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Full Length Research Paper

Assessment of plant diversity, regeneration status, biomass and carbon stock in a Central Himalayan cypress forest

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The present study assessed population structure, biomass, carbon stock, phytosociociological and regeneration status of a Central Himalayan cypress forest of India. A total of 36 plant species (07 trees, 08 shrubs and 21 herbs) were recorded from the study site. Total tree density ranged from 460 to 600 tree ha^{-1} and total basal area ranged from 19.11 to 58.20 m^2 ha^{-1}. The total biomass of trees across all the sites ranged between 178 and 431 t ha^{-1} while carbon stock ranged between 89.07 and 206 t ha^{-1}. *Cupressus torulosa* was the only tree species showing fair regeneration at all the sites while most of the species were represented by seedling and sapling indicating new regeneration.

Key words: Biomass, carbon stock, diversity, regeneration, vegetation structure.

INTRODUCTION

Cupressus torulosa D. Don, commonly known as Himalayan cypress is an evergreen conifer tree species distributed throughout the Himalayan region at elevations of 1800 to 2800 m (Shahni, 1990). It is an important species forming Himalayan moist temperate forest (12/E$_1$) in the western Himalayan region and occurs as open forest of scattered trees on steep rocky ground with xerophytic shrubs and little grass (Champion and Seth, 1968).

Cypress forest most frequently grows on limestone, which provides relatively dry soil conditions on limestone cliffs and shale, and occasionally on other rock types (Troup, 1921). This species generally occur in stands of varying extent, sometimes pure, sometimes associated with deodar (*Cedrus deodara*), spruce (*Picea smithiana*), silver fir (*Abies pindrow*), blue pine (*Pinus wallichiana*) or oaks (*Quercus* spp.). These forests are of immense significance from the environmental conser-vation and sustainable development view point as they provide a diverse range of resources; they store carbon, aid in regulating the planetary climate and purify water (Baduni and Sharma, 1996). Of the different types of forest vegetation, the coniferous forests have played an important role in human culture as they have been the subject of various uses including folklore and mythology.

In last four decades many studies (Singh and Singh, 1987; Rawat and Singh, 1988; Singh et al., 1994; Bargali et al., 2013, 2014, 2015) concentrated on the structure and function of major forests types and adjacent tree plantations of the region.

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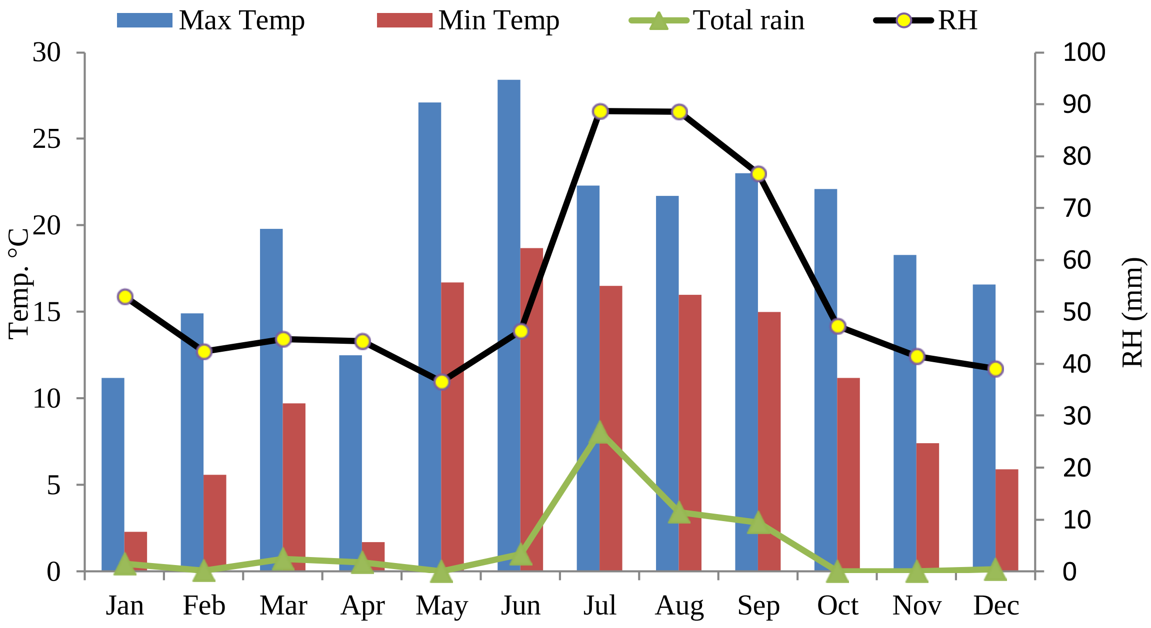

