restoration, PNW households are willing to pay an additional $68 million for full restoration instead of moderate restoration. Conditional on full restoration, at 15,000 acres, the WTP to maintain current level of recreation as opposed to restricting recreation is $58 million.

6. Conclusions

Pacific Northwest coastal dunes are a unique type of ecosystem that is now rare (virtually non-existent) in its near-original form despite recent restoration efforts (Hacker et al. 2012; Ruggiero et al. 2018). This is the first study of the nonmarket benefits of coastal dunes restoration on the PNW coast. We use a choice experiment survey to examine the preferences regarding the trade-offs between restoration and public access to recreation, as well as the trade-off between restoration quality and quantity. The nonmarket gains when increasing quality–the closeness of the restored coastal dunes to its natural state–are substantially greater than those generated by increasing the total size of restored areas alone. Furthermore, we find evidence of substantial disutility from changes in recreation access in restored areas, whether to allow more activities such as ORV use or restrict certain activities. In addition, preferences for restoring coastal dunes are heterogenous.

We calculate aggregate WTP based on median household WTP and response rates. The program with the highest WTP has the largest total restored areas (which was set at 15,000 acres in our choice experiment), full restoration, and the same level of recreation. Its lower bound WTP is $93 million per year for 10 years. At the same time, the lower bound aggregate WTP for an equally large area of moderate restoration and the same level of recreation stands at $25 million per year for 10 years. Three restoration – recreation combinations in programs yield positive WTP: full restoration with the same level of recreation access, full restoration with fewer recreational activities allowed, and moderate restoration with the same level of recreation. In all scenarios, the number of flooding days per year does not significantly affect WTP.

Recent restoration programs of coastal dune ecosystems in the PNW tend to focus on increasing populations of one federally threatened species, the western snowy plover, which most closely resemble the moderate restoration scenario described in the survey. Our results suggest there are large potential gains associated with more ambitious ecological restoration that aims to restore the ecosystems so that it closely resembles the natural state. Findings from this study may help policy makers by contributing information on overlooked benefits from restoration. WTP estimates from our analysis can thus be used in formal benefit-cost analysis and in resource management decisions regarding restoration strategy. Finally, we believe our approach to valuing ecosystem attributes may be applicable in other contexts that face similar trade-offs, with facets of restored ecosystems that may currently be neglected in nonmarket valuation studies and in conservation planning.

Acknowledgements

We thank Lydia Newton and the Oregon State University (OSU) Survey Research Center for outstanding survey administration, Christopher Parish and his laboratory at OSU for producing maps used in this research (including Figure A1), and Tom Kaye (Institute for Applied Ecology) and Dan Elbert (U.S. Fish and Wildlife Service) for providing insight on the threatened and endangered species in the study area. We also acknowledge funding that supported this research from the NOAA National Centers for Coastal Ocean Science Competitive Research Program through NOAA Cooperative Institutes Program award numbers NA11OAR4320091A and NA16OAR4320152 to the Cooperative Institute for Marine Resources Studies at Oregon State University. All errors are the responsibility of the authors. The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the authors and do not necessarily reflect those of NOAA or the Department of Commerce.

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Tables

TABLE 1
Attributes and their levels

Attribute	Meaning	Levels
Level of restoration	The level of restoration done within the restored areas, if any. More restoration involves active plantation of native species in addition to dune flattening and invasive grass removal, the latter two are also carried out in moderate restoration.	1: No new restoration (status quo, only possible in status quo) 2: Moderate restoration 3: Full restoration
Size of all restored areas combined	The total restored areas would be split up into 10 sites. This attribute shows the total size of these areas. Larger areas cost more to maintain.	1: 0 acres (status quo, only possible in status quo) 2: 3,000 acres 3: 7,000 acres 4: 10,000 acres 5: 15,000 acres
Recreation	Type of recreational activities allowed. Fewer recreation activities allowed means only walking on wet sand is allowed, while more recreation involves all the current activities allowed (such as hiking, picnic, walking dog) plus riding all-terrain vehicles (ATV).	1: Fewer recreational activities 2: Same (status quo) 3: More recreational activities
Number of flooding days	Number of days per year (usually in the winter) the restored areas, or areas where restoration could be, are temporarily flooded on average. Full restoration may lead to more flooding due to flattened dunes.	1: 2 days (status quo, only possible in status quo) 2: 5 days 3: 10 days 4: 20 days
Added cost to household	Total cost to household per year for the next 10 years in terms of increased taxes.	1: $0 (status quo, only possible in status quo) 2: $10 3: $20 4: $50 5: $75 6: $100 7: $175 8: $250 9: $350

