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Research Papers

Title

Application of the double-bounded dichotomous choice model to the estimation of crowding acceptability in natural recreation areas

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5

6 Abstract

7 Investigating visitors' crowding norms is necessary to establish the carrying capacity of
8 natural recreation areas. For this purpose, several question formats have been used, but it is
9 known that these have methodological issues. To reduce these methodological issues, we
10 compared several different question formats to investigate respondents' perceptions of
11 acceptable crowding limits, using montage photographs of different numbers of people at four
12 sites in Shiretoko and Yakushima World Natural Heritage Site in Japan. We applied the
13 double-bounded dichotomous choice model used in the contingent valuation method. Our use
14 of conventional long- and short-format question models shows that acceptability decreases as
15 the number of people increases, in single- and double-bounded models. This confirms the
16 findings of past studies. Despite differences in the crowding norms as measured using
17 different question formats, there was little difference in the number of people depicted in the
18 photographs. The logit model of the double-bounded dichotomous choice model makes it
19 possible to analyze the impact of differences in the number of people and other relevant
20 factors, including the respondents' characteristics and attitudes. The number of respondents
21 and the burden on respondents vary in each question format, and each provides different
22 information to managers.

23

24 Management Implication

25 / A double-bounded dichotomous choice model is shown to be a suitable method to analyze
26 crowding norms at natural recreation sites.

27 / This model is less burdensome for respondents and requires fewer samples than some other
28 methods.

29 / The choice model also permits one to analyze the influences of visitors' characteristics and
30 other factors on crowding norms.

31

32 Keywords: Normative method; Visual approach; Crowding norm; Choice model

33

34 1. Introduction

35 1.1. Studies of crowding norms in natural recreation areas

36 Indicators and standards of quality are the critical elements underpinning carrying capacity
37 setting in protected areas (Manning, 2011). Indicators of quality are defined using area
38 objectives and the concerns of managers, stakeholders, and visitors. Standards of quality are
39 defined by the norms that stakeholders and visitors consider acceptable. The norm in
40 recreational research “address conditions that are the result of behavior and measure the
41 degree to which selected conditions ought to exist” (Manning, 2011). Therefore, methods for
42 investigating visitor perceptions of crowding are needed to assess the carrying capacity of
43 natural recreation areas.

44 Methods for investigating crowding norms have been developed in various ways. It was
45 mainstream practice in early studies to ask respondents directly to provide answers in the
46 form of numerical values (Manning, 2011; Shelby, 1981). This approach generated a low
47 survey response rate, with many respondents finding it difficult to answer the questions (Hall
48 & Roggenbuck, 2002; Hall, Shelby, & Rolloff, 1996; Vaske, Donnelly, & Bingül, 2016). As a
49 result, a different method was developed, in which respondents were presented with several
50 options and asked to choose an acceptable one. The response rate for questions involving
51 crowding norms in a popular and easily accessible outdoor area with many visitors is low
52 (Roggenbuck, Williams, Bange, & Dean, 1991; Vaske et al., 2016). For this reason, many
53 researchers have used a visual approach, which presents respondents with illustrations or
54 photographs and asks them to identify the most acceptable level of crowding (Manning &
55 Freimund, 2004; Manning, Valliere, Wang & Jacobi, 1999; Manning, 2011; Manning, Lime,
56 Freimund, & Pitt, 1999). The illustrations or photographs enable respondents to perceive and
57 recall the number of visitors clearly. This approach also has the advantage of being suitable

58 for high-density locations and virtual situations; therefore, it has been applied to a wide range
59 of places and activities. It has been used to assess the number of visitors to an area; bikers on
60 a trail (Arnberger & Haider, 2005; Arnberger, Aikoh, Eder, Shoji, & Mieno, 2010; Mieno,
61 Shoji, Aikoh, Arnberger, & Eder, 2016), vehicles on a road (Anderson, Manning, Valliere, &
62 Hallo, 2010), vessels in a protected ocean area (Needham, Szuster, & Bell, 2011), visitors at
63 tourism sites (Manning, Wang, Valliere, Lawson & Newman, 2002), and visitors to a coastal
64 wilderness site (Pierce & Manning, 2015). This method can be used to measure the acceptable
65 impacts on natural resources by recreational activities, such as a piece of bare land (Kim &
66 Shelby, 2005, 2006), in addition to measuring social conditions, such as the number of people
67 and cars in an area.

68 Other studies have applied stated choice experiments to recreation research. The methodology
69 was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983)
70 and has been used primarily within the fields of transportation and marketing (e.g. Hensher
71 1994; Louviere 1994). This methodology allows individual preferences to be assessed by
72 asking respondents to choose among various multi-attribute scenarios. In the literature of
73 recreation research, the result shows the importance and their tradeoffs among natural
74 resources, social, and managerial conditions, and visitors' experiences. Haider and Ewing
75 (1990) made an early application of choice experiments to study leisure behaviors of visitors.
76 They analyzed destination choices of Caribbean tourists. Stated choice experiments are now a
77 widely used method, capable of evaluating the influence of factors including differences in
78 recreational activities and settings and the number of people involved (Arnberger & Haider,
79 2005; Lawson & Manning, 2002; Newman, Manning, Dennis, & McKonly, 2005; Pettebone
80 et al., 2011; van Riper, Manning, Monz, & Goonan, 2011). Louviere and Timmermans (1990)
81 summarize the use and usefulness of the models in recreation research.

82 Most crowding-related studies have been conducted in North America (Manning, 2011;
83 Vaske & Shelby, 2008). In Japan, which is the subject of this study, managers and researchers
84 are interested in determining the carrying capacity of natural recreation sites, including
85 crowding norms. The control of visitors and cars has become an issue at sites such as
86 Yakushima, Shiretoko, and Mt. Fuji, which have been designated as World Heritage Sites in

87 recent years (Ishikawa et al., 2013). Since the 1990's, studies of crowding norms and other
88 relevant issues have been carried out, drawing on research examples in North America
89 (Aikoh, Cheng, & Asakawa, 2002; Mieno et al., 2016; Terasaki et al., 2011). The visual
90 approach has also made it possible to conduct international comparison studies of sites that
91 are distant from each other, such as a comparative of sites in Austria and Japan (Arnberger et
92 al., 2010). Similar comparisons have been made between destinations in North America and
93 Turkey (Sayan, Krymkowski, Manning, Valliere, & Rovelstad, 2013). This approach is
94 expected to make an important contribution to studies investigating the impact of cultural
95 factors on crowding norms (Evans, Lepore, & Allen, 2000) and the influence of
96 internationalization on tourism.