Figure 1. Monthly metrological observations of 2012 (source: GIC Nainital).

The plant diversity and regeneration status of a particular forest provide valuable information for the management and conservation of biodiversity. Therefore, in the present study species diversity, population structure, regeneration status, biomass and carbon stock of tree species in *C. torulosa* forest of Indian Central Himalaya were carried out.

MATERIALS AND METHODS

Study area

The study sites were selected between 2100 to 2400 m above mean sea level (at 29°19' to 29°28' N and 79°22' to 79°38' E) in Nainital, Central Himalaya in an area dominated by *C. torulosa* forest. As altitudinal gradients influence tree species diversity and distribution; the study site was therefore, divided into three sub sites, hill base (low altitude; 2,120 m), hill slope (mid altitude; 2,220 m) and hill top (high altitude 2,325 m).

Climate

Nainital has long cold and often snowy winter and short summer. The climate is determined by the monsoon rhythms and the year can be divided into three main seasons: winter, usually cold and relatively dry (mid-December to mid- February); summer, warm and dry (April to mid-June); and a rainy season, which is warm and wet (mid-June to mid- September). The period of transition occur between summer and winter and between winter and summer are autumn (October to November) and spring (February to March), respectively. The rainy season accounts for about three-fourths of the annual rainfall (Figure 1). Mean minimum monthly temperature ranges from 2.3°C (January) to 18°C (June) and mean maximum monthly temperature varies from 11.2°C (January) to 28.4°C (June). Mean annual rainfall is 2,195 mm. Average humidity fluctuates near the saturation point during the monsoon and is lower during summer, and ranging between 36.5% (May) to 88.7% (July). The study sites are located within the krol formation and Blaini formations (Valdiya, 1980). Soil is thin due to topography (mainly slope) and usually acid in nature. Soil moisture and water retention capacity ranged between 14.1 to 27.4% and 30.9 to 40.7%, respectively.

Vegetation analysis

For the phytosociological study, the quadrat method was used. The number and size of the quadrats were determined by the running mean method (Kershaw, 1973) and species area curve (Misra, 1968). Ten (10) plots of 10 × 10 m at each site were randomly established at hill base, hill slope and hill top for determination of species richness and other vegetation parameters. Trees and saplings were sampled in 10 × 10 m quadrats, shrubs in 5 × 5 m quadrats, and seedlings and herbs in 1 × 1 m quadrats within each plot (Curtis and McIntosh, 1950; Phillips, 1959). Circumference at breast height (CBH at 1.37 m from the ground) of individual tree and sapling was measured in each quadrat. Individual trees having ≥ 30 cm girth were considered as trees, 30 to 10 cm was considered as saplings and ≤10 cm at the base were considered as seedlings.

Density, frequency, abundance, basal area and Importance value index (IVI) were calculated following Cottam and Curtis (1956). Species richness (Margalef, 1958), Shannon - Wiener diversity Index (Shannon and Weaver, 1963), Simpson dominance Index (Simpson, 1949), and evenness (Pielou, 1966) were also computed based on phytosociological data. Dispersion pattern of individual plant species was calculated as an abundance/frequency (A/F) ratio. A/F ratio < 0.025 indicates regular distribution, between 0.025 and 0.05 indicates random distribution and >0.05 indicates contagious distribution (Cottam and Curtis, 1956).

Index of similarity (IS) between forests was calculated following (Muller–Dombois and Ellenberg 1974) using species richness in different forests as:

$$\textbf{Index of similarity (IS)} = \frac{2C}{A+B} \times 100$$

Where C is the number of common species shared between compared sites, and A and B are the number of species in each site.