TABLE 2
Summary Statistics

Variable	Sample Mean (Standard Deviation)	PNW population Mean
Age	57.34 (15.70)	37.75
Female	40.97% (0.49)	50.51%
White	92.01% (0.27)	81.94%
Education (% with bachelor's degree or above)	49.78% (0.50)	32.97%
Median Income (Thousands of Dollars)	$60,000 - $69,000	$60,000 - $69,000
Employment (% employed)	53.08%	59.11%
Household Size	2.44 (1.27)	2.55

TABLE 3
Logit Estimation Results

Attribute	Main effects ML (1)			Main effects MXL (2)			Interaction Effects MXL (3)		
	Coef.		Std. Err.	Coef.		Std. Err.	Coef.		Std. Err.
Estimated parameter means									
Log (Cost)	-0.54	***	0.32	-0.77	***	0.16	-0.77	***	0.27
Size	0.04		0.07	0.45	**	0.23	1.00	*	0.57
Flood	0.07		0.07	0.04		0.22	0.08		0.33
Full	0.41	***	0.08	1.74	***	0.35	2.11	***	0.74
Fewer Rec	-0.18	**	0.07	-1.28	***	0.30	-0.83	*	0.49
More Rec	-0.61	***	0.08	-3.31	***	0.55	-2.86	***	0.76
ASC	-0.41	***	0.10	-5.20	***	0.82	-4.86	***	1.60
Size*FewerRec							-0.72		0.56
Size*More							-0.48		0.48
Size*Full							-0.57		0.53
Estimated parameter standard deviations									
Log (Cost)				1.38	***	0.10	1.38	***	0.18
Size				1.31	**	0.64	0.94		2.50
Flood				0.29		2.12	0.77		2.47
Full				3.79	***	0.64	3.84	***	0.69
Fewer Rec				3.26	***	0.63	3.49	***	0.74
More Rec				4.16	***	0.80	4.38	***	1.26
ASC				8.73	***	1.28	9.20	***	1.75
Size*FewerRec							1.12		1.46
Size*More							1.31		1.66
Size*Full							0.04		0.28
Log-Likelihood	-3397			-2675			-2670		

p-values: 0.01 '***', 0.05 '**', 0.1 '*'
N: 3373

TABLE 4
Median Annual Household WTP and Aggregate Population Benefits for PNW Sandy Beach and Coastal Dune Restoration

Restoration Outcome			Household WTP (US $)	Lower Bound Population Benefits (US $ millions)
Restoration level	Recreation access	Size (Acres)	Median (95% CI)	Median (95% CI)
Full	Same	3,000	$48 (33, 65)	$69 million (47, 93)
		7,000	$54 (36,774)	$77 million (52, 105)
		10,000	$58 (37,81)	$83 million (53, 116)
		15,000	$65 (38, 93)	$93 million (55, 134)
Full	Limited	3,000	$12 (0, 27)	$17 million (0, 39)
		7,000	$15 (2, 33)	$22 million (3, 47)
		10,000	$19 (3,37)	$27 million (4, 53)
		15,000	$25 (4, 48)	$35 million (6, 70)
Mooderate	Same	3,000	$4 (-6, 17)	$6 million (-7, 25)
		7,000	$8 (-1, 23)	$12 million (-1, 33)
		10,000	$12 (1, 29)	$17 million (1, 42)
		15,000	$18 (2, 42)	$25 million (3, 59)

Figures

FIGURE 1.
Visual Illustrations of Three Levels of Restoration Quality

FIGURE 2
Example of a Choice Card

FIGURE 3
Median Annual Household WTP and Changes in WTP from Changing One Attribute

Footnotes

[i] The world's best-selling science fiction novel Dune is inspired by the Oregon Dunes in Florence, Oregon (Oregon Dunes Restoration Collaborative 2018).