97 The present study aims to compare several different question formats to investigate
98 respondents' perceptions of acceptable crowding limits, using montage photographs. We have
99 applied the single-bounded and double-bounded methods used in contingent valuation
100 research to remove the known methodological issues associated with such approaches and
101 compared them with the conventional question formats.

102

103 1.2. Methodological issues in studies of crowding norms

104 Given the broad range of studies of crowding norms, several methodological issues have been
105 pointed out and the questionnaire format has evolved through the development of new
106 techniques (Manning, 2011). One issue involves the response format. At first, researchers
107 used an open-ended method, directly asking respondents to identify an acceptable number of
108 people (Shelby, 1981; Vaske & Donnelly, 2002). However, when use levels were high,
109 agreement on norms was low. In addition, some respondents felt strongly about the issue of
110 crowding, but could not answer the questions clearly (Hall et al., 1996). Consequently, a
111 semi-open method was adopted, which included options such as, "It matters to me, but I
112 cannot specify a number" (Hall et al., 1996). Although crowding norms were similar to those
113 obtained with open-ended questions, the standard deviation was different (Hall et al., 1996).
114 The closed-ended method has been used with respondents who are not fully aware of numeric
115 norms; it asks them to choose an acceptable item from a range of given possible responses.

116 The response rate for crowding norm is higher for closed-ended methods, which allow
117 respondents to choose an item, than for the semi-open method of asking them to write a
118 number in the blank space. However, there is no difference in the crowding norms identified
119 using these two methods (Hall & Roggenbuck, 2002; Vaske et al., 2016).

120 The introduction of the visual approach, which allows researchers to present a visual
121 representation of the natural resource and the number of people through illustrations and
122 photographs, has also led to variations in the question format. One approach is the short-
123 format question method, in which respondents select the most acceptable picture from among
124 a group of images of different numbers of people across a certain range. Since this method
125 requires only one response, the burden on the respondent is small (Manning et al., 1999b). It
126 produces an acceptable curve, depicted as a graph in which the number of people is
127 represented on the x-axis and the ratio for considering a situation acceptable on the y-axis. A
128 second method, the long-format question method, presents photographs one-by-one, asking
129 respondents to rate the acceptability of each photograph on a Likert scale—a 9-point scale is
130 most commonly used. This method is almost identical to full profile ratings-based conjoint
131 analysis. However, long-format questions constitute a single attribute and the statistical
132 analysis applied is also different. The full profile ratings-based conjoint analysis is generally
133 applied to understand trade-offs among attributes, so profiles are multi-attribute. In this
134 method, the burden on respondents is heavier, as they must respond to all of the pictures.
135 Manning et al. (1999b) compared these formats and showed that the difference in norms was
136 small; however, perceived crowing norms in short-format questions were lower than those in
137 long-format question. Other studies have examined the acceptability of trail conditions with
138 long- and short-format responses. These studies have found that the differences tend to be
139 small, although some combinations show statistical differences (Kim & Shelby, 2005, 2006).

140 When asked how difficult they found it to answer the questions, respondents said that long-
141 format questions were more difficult to answer than short-format ones (Kim & Shelby, 2006).

142 Study of norm crystallization, which is the level of agreement about social norms, have also
143 shown differences between short- and long-format questions, although the differences are
144 considered slight (Krymkowski, Manning, & Valliere, 2009).

145 Previous studies have pointed out the possibility of bias associated with the presentation of
146 photographs (Manning, 2011). The two types of bias identified are starting point bias, in
147 which images seen at the beginning have a disproportionate influence, and range bias, in
148 which respondents are influenced by the range of the number of people that are shown
149 (Manning, Lawson, Newman, Laven & Valliere, 2002; Manning and Freimund, 2004). The
150 first image elicits “anchoring” in the field of psychology and economics; therefore, a
151 respondent relies on the information offered (Mitchell & Carson, 1989). These biases are
152 similar to those identified in environmental economics studies that use the contingent
153 valuation method to ascertain willingness to pay. Manning et al. (2002a) have shown that
154 evaluation values are slightly different when the order of photographs is reversed. A recent
155 study by Gibson et al. (2014) has confirmed that crowding norms differ significantly when
156 photographs are presented in a discontinuous order. The study has also confirmed the
157 influence of different ranges of people in photographs. Studies on landscape preferences are
158 similar to the studies on crowding norms, in that they use photographs as a stimulus.
159 Researchers consider there may be an order effect, as well as start and end effects. Therefore,
160 other methods are used, such as presenting the images at random or inserting dummy pictures
161 that are not evaluated before and after the survey (Kaplan, Kaplan, & Brown, 1989; Strumse,
162 1996). The stated-choice model asks respondents to choose one picture from a set of several
163 kinds of photographs by selecting the acceptable number of people and various other factors;
164 therefore, this method is not affected by order bias (Gibson et al., 2014).

165

166 1.3. Applying the contingent valuation method to recreation research

167 The contingent valuation method and recreation studies on crowding norms use the same
168 method of asking questions. There is little difference between stating the amount of money
169 you are willing to pay and proposing an acceptable number of people. Similarly, choosing the
170 right amount of money to pay or an acceptable number of people from a group of presented
171 items are similar tasks (Shelby, 1981; Manning, Lawson & Frymier, 1999; Vaske et al.,
172 2016). Current studies are examining the question of bias in the contingent valuation method

173 based on answer format and the potential for mitigating any bias. It is possible that this
174 approach could be applied to research into crowding norms.

175 Elicitation formats that are less susceptible to bias have been developed in contingent
176 valuation research (Bateman et al., 2002; Mitchell & Carson, 1989). Open-ended questions,
177 bidding games, payment cards, and dichotomous choice are representative elicitation formats
178 for contingent valuation.