Population structure and regeneration pattern

To describe population structure and to understand species regeneration, individuals were measured for CBH with a girthing tape at each site for each tree species. In addition to seedling and sapling classes (Good and Good, 1972), six or more classes based on CBH were arbitrarily established. The total number of individuals belonging to these size classes was calculated for each species at each site. Regeneration status of individual tree species was determined on the basis of the population size of seedlings, saplings and trees (Khumbongmayum et al., 2006). If the population size is seedlings > saplings > trees the regeneration status of tree species is “good”. If the population size is of seedlings > or ≤ saplings ≤ trees, seedlings ≤ saplings > trees, seedlings ≤ saplings and the species had no adult trees, the regeneration status of tree species is “fair”. If the species survives only at sapling stage, but not as seedlings (saplings may be <, > or = trees), the regeneration status of tree species is “poor”. If a species is absent both in sapling and seedling stage, but present only as trees it is considered as “not regenerating”. A species is considered as “new” if the species are found only either in seedling or sapling stage without any tree.

Biomass and carbon stock estimation

The biomass for each tree component was estimated using the regression equation of Rawat and Singh (1988) and Adhikari et al. (1998):

$$\ln Y = a + b \ln X$$

Where, ln = natural log, Y= dry weight of component (kg), X= CBH (cm), a = the y intercept and b = slope of regression.

The carbon stock was assumed to be half of the total estimated biomass of each tree species (Brown, 2002; Jhariya et al., 2014).

RESULTS AND DISCUSSION

Species composition and forest structure

A total of 36 plant species were recorded in the study area, of which 7 were trees, 8 were shrubs and 21 were herbs. At hill base, 26 species (5 trees, 6 shrubs and 15 herbs) were recorded; at hill slope 25 species (5 trees, 8 shrubs and 12 herbs) were recorded while at hill top 28 species (4 trees, 6 shrubs and 18 herbs were recorded. Among trees, *C. torulosa* was dominant (IVI 205 to 300) at all three sites (Table 1) whereas, *Cedrus deodara* was co-dominant. Highest tree density (360-600 tree ha^{-1}) was also reported for *C. torulosa* (Table 1). Total density of trees ranged from 460 to 600 trees ha^{-1} and within the range (420 to 1640 trees ha^{-1}) was reported for temperate forest of Kumaun Himalaya by Saxena and Singh (1982). Similar ranges for density were reported (Adhikari et al., 1998, Baduni and Sharma, 1996, Pande et al., 2014) for other cypress and cypress-mixed oak forests in the region. Tree density increased with increasing elevation from hill base to hilltop which could have been due to less anthropogenic disturbances at hill top compared to hill base. Total basal area of trees was higher at hill top (58.20 m^2 ha^{-1}) than at hill base (19.11 m^2 ha^{-1}) of which *C. torulosa* contributed from 70% (at hill base) to 100% (at hill top). Baduni and Sharma (1996) reported 19.83 to 56.46 m^2 ha^{-1} basal area for *C. torulosa* in forest of Garhwal Himalaya and Adhikari et al. (1998) reported 26.5-51.4 $m^2 ha^{-1}$ basal area for *C. torulosa* in forest of Kumaun Himalaya.

Sapling density ranged from 200 to 520 saplings ha^{-1} and it was maximum at hill top (Table 1). Baduni and Sharma (1996) reported maximum density of saplings at hill slope in a *C. torulosa* forest, possibly due to the suitable moisture conditions. Maximum density of saplings (80 to 400 ha^{-1}) was shared by *C. torulosa* at all the three sites. Seedling density ranged from 300 to 400 individuals ha^{-1} and it was greatest at hill base (Table 1). Adhikari et al. (1998) reported density of 90 to 420 seedlings ha^{-1} and 100 to 810 seedlings ha^{-1} for saplings in moist temperate cypress forest.

A total of 8 shrub species were reported from the study area and *Reinwardtia indica* was dominant at hill base and slope while *Colquehonia coccinea* was dominant at hill top. The density values of shrubs ranged from1303 ind ha^{-1} to 5380 ind. ha^{-1} (Table 1). For other cypress forest of the region a lower range of 1280 to 4170 ind ha^{-1} was reported by Adhikari et al. (1998). Numbers of herbs species ranged from 15 at hill base to 18 at hill top (Table 1). A higher number of herbs (22 to 25) were reported by Rawat and Singh (1988) for oak forest and by Pande et al. (2014) for mixed oak forests of the region.