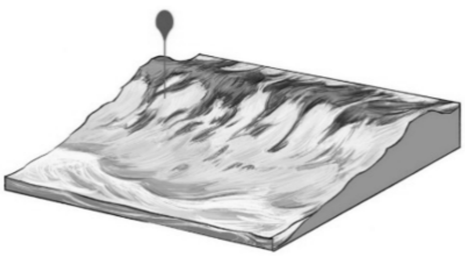
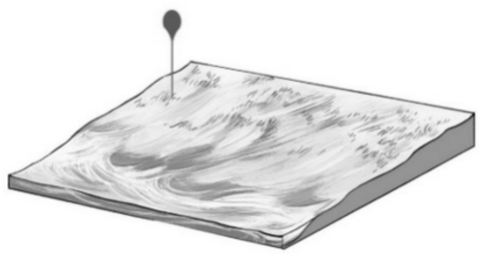
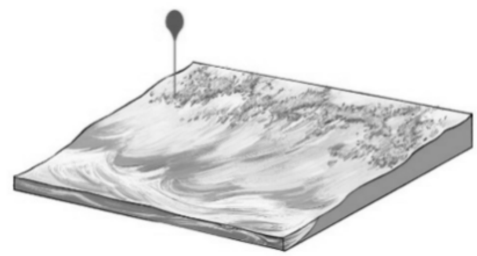
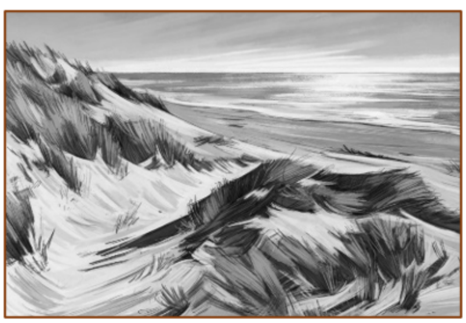
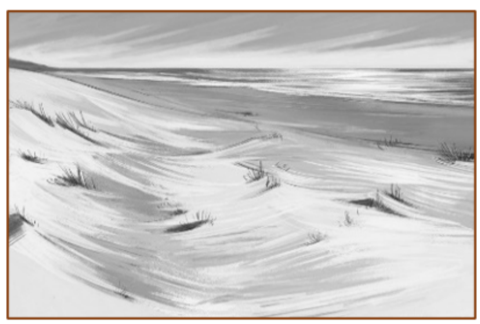
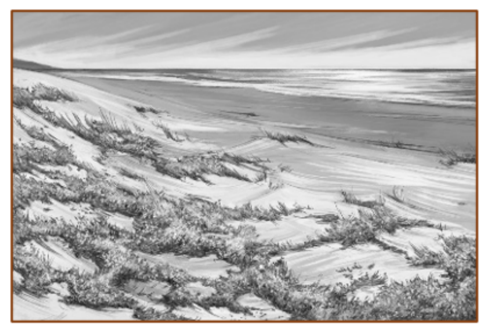
[ii] SSI maintains a database of U.S. households that is commonly used by researchers to draw from when generating random samples of the U.S. population.

[iii] Source: Conversation with Dan Elbert at the U.S. Fish and Wildlife Service

[iv] In practice, we assume that coefficients are independent, so Ω does not include off-diagonal elements.

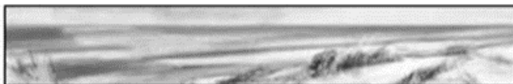
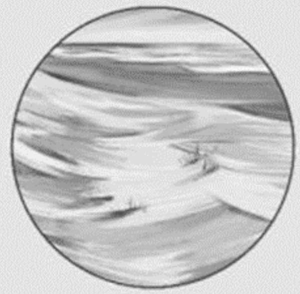
[v] We used 1000 Halton draws for estimation. Results are produced using two software packages: the mlogit package in R and an adapted version of MATLAB code from the EPA workshop "Revealed Preferences Outside Markets" written by Alan Klaiber.