179 Early studies often used the open-ended and bidding game format (Mitchell & Carson, 1989).
180 The open-ended format asks respondents to choose their willingness-to-pay freely. However,
181 respondents who are not used to pricing items find it difficult to answer the question.
182 Therefore, no response and the nomination of extreme amounts such as "\$0" occur frequently.
183 Consequently, current studies do not often use this format. In the bidding game, respondents
184 are presented with an amount and asked whether they are willing to pay the amount or not.
185 Respondents who answer "yes" to the initial amount are presented a higher amount and asked
186 whether they are willing to pay the higher amount. Respondents who answer "no" to the
187 initial amount are presented with a lower amount and asked whether they are willing to pay it.
188 Repeating the questions reveals the level of the willingness to pay. The bidding game format
189 is easier to answer than open-ended questions; therefore, problems such as respondents giving
190 no answer or nominating extreme amounts do not occur. However, the starting point bias
191 might occur, in which the initial amount presented affects the answer. For example, a
192 respondent's answer is different when the initial amount presented is five USD from their
193 answer when the first amount presented is 50 USD. This is because respondents perceive the
194 initial amount as reasonable.

195 The payment card method, in which respondents are presented a list of several amounts and
196 asked to choose the amount they prefer, is also relatively easy to answer. No response or
197 responses nominating an extreme amount does not occur as frequently in the payment card
198 format as in open-ended questions. Moreover, starting point bias does not occur, as in the
199 bidding game format. However, range bias occurs, in which the range of amounts presented
200 affects responses (Mitchell & Carson, 1989). For example, a respondent's answers are
201 different when choosing an amount between 0 and 30 USD from their answer when choosing

202 an amount between 0 and 1,000 USD. This is because respondents perceive the range of the
203 amounts presented as reasonable.

204 In the dichotomous-choice format, respondents are presented with a hypothetical
205 environmental change, the amount of money necessary to achieve the change, and asked
206 whether they are willing to pay the amount. The biases that occur in other formats, such as
207 starting point bias and range bias, do not occur in this format. In addition, dichotomous-
208 choice format avoids bias arising from the strategic behaviors of respondents under certain
209 conditions (Hoehn and Randall, 1987). Respondents find it easy to answer questions
210 presented in this format because judging whether to accept the cost of achieving the
211 environmental change is similar to the daily purchasing behavior of judging whether to buy
212 goods with a specific price. These advantages have resulted in dichotomous-choice becoming
213 the most widely used at present. The National Oceanic and Atmospheric Administration
214 (NOAA) guideline recommend using this format (Arrow et al., 1993).

215 The double-bounded format is statistically more efficient than the single-bounded format, and
216 the confidence interval of the estimated willingness-to-pay is narrower (Hanemann, Loomis,
217 & Kanninen, 1991). In the double-bounded format, respondents need to answer two
218 consecutive questions. If he or she accepts the initial amount at the first step, they are
219 presented with a higher amount in the second step. If respondents do not accept the initial
220 amount, they are presented with a lower amount in the second step. More information is
221 obtained in the double-bounded format than in the single-bounded format, which asks only
222 one question. It can estimate willingness-to-pay, even with a smaller number of respondents
223 than the single-bounded format.

224

225 1.4. Objective of the study

226 This study sought to identify the optimal method for estimating the carrying capacity at
227 natural recreation areas by comparing the three most commonly used methods for eliciting
228 people's crowding norms with the double-bounded dichotomous choice model. It compared
229 double-bounded dichotomous choice model for photo-based evaluations of crowding norms
230 with conventional question formats, such as short-format and long-format questions and the

231 single-bounded dichotomous choice model. We have applied the approaches used in
232 contingent valuation method to resolve the methodological issues in the evaluation of
233 crowding norms and discussed the differences among the three methods and their application
234 in estimating the carrying capacity in protected areas.

235

236 2. Method

237 2.1. Questionnaire research design

238 This study aims to investigate acceptable crowding norms, using photographs of different
239 numbers of people at four study sites in Shiretoko and Yakushima World Natural Heritage
240 Site in Japan, in combination with three different answer formats in February 2014. Seven
241 photographs with varying numbers of “people at one time” (PAOT) depict the two sites in
242 Shiretoko and two sites in Yakushima. Responses were obtained using a web questionnaire
243 survey. They were registered respondents of a research company (Nikkei Research Inc.),
244 living in the Tokyo metropolitan area; they are men and women aged 20–69. According to the
245 age structure of populations in the area, 10,000 registered respondents were asked to
246 participate in the survey via email. Respondents who accepted the request submitted their
247 answers on the web page provided. The web page had been opened until the day when
248 respondents reached more than 1,000 people. The total number of respondents was 1,192 in a
249 week.

250 The respondents were divided into four groups (Table 1): 239 were asked to assess photo
251 montages of site 1 & 2 in Shiretoko in long-format; 244 were asked to assess photo montages
252 of site 3 & 4 in Yakushima in long-format; 249 respondents were asked to assess all four sites
253 in short-format; and 460 were asked to make single- and double-bounded dichotomous choice
254 (hereinafter referred to as “single-bounded” and “double-bounded”) for all four sites. In long-
255 format, we asked the respondents to evaluate seven photographs of two sites, using a seven-
256 point scale, which ranged from “absolutely unacceptable” to “very acceptable.” In short-
257 format, we presented all seven pictures of each of the four sites and asked respondents to
258 choose one photograph that showed an acceptable limit. In the single-bounded survey, we
259 asked respondents to answer questions relating to each of the four sites. First, we presented

260 one of the seven photographs randomly and asked them their acceptability as “Yes,” “No” or
 261 “I don’t know.” Then we asked respondents to answer second questions for the double-
 262 bounded survey. If they accepted the first photograph, we showed them a second photograph
 263 which the PAOT was one level higher, asking them their acceptability again. If they did not
 264 accept the first photograph, we showed them a second photograph which the PAOT was one
 265 level lower, asking them their acceptability again. We also asked respondents if they have
 266 visited Shiretoko or Yakushima World Natural Heritage sites in the past. Their crowding
 267 concern whether they thought about the issue of crowding when planning trips to any natural
 268 recreation areas were asked, using a five-point scale, which ranged from “unimportant” to
 269 “very important.”