Plant diversity

A higher Shannon diversity index (0.96) for tree species was recorded in hill base (Table 1). At hill top, only one species was present in tree layer so diversity indices were not calculated. In all the three sites, herb diversity was found to be higher than trees and shrubs. Devi and Yaddava (2006) reported that for Indian forests Shannon diversity Index (H’) ranged from 0.83 to 4.1. The value of the Shannon diversity Index in the present study lies within the range reported for temperate forests (Singh et al., 1994, Bargali et al., 2013). The Simpson index (Cd) was 0.67 in hill slope and 0.64 in hill slope for tree species. The evenness index was maximum (1.07) in hill slope and minimum (0.88) in hill base.

For shrub species diversity was maximum (0.75) at hill slope and minimum (0.52) at hill base. The Simpson and evenness index were maximum at hill slope and minimum at hill top. Herb layer also followed the same pattern as recorded for shrub layer (Table 1).

The similarity index value was maximum for herb layer

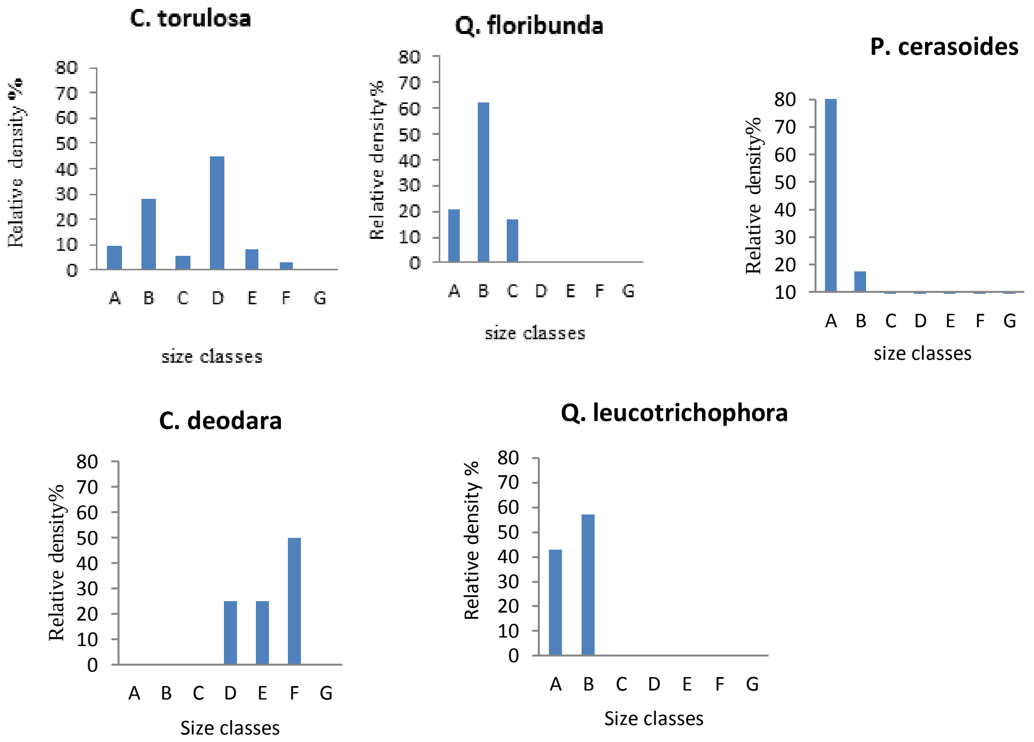

Figure 2A. Population structure of tree species at hill base of Central Himalayan cypress forest. A= seedlings, B= sampling, trees: C= 31-60 cm, D=61-90 cm, E=91-120 cm, F= 121-150 cm and G=>150 cm CBH.

(48.8) and minimum for tree and sapling layer (33.3) indicating that the species were more common in the herb layer as compared to other layers (Table 1). *β*-diversity was maximum (1.91) for seedling layer and minimum (1.20) for shrub layer (Table 1).