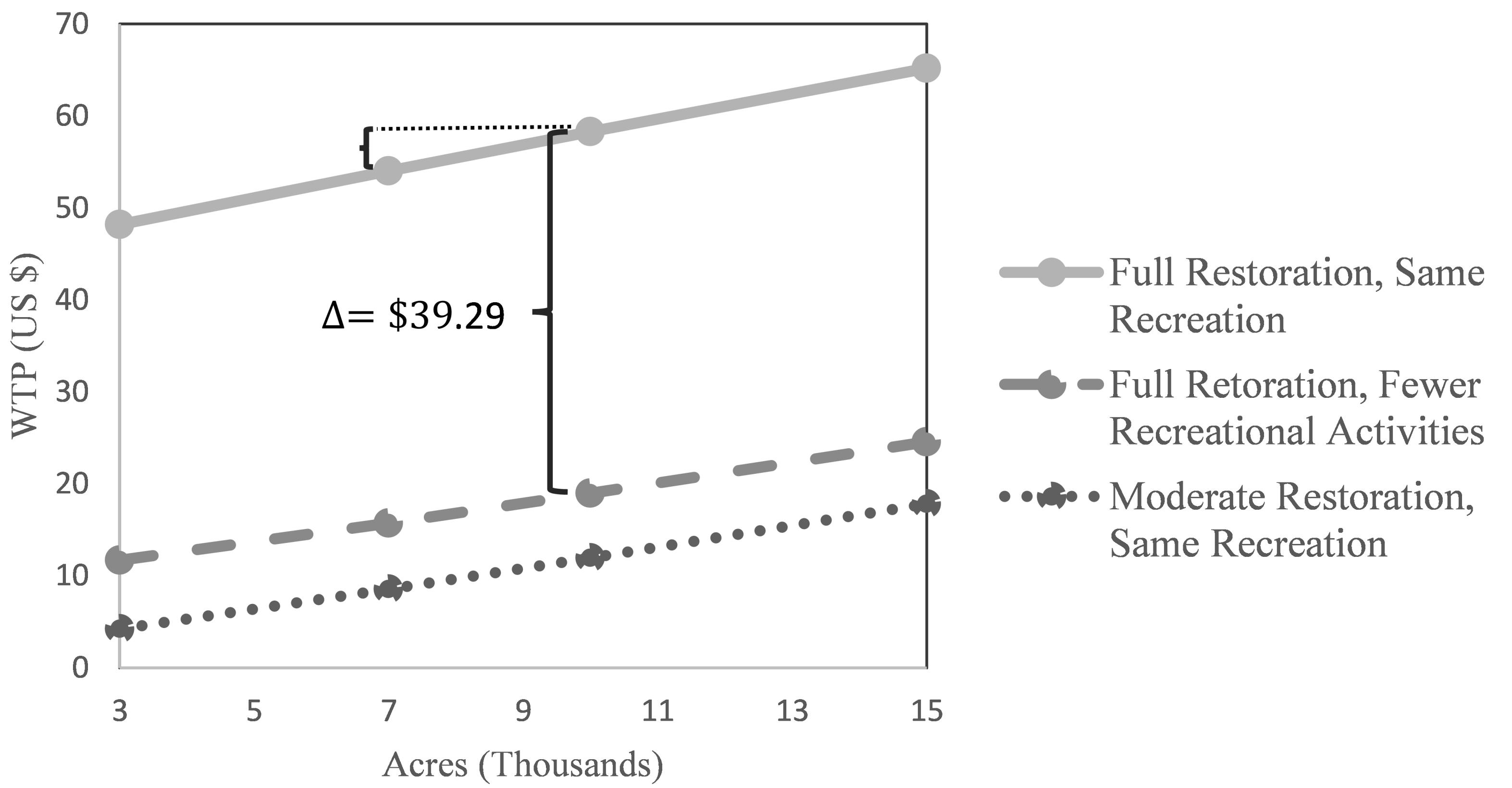
[vi]. Alternative specifications examining interaction effects related to state of residence, recreation habits and demographics were estimated but generally found not to lead to additional insights about the role of these factors on utility

	No new restoration	Moderate restoration	Full restoration
View of the dunes from a vantage point			
View from the dunes looking toward the ocean			

Q13: Alternative A and Alternative B are potential restoration plans for PNW sandy beach and coastal dune landscapes. The Status Quo alternative means no new restoration happens. Given the choice among these three alternatives, which one would you prefer?

Please mark you answer below.

	**Results for each alternative**		
	Status Quo	**Alternative A**	**Alternative B**
Level of Restoration	 **None**	 **Moderate**	 **Full**
Size of All Restored Areas Combined (acres)	**0 Acres**	**3,000 Acres**	**15,000 Acres**
Recreation (Recreational activities remain the same outside restored areas)	 **No Change**	 **No Change**	 **Fewer Activities Allowed**
Number of Flooding Days (per year)	**2 Days**	**5 Days**	**10 Days**
Added Cost to Your Household Each Year for <u>10 Years</u>	**$ 0**	**$ 175**	**$ 250**
Which alternative do you prefer? (*Choose one*)	◯ 1 **Status Quo**	◯ 2 **Alternative A**	◯ 3 **Alternative B**


70
60
50
40
30
20
10
0
WTP (US $)
Δ= $39.29
3
5
7
9
11
13
15
Acres (Thousands)
Full Restoration, Same Recreation
Full Retoration, Fewer Recreational Activities
Moderate Restoration, Same Recreation