270

271 Table 1 Number of respondents of the web questionnaire survey for different question formats
 272 and study sites

Question format	Site	Number of respondents
Long-format	1, 2	239
	3, 4	244
Short-format	1, 2, 3, 4	249
Single- and Double-bounded	1, 2, 3, 4	460

273 Site 1: Kamui-Wakka entrance, 2: Kamui-Wakka waterfall, 3: Jomon-Sugi tramway trail, 4:
 274 Jomon-Sugi forest trail

275

276 2.2. Study sites and photographs

277 The study sites were selected from a group of places in Japan that attract a large number of
 278 visitors, in which some strategies for managing the number of people and vehicles have been
 279 implemented or considered. Study site 1 is the Kamui-Wakka entrance, and site 2 is the
 280 Kamui-Wakka waterfall at the Shiretoko World Natural Heritage site. Site 3 is the Jomon-
 281 Sugi tramway trail, and site 4 is the Jomon-Sugi forest trail at the Yakushima World Natural
 282 Heritage site.

283 In Shiretoko Kamui-Wakka, hot springs spurt into the river; visitors can enjoy wading in the
284 shallow warm river and bathing in natural hot-water pools. It is a 300m round trip trail to the
285 upper stream, which climbs up the top waterfall for about 5 meters and returns to the
286 trailhead. Approximately 55,000 people visit the site between June and October each year.
287 During the summer vacation, about 1,000 people visit in every day. The managers and local
288 stakeholders must grapple with congestion in the river and around the waterfall and a shortage
289 of parking. During the summer vacation, visitors must take a shuttle bus to the site, as access
290 using private vehicles is prohibited.

291 “Jomon-Sugi (big old cedar)” is the popular hikers’ destination in Yakushima island
292 (Shibasaki, 2018). Hikers take shuttle buses to the trailhead and walk for about ten hours, to
293 complete the whole trail. The first half follows a former logging tramway, and the second half
294 is a steep climb through a subtropical broadleaf forest to “Jomon-Sugi.” Approximately
295 60,000 people visit each year. About 800 people can visit in a single day during the holiday
296 season in the beginning of May. There is so much congestion on the trail and observation
297 deck in front of “Jomon-Sugi,” not to mention a shortage of toilets, that the town council once
298 discussed restricting the number of hikers.

299 For the Kamui-Wakka entrance, Kamui-Wakka waterfall, Jomon-Sugi tramway trail, and
300 Jomon-Sugi forest trail, we have estimated the maximum density, based on past records, and
301 determined the PAOT in each photograph. In photographs of the site 1: Kamui-Wakka
302 entrance, the PAOT was 0, 5, 10, 16, 22, 29, and 36. In photographs of the site 2: Kamui-
303 Wakka waterfall, the PAOT was 0, 3, 6, 10, 14, 19, and 24. The PAOT on the site 3: Jomon-
304 Sugi tramway trail was 0, 2, 4, 6, 8, 11, and 14. Finally, the PAOT on the site 4: Jomon-Sugi
305 forest trail was 0, 3, 6, 10, 14, 18, and 23. We took the background photographs on a clear
306 day and placed hikers at each site, (Fig. 1) using Adobe Photoshop CS to create photo
307 montages. The images on the website are in full color and displayed in 400 horizontal and 270
308 vertical pixels.

309

Site 1: Kamui-Wakka entrance



Photo 1 (0 PAOT)



Photo 7 (36 PAOT)

Site 2: Kamui-Wakka waterfall



Photo 1 (0 PAOT)



Photo 7 (24 PAOT)

Site 3: Jomon-Sugi tramway trail



Photo 1 (0 PAOT)



Photo 7 (14 PAOT)

Site 4: Jomon-Sugi forest trail



Photo 1 (0 PAOT)



Photo 7 (23 PAOT)

311 Fig.1 Examples of presented study photographs in the web questionnaire with varying
 312 numbers of people at one time for four study sites. Photo 1 have no people, photo7 have the
 313 most people.

314

315 2.3. Analyzing single- and double-bounded dichotomous choice model

316 The response data obtained through the single-bounded and double-bounded dichotomous
 317 choice format is analyzed by using the logit model derived from the random utility model
 318 (Hanemann, 1984; Hanemann et al. 1991).

319 In the model, the following is assumed for the utility function of the respondent k :

320

$$321 \quad U_k^i = V_k^i + \varepsilon_k^i$$

322

323 where \mathbf{z} takes Y when the respondent k answers yes to the bid, while takes N when the

324 respondent k answers no to the bid. Here, V_k^i and ε_k^i represent the deterministic and

325 stochastic terms of the utility, respectively. It is assumed that the respondent k considers the

326 environmental change and the associated payment and chooses the alternative with the higher

327 utility. Since the probability P_k^Y that the respondent k will answer yes is equal to a

328 probability for which the utility from the alternative Y , U_k^Y is larger than the utility from the

329 alternatives n , U_k^N , described as below:

330

$$331 \quad P_k^Y = \Pr(U_k^Y > U_k^N) = \Pr(V_k^Y + \varepsilon_k^Y > V_k^N + \varepsilon_k^N)$$

332

333 Assuming that the error term ε_k^i follows a type I extreme value distribution (Gumbel

334 distribution), the probability P_k^Y is described by the following binary logit model:

$$335 \quad P_k^Y = \frac{1}{1 + e^{-\Delta V}}$$

336

337

338

339 where ΔV represents the utility difference function and the following log-linear function is
 340 assumed: $\Delta V = \alpha + \beta \ln T_k$. In the utility difference function, T_k represents the bid offered to
 341 the respondent k , while the α and the β indicate the utility obtained from the improvement
 342 of the environment and the utility obtained from the payment, respectively. By extending the
 343 utility difference function as follows, it is possible to analyze the influence of other factors
 344 such as the knowledge on the subjects, the degree of interest in the issue and the socio-
 345 demographic variables of the respondents such as gender, age and income on the answers of
 346 the respondents: $\Delta V = \alpha + \beta \ln T_k + \gamma \mathbf{z}_k$, where, \mathbf{z}_k is a vector of other factors that may affect
 347 the answer of the respondent k , and γ is a vector of parameters of those factors.