Population structure and regeneration pattern

According to the criteria given by Saxena and Singh (1984), four types of population structure were reported at hill base (Figure 2A). The dominant species, *C. torulosa* showed higher number of population in the middle size class than lower and higher size classes. This indicates that seedlings were not sufficient to replace trees. Benton and Werner (1976) suggested that such type of population could become extinct if such tendency continues. In *Q. floribunda* more individuals were recorded in the middle size class (saplings), indicating a poor generation. In *C. deodara* most trees belonged to higher girth classes while populations of lower girth classes including seedlings and saplings were completely absent. This indicates that this species did not reproduce well in the past and seedlings were not establishing. In *P. cerasoides* and *Q. leucotrichophora,* individuals belonged to lower size classes (seedlings and saplings) while higher girth classes were completely absent, indicating that these species were new to the area and on maturity they could reproduce well and expand their populations. At this site the maximum tree species (60%) were included in the category of “Fair” regeneration while 20% were included in “new” and 20% in “not regenerating” category.

At hill slope, *C. torulosa* indicated good regeneration followed by a phase of poor regeneration. Fewer established seedlings compared to saplings indicated poor regeneration. It reproduced well in the immediate past and continued to do so at present but at a lower rate. Occurrence of only seedlings and saplings in *Q. floribunda* and *P. cerasoides* indicated that these species has recently invaded the area and might become canopy (upper most strata in the forest) or sub canopy species later on. Absence of established seedlings of *C. deodara* indicated that this species reproduced well at first but at present its regeneration has been stopped. *Q. leucotrichophora* was represented by saplings only and reflect that this species was new to the area. At this site, 60% species showed “fair” regeneration, 20% showed “poor” regeneration and 20% were included in “new” (Figure 2B)

At hill top, *C. torulosa* had high density in intermediate size classes and decreasing number toward higher and lower size classes. According to Saxena and Singh (1984) and Kittur et al. (2014), the population is on the way to extinction if such a trend continues. Knight (1975) referred to the species showing such population