348 The parameters are estimated by the maximum likelihood method. The log likelihood
 349 function can be written as follows:

350

$$351 \quad \ln L = \sum_k \left(\delta_k^Y \ln P_k^Y + \delta_k^N \ln P_k^N \right)$$

352

353 where δ_k^Y and δ_k^N are the dummy variable such that $\delta_k^Y = 1$ when the respondent k answers
 354 yes to the bid and $\delta_k^Y = 0$ otherwise, while $\delta_k^N = 1$ when the respondent k answers no to
 355 the bid and $\delta_k^N = 0$ otherwise.

356 So far, we explained the single-bounded dichotomous choice. The response data obtained
 357 through the double-bounded dichotomous choice format is analyzed by using an extended
 358 version of the above model.

359 The probability P^{NN} that the respondent k answers no to both the first bid (T_k) and the
 360 second lower bid (T_k^L) is as follows (Hanemann et al. 1991):

361

$$362 \quad P^{NN}(T_k, T_k^L) = Pr\{T_k > WTP \text{ and } T_k^L > WTP\} = G(T_k^L; \theta)$$

363

364 where G is a distribution function and θ is the parameter vector. Likewise, P^{NY} which is
 365 the probability that the respondent k answers no to the first bid and answers yes to the
 366 second lower bid, P^{YN} which is the likelihood that the respondent k answers yes to the first
 367 bid and answers no to the second higher bid (T_k^U) and P^{YY} which is the likelihood that the
 368 respondent k answers yes to both the first and the second higher bid are as follows,
 369 respectively;

370

$$371 \quad P^{NY}(T_k, T_k^L) = Pr\{T_k \geq WTP \geq T_k^L\} = G(T_k; \theta) - G(T_k^L; \theta)$$

372

$$373 \quad P^{YN}(T_k, T_k^U) = Pr\{T_k \leq WTP \leq T_k^U\} = G(T_k^U; \theta) - G(T_k; \theta)$$

374

$$375 \quad P^{YY}(T_k, T_k^U) = Pr\{T_k \leq WTP \text{ and } T_k^U \leq WTP\} = 1 - G(T_k^U; \theta)$$

376

377 The parameters are estimated by the maximum likelihood method. The log likelihood
 378 function can be written as follows:

379

$$380 \quad \ln L(\theta) = \sum_k \{d_k^{YY} \ln P^{YY}(T_k, T_k^U) + d_k^{YN} \ln P^{YN}(T_k, T_k^U) + d_k^{NY} \ln P^{NY}(T_k, T_k^L) + d_k^{NN} \ln P^{NN}(T_k, T_k^L)\}$$

381

382 where d_k^{YY} is a dummy variable such that $d_k^{YY} = 1$ when the respondent answers yes to
 383 both of the two bids and $d_k^{YY} = 0$ otherwise. Similarly, d_k^{YN} , d_k^{NY} and d_k^{NN} are the
 384 dummy variables corresponding to each response pattern.

385 We assume a log-linear function for $G(T)$ and the constant term α and the parameter of
 386 logarithmic value of the bid β for θ as follows:

387

$$388 \quad G(T) = \frac{1}{1 + \exp\{-(\alpha + \beta \ln T)\}}$$

389

390 where T is the bid for the respondents.

391 The median and mean WTP can be calculated by using the estimated parameters, α and β
392 (Hanemann 1984). The median WTP is the amount that the probability that the respondent
393 will answer yes to the bid is 0.5 and can be calculated as follows:

394

$$395 \quad \text{Median WTP} = \exp\left(-\frac{\alpha}{\beta}\right)$$

396

397 Whereas the mean WTP is obtained by integrating the probability that the respondent will
398 answer yes with respect to the bid. However, since it is not realistic to integrate to the
399 extremely high amount, the maximum bid is often used as the integration upper limit. In that
400 case, the mean WTP is calculated as follows:

401

$$402 \quad \text{Mean WTP}(\text{truncation at } T_{max}) = \int_0^{T_{max}} \frac{1}{1 + \exp^{-\Delta V}} dT$$

403

404 where T_{max} is the maximum bid.

405 Similar to single-bounded format, it is possible to analyze the influence of other factors
406 (e.g. household income).