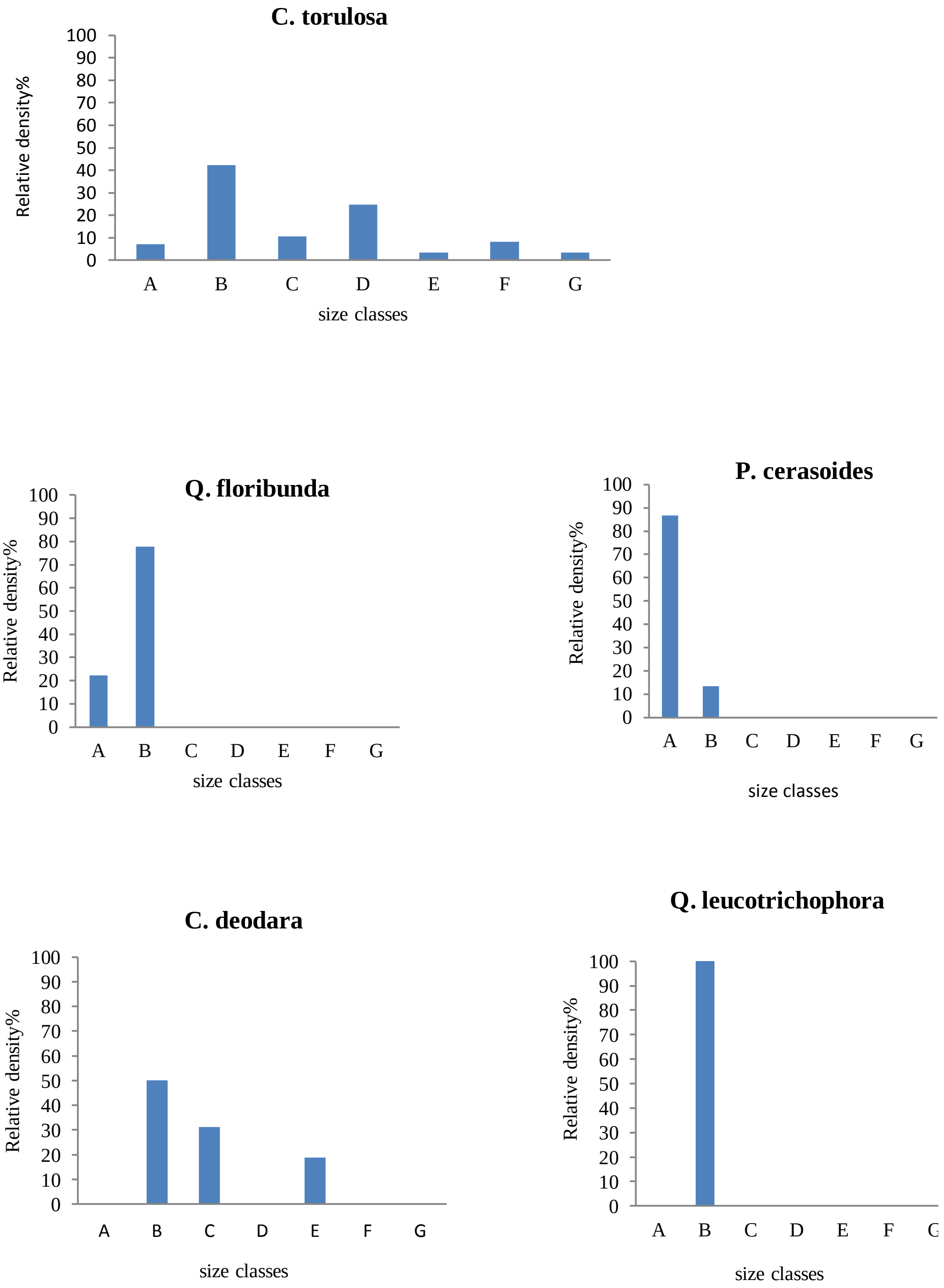

Figure 2B. Population structure of tree species at hill slope of Central Himalayan cypress forest. A= seedlings, B= sampling, trees: C= 31-60 cm, D=61-90 cm, E=91-120 cm, F= 121-150 cm and G=>150 cm CBH.

structure as infrequent reproducer. *P. cerasoides, F. numoralis* and *R. purpurea*, were represented by seedlings and saplings only indicating that these species were new to area and may become established in due course of time to become canopy and sub- canopy species. At this site all the species showed fair regeneration (Figure 2C).

Biomass and carbon stock

The total biomass of trees across all three sites ranged from 178.1 t ha^{-1} at hill base to 431 t ha^{-1} at hill top. Above-ground biomass contributed from 68 to 85%. Among the tree components, bole contributed maximum biomass of 36% at hill base and 54% at hill top. Leaves