407 The analyses for this study were carried out using SPSSver.22 and NLOGIT3.0.

408

409 3 Results

410 3.1 The acceptability curve of three types of question formats

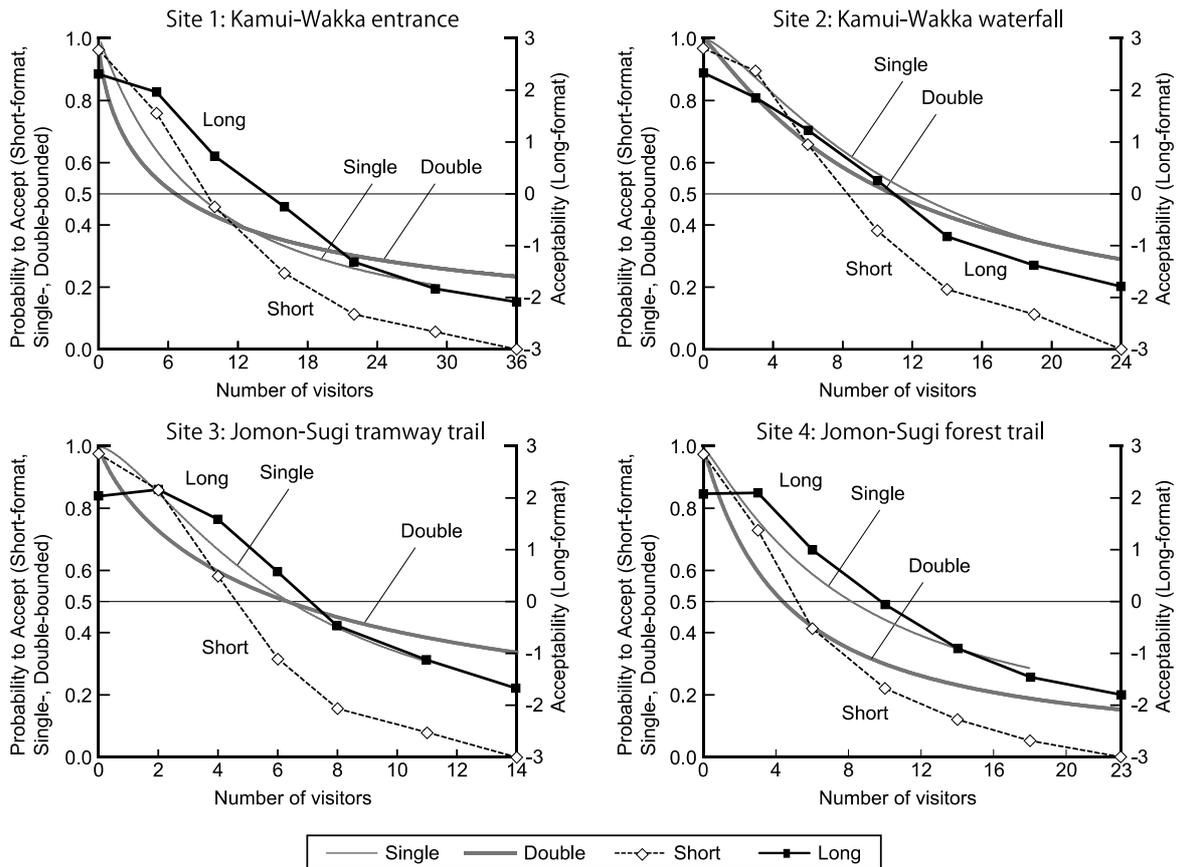
411 The acceptability curve of the crowding norms in each question format (long-format, short-
412 format, single-bounded, and double-bounded) are shown below (Fig. 2). For the long-format,
413 it shows the average acceptability value of each PAOT in the presented pictures. Their
414 acceptability declined gradually, as the number of people increased from 0 PAOT. The short-
415 format method shows the cumulative ratio of respondents who chose the most acceptable
416 photographs. As it was the case with the long-format method, the ratio of acceptability
417 declined gradually, as the number of people increased from 0 PAOT. For the single-bounded

418 approach, a curve was presumed by analyzing the ratio of respondents who judged the PAOT
419 of each randomly presented photograph to be acceptable. As for the results of the four study
420 sites, as the number of people increased from 0 PAOT, the ratio of acceptability tended to
421 decrease. For the double-bounded approach, the curve was estimated using a logit model
422 analysis, based on the acceptability of the first PAOT randomly presented and the response to
423 a second photograph. In all formats, as the number of people increased from 0 PAOT, the
424 ratio of acceptability tended to decrease.

425 When comparing question formats, the curve was gentlest in the long-format; the double-
426 bounded method had the steepest slope until the tolerance ratio hit 0.5. As the number of
427 people increased, the slope of the single-bounded and double-bounded graphs became
428 moderate, while the slope of the short-format became steep. Although no respondent found
429 the largest PAOT in the short-format acceptable, the logit model estimated a ratio of 0.2 for
430 the single-bounded and double-bounded approaches.

431 A comparison of study sites found that the site 1 had a higher PAOT and gentler slope than
432 the site 2 or site 4. The site 3 had the steepest slope. The number of people grew less
433 acceptable from 0 PAOT onwards. For the site 4, the acceptability of 2 PAOT was higher for
434 0 PAOT only in the long-format version.

435



436

437 Fig.2 The acceptability curves of crowding norms in each question format at four study sites

438

439 3.2 A comparison of the crowding norm among three types of question format

440 Table 2 shows the crowding norms for each question format. For the long-format, the
 441 crowding norm is the number of people at the acceptability thresholds where the acceptability
 442 curve intersects scale 0 of acceptability. For the short-format, it is the average value of the
 443 number of people in selected photographs. For the single- and double-bounded approaches,
 444 the median value intersecting 0.5 is shown using each logit-model estimate. Although
 445 Manning et al. (2002a) have pointed out that it is difficult to statistically compare the
 446 acceptability curve of the long-format, short-format, and dichotomous choice approaches, we
 447 estimated 95% confidence interval of single- and double-bounded model's median value by
 448 the Monte Carlo method based on Krinsky and Robb (1986).

449 The long-format crowding norms are larger than the short-format crowding norms in all sites.
 450 Although the double-bounded crowding norms are smaller than the single-bounded norms,
 451 the confidence intervals of them are overlapped. The crowding norms of long-format for the

452 site 1 and 4 are larger than any of the other question format and the confidence intervals of
 453 single- and double-bounded. In site 2 and 3, the crowding norms of short-format are smaller
 454 than any of the other question format and the confidence intervals.

455

456 Table 2 Crowding norms among different types of question format for the four study sites

Question format	Crowding norms			
	Site 1: Kamui- Wakka entrance	Site 2: Kamui- Wakka waterfall	Site 3: Jomon- Sugi tramway	Site 4: Jomon- Sugi forest trail trail
Long-format ^a	14.5	10.9	7.0	9.8
Short-format ^b	8.6	7.5	4.1	5.0
Single-bounded ^c	8.4	12.1	6.4	6.0
Confidence interval	(6.3 – 10.3)	(10.3 – 14.6)	(5.5 – 7.5)	(5.1 – 8.0)
Double-bounded ^c	6.7	10.9	6.3	4.4
Confidence interval	(4.8 – 8.9)	(9.2 – 13.0)	(5.1 – 6.9)	(3.5 – 5.4)

457 ^a Number of people at which the acceptability curve intersects scale 0 of acceptability.

458 ^b Average number of people in the selected photographs.

459 ^c The median value intersecting 0.5 using each logit-model.