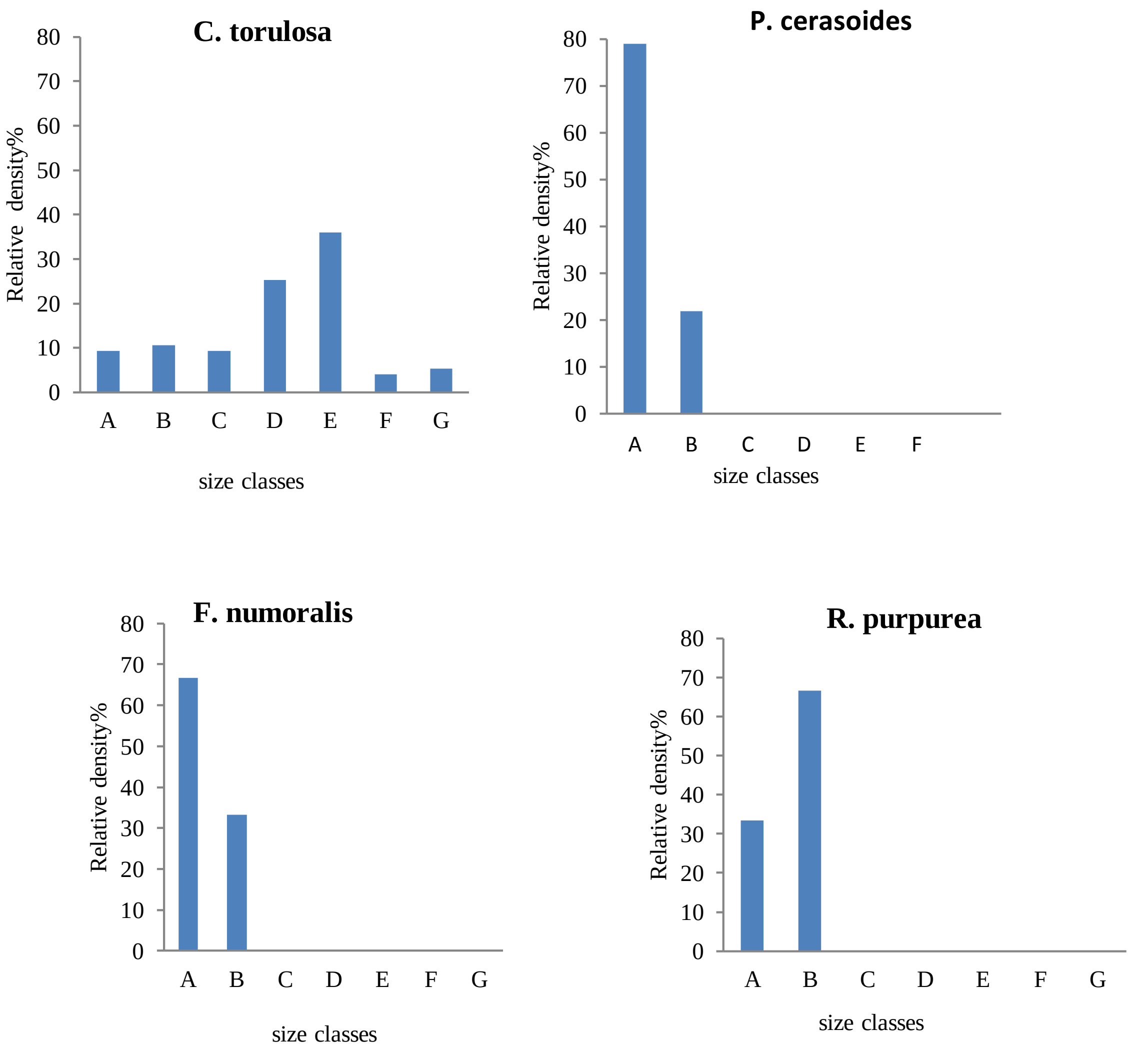

Figure 2C. Population structure of tree species at hill top of Central Himalayan cypress forest. A= seedlings, B= sampling, trees: C= 31-60 cm, D=61-90 cm, E=91-120 cm, F= 121-150 cm and G=>150 cm CBH.

contributed about 4-6%. Fine root contributed the minimum value (1.1 to 1.5%) of biomass (Table 2).

The contribution of the foliage to total above ground biomass was 4.9 to 7.5% and was similar to that reported for *P. roxburghii forest* (Chaturvedi and Singh, 1987), oak forest (Rawat and Singh, 1988) and *P. patula* forest (Bargali and Singh, 1997) of the region. Total root biomass ranged from 34.3 to 65. 6 t ha^{-1}. These value are comparable to the value (47.6 to 95.9 t ha^{-1}) reported for oak forest (Rawat and Singh, 1988). Root biomass contributed 15-32% of total biomass. The carbon stock in *C. torulosa* forest ranged from 89.07 to 206.14 t ha^{-1} (Table 3). Rana et al. (1989) reported a higher range of carbon stock values (166.8 tree ha^{-1} C for *P. roxburghii* mixed broad leaf forest to 440.1 tree ha^{-1} C for *Quercus floribunda* dominated mixed oak forest). The total carbon storage of *C. torulosa* forest was comparable with that of *P. roxburghii* forest.

Conclusions

Phytosociological analysis of the present study indicate the dominance of *C. torulosa* at all three sites. However, co-dominant species and composition varied from the base to the top of the hill. These results probably indicate a wide ecological amplitude and tolerance of *C. torulosa*. Most species showed random or contagious distribution patterns.

The population structure of a tree species reflects its biological and ecological characteristics and it describes the distribution of individuals by size class. In the present study, *C. torulosa* was the only tree species showing fair regeneration at all three sites. The variation among the population size of seedlings, saplings and adults at the three study stands might be due to the variation in climatic as well as edaphic factors required by the species for growth and survival. Seedling and saplings of

Table 1. Ecological indices of tree, shrub and herb in cypress forest of Central Himalaya.

Stage	Site	Species richness	No. of genera	Shannon index (H')	Simpson index (Cd)	Evenness (e)	Density (ind.ha^{-1})	Basal area (m^{2} ha^{-1})	Similarity index	β-diversity
Tree	HB	03	03	0.96	0.64	0.88	460	19.11	33.33	1.50
	HS	02	02	0.74	0.67	1.07	520	24.35		
	HT	01	01	-	-	-	600	58.20		
Sapling	HB	03	03	0.86	0.69	0.98	500	1.65	33.33	1.75
	HS	05	04	1.60	3.31	1.00	520	1.40		
	HT	04	04	1.80	1.31	1.29	200	0.54		
Seedling	HB	04	03	1.62	0.38	1.18	440	-	36.00	1.91
	HS	03	03	1.51	0.36	1.37	300	-		
	HT	04	04	1.88	0.42	1.35	300	-		
Shrub	HB	06	06	0.52	0.42	0.05	5380	-	40.00	1.20
	HS	08	08	0.75	0.99	0.09	3046	-		
	HT	06	06	0.65	0.26	0.09	1303	-		
Herb	HB	15	15	1.24	0.40	0.12	5110	-	48.8	1.40
	HS	12	12	2.17	0.34	0.23	10320	-		
	HT	18	18	1.22	0.44	0.13	15480	-		

Table 2. Component – wise biomass (t ha^{-1}) of tree layer in a Central Himalayan cypress forest

Species	Bole	Bark	Branch	Twig	Foliage	Stump Root	Lateral root	Fine root	Total (t ha^{-1})
Hill base									
C. torulosa	43.51	2.38	26.1	8.53	7.63	12.34	8.84	1.90	111.23
C. deodara	9.16	0.49	2.13	0.79	0.55	1.61	0.67	0.08	15.46
Q. floribunda	16.77	1.47	7.63	1.73	1.65	29.36	4.90	0.83	64.31
Total									**191.00**
Hill slope									
C. torulosa	70.20	3.57	36.44	10.56	9.67	17.55	10.62	2.42	161.03
C. deodara	7.28	0.42	2.96	1.57	1.12	2.28	1.29	0.17	17.09
Hill top									
C. torulosa	233.43	9.08	85.97	18.80	18.23	43.36	17.62	4.59	431.08

C. deodara were absent both at hill base and hill slope, indicating that this species reproduced well in the immediate past but its regeneration hadd stopped. Most of the species, viz. *Q. floribunda*, *Q. leucotrichophora, P. cerasoides, F. numoralis* and *R. purpurea* were represented by only seedlings and/ or saplings. These species could be recent invadders.

Conflict of interest

The authors did not declare any conflict of interest.

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Table 3. Carbon stock (t ha^{-1}) of different component of tree species in *C. torulosa* forest

Species	Bole	Bark	Branch	Twig	Foliage	Stump Root	Lateral root	Fine root	Total (t ha^{-1})
Hill Base									
C. torulosa	21.75	1.19	13.05	4.26	3.81	6.17	4.42	0.95	55.60
C. deodara	4.58	0.24	1.06	0.39	0.27	0.80	0.33	0.04	7.71
Q. floribunda	8.38	0.73	3.81	0.86	0.82	14.68	2.45	0.41	32.14
Total									**95.45**
Hill Slope									
C. torulosa	35.10	1.78	18.22	5.28	4.83	8.77	5.31	1.21	80.05
C. deodara	3.64	0.21	1.48	0.78	0.56	1.14	0.64	0.08	8.53
Total									**88.58**
Hill Top									
C, torulosa	116.71	4.54	42.98	9.40	9.11	21.68	8.81	2.29	**215.52**

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REFERENCES

Adhikari BS, Dhaila S, Rawat