460

461 3.3 Coefficient estimates for the single- and double-bounded models

462 In both the single- and double-bounded models, the study site results were significant and
 463 converged. The coefficient estimates are shown below, in Table 3. In both models for four
 464 study sites, estimated coefficients of logit models were statistically significant. The t-statistics
 465 of the double-bounded models were larger than that of single-bounded models. The larger the
 466 t value, the smaller the variance of the estimated value (Hanemann et al., 1991).

467

468 Table 3 Coefficient estimates of the single- and double-bounded models for the four study
 469 sites

	Single-bounded	Double-bounded
--	----------------	----------------

Study sites	Constant		Number of visitors		Constant		Number of visitors	
Site 1: Kamui-Wakka entrance								
Coefficient estimate	2.32		-1.09		1.33		-0.70	
t-statistic	5.04	***	-6.12	***	10.15	***	-16.25	***
Site 2: Kamui-Wakka waterfall								
Coefficient estimate	3.45		-1.38		2.70		-1.13	
t-statistic	7.52	***	-7.17	***	17.35	***	-19.77	***
Site 3: Jomon-Sugi tramway trail								
Coefficient estimate	2.76		-1.49		1.58		-0.86	
t-statistic	7.60	***	-7.45	***	13.64	***	-18.96	***
Site 4: Jomon-Sugi forest trail								
Coefficient estimate	2.97		-1.66		1.55		-1.04	
t-statistic	7.15	***	-8.59	***	11.56	***	-20.19	***

470 ***: p<0.001

471

472 In addition to the PAOT in the photographs, the double-bounded models incorporated
473 relevant factors relating to past visits to both World Natural Heritage sites; the respondents'
474 concerns about crowding were estimated (Table 4). The logit models of both the site 1 and 2
475 at the Kamui-Wakka were significantly affected by visitors' past experiences and crowding
476 concerns. Positive coefficients of past experience indicated that respondents who had visited
477 the sites previously were tolerant of the PAOT in photographs. Negative coefficients of
478 crowding concern indicated that respondents who dislike crowding are sensitive to PAOT in
479 photographs. The model of the site 3 showed statistical significant influence only in relation
480 to crowding concern. The model of the site 4 showed no influence of either past experience or

481 crowding concern. As an example, the curve of site 1 is shown in Fig. 3. The acceptability
 482 curve of respondents who had visited at Shiretoko, and were not concerned with crowding
 483 was gentler; the curve of respondents who had not visited there, and were concerned with
 484 crowding was steeper. The logit model could concretely illustrate the influence of relevant
 485 factors.

486

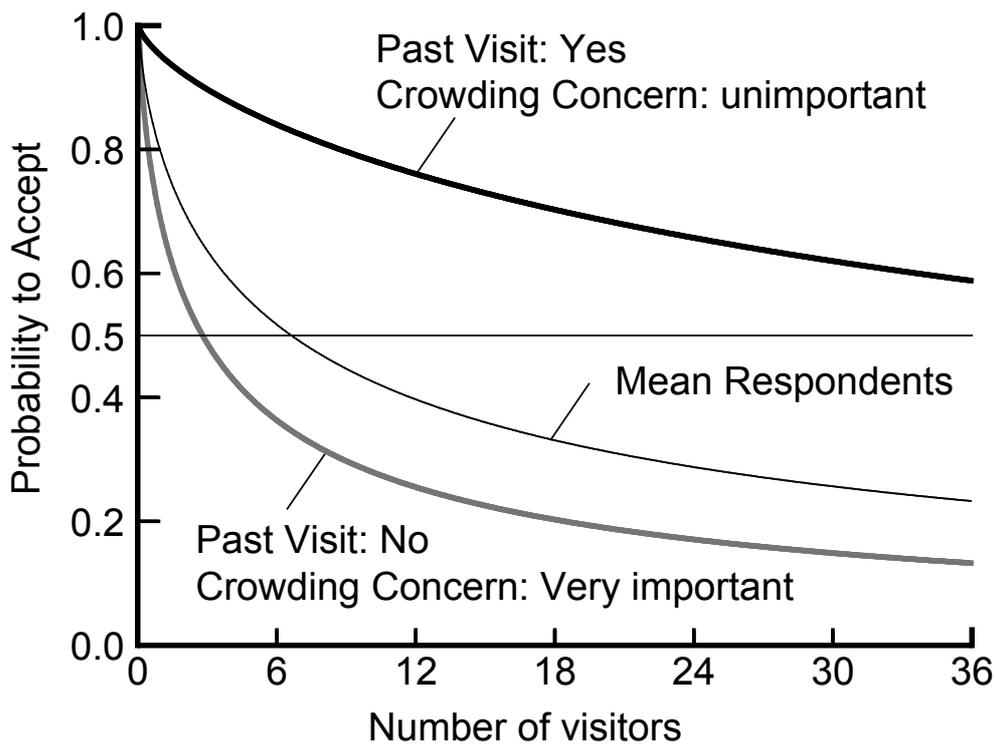
487 Table 4 Coefficient estimates of double-bounded models for crowding norms, past visit and
 488 crowding concerns of respondents

	coefficient	t-value	
Site 1: Kamui-Wakka entrance			
Constant	2.67	4.71	***
Number of visitors	-0.73	-16.55	***
Past visit	0.69	2.89	**
Crowding concern	-0.38	-2.76	***
Site 2: Kamui-Wakka waterfall			
Constant	3.73	6.33	***
Number of visitors	-1.16	-20.21	***
Past visit	0.56	2.38	**
Crowding concern	-0.29	-2.00	**
Site 3: Jomon-Sugi tramway trail			
Constant	3.34	5.63	***
Number of visitors	-0.87	-18.57	***
Past visit	0.35	0.79	
Crowding concern	-0.45	-3.12	**
Site 4: Jomon-Sugi forest trail			

Constant	2.46	3.98	***
Number of visitors	-1.05	-19.75	***
Past visit	0.37	0.79	
Crowding concern	-0.23	-1.56	

***: $p < 0.001$, **: $p < 0.01$

489



490

491 Fig.3 The acceptability curve for crowding norms with / without past visit at Shiretoko and
 492 crowding concerns of respondents at site 1

493

494 4. Discussion

495 In this study, respondents' acceptance of the level of crowding decreased as the number of
 496 people in the photograph increased. This result confirms previous findings on congestion
 497 norms and supports the robustness of methods based on an acceptability curve (Manning,
 498 2011). When acceptability curves were compared across the various question formats, it was
 499 clear that the short-format curve was steeper than the long-format curve. As past studies have
 500 shown, the short-format norm tends to be slightly less than the long-format norm (Kim

501 &Shelby, 2005; Manning et al., 1999b; Manning et al., 2002a). The curve of the logit model
502 shifted downward, and the slope of the double-bounded curve was steeper than the single-
503 bounded curve. We found a similar tendency in studies based on the contingent valuation
504 method. Estimates of willingness to pay have been shown to be lower in the double-bounded
505 model than in the single-bounded model (Hanemann et al., 1991).

506 The present study confirmed the findings of past studies regarding crowding norm values
507 across different question formats. Single- and double-bounded approaches varied slightly,
508 depending on the study site involved. In the case of the Jomon-Sugi trails (site 3 and 4), the
509 single-bounded approach produced a value between short and long format, as previous studies
510 have shown. On the other hand, in some of the Kamui-Wakka examples (site 1 and 2),
511 double-bounded estimates produced a smaller value than the short-format, and single-
512 bounded estimates produced a value larger than the long-format. However, the confidence
513 interval of the single- and double-bounded approaches are overlapped, and the value of the
514 crowding norm was within one level of PAOT across the question formats. The present study
515 demonstrated the robustness of the visual crowding norm approach, as was the case in
516 previous studies (Manning et al., 1999b; Manning et al., 2002b; Manning, 2011), and showed
517 that the double-bounded approach produced results comparable to conventional methods.

518 In addition to exploring the conventional question formats, the contingent valuation method
519 was used to estimate crowding norms, using the double-bounded dichotomous choice model.
520 The norms were comparatively stable, and the results confirmed existing studies (Hanemann
521 et al., 1991). Further, this study clarified various influences by adding past visiting
522 experiences and the attitudes of respondents to the logit model. In addition, social and
523 managerial attributes may also be affected. The logit model is known to be useful for
524 examining the magnitude of particular influences. The long-format model can obtain the
525 significant amount of information, for example, involving the crystallization of norms, but
526 respondents frequently find the burden of answering long-format questions too heavy. In the
527 short-format model, the respondents' burden is light, and the answers do not seem difficult,
528 but the value of the norm is slightly reduced. In addition, results can be influenced by
529 presentation order and ranges of people in the photographs. The single-bounded and double-

530 bounded methods can mitigate the influence of starting point bias in contingent valuation
531 methods. A single-bounded dichotomous choice requires a certain number of respondents
532 (Mitchell & Carson, 1989), as is the case with the short-format. On the other hand, the
533 double-bounded method is considered effective for a finite sample (Hanemann et al., 1991). It
534 is likely to be useful for studies of crowding norms.

535 Although the differences in question format are slight, the burden on the respondent, the
536 necessary sample size, and the information obtained are different in each format. In this study,
537 we obtained data from a web questionnaire. As a result, there were sufficient responses, and
538 the respondents were given sufficient time to answer. Study sites with few visitors might not
539 get sufficient responses. Further, if the visitor's stay is short, there may not be enough time to
540 answer the questionnaire. All these methods can be used appropriately, depending on the
541 purpose of the survey and the situation of the study site.

542 The order of the crowding norms for the four sites varied from place to place. In the case of
543 the Jomon-Sugi tramway trail (site 3), acceptability declined abruptly as the number of people
544 increased. In Jomon-Sugi (site3 and 4), people are walking in regular rows in the
545 photographs, but in Kamui-Wakka (site 1 and 2), some of the people are standing apart in the
546 river. The background of each picture and the arrangement of people were different. There is
547 also a possibility that the difference in the ranges pointed out by existing research may have
548 been influenced (Gibson et al., 2014). Differences of behavior and placement of people in the
549 photographs of the four sites may have affected the responses (Aikoh et al., 2002; Arnberger
550 & Haider, 2005; Arnberger et al., 2010; Manning and Freimund, 2004).

551 More case studies are needed to compare the validity of the question format, across various
552 activities, settings, and indicators. To date, only a few studies have set out to compare these
553 question formats (Hall et al., 1996; Krymkowski et al., 2009; Manning et al., 1999b; Manning
554 et al., 2002a). Although all four acceptability curves are drawn based on different methods,
555 the comparison method of curves can be a future research topic. In addition, the influence
556 exerted by the range of photographs that are shown to respondents means that any future
557 studies will need to prepare and consider a wider range of photographs, as Gibson et al.,

558 (2014) have done. The results of a web survey should be compared with those of on-site
559 surveys.

560

561 5. Conclusion

562 We compared perceived crowding at four areas in natural heritage sites in Japan, using long-
563 and short-format questions, single-bounded, and double-bounded methods. As in previous
564 studies, acceptability tended to decrease as the number of people in the photographs
565 increased. Although the values of the crowding norms represented by the four methods are
566 different, as previous studies have shown, these differences are not large. It would be possible
567 to develop a significant and stable model using the single-bounded or double-bounded
568 method. The double-bounded model is more efficient than the single-bounded model but
569 tends to produce a small norm. Using the logit model, it is possible to analyze influence, by
570 taking factors such as respondents' attributes and attitudes into account.

571 The contingent valuation method of analysis, both single-bounded and double-bounded, was
572 shown to be useful in analyzing perceived crowding. In addition, each method entails
573 different sample sizes, the burden on respondents, and results; all of them have value.

574 In addition to long-format and short-format questions, the double-bounded method can be
575 applied to determine the crowding norms of natural recreation sites. It is possible to analyze
576 the influence of visitors' characteristics and other factors through this method, using a logit
577 model. In each question format, the number of respondents and the burden on them vary, but
578 they provide different information to managers. If there are few visitors and their stay is short,
579 the double-bounded dichotomous choice model may be more useful. Managers will be able to
580 choose the question format according to the situation at the study site and the purpose of the
581 research, and management's interests.

582

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590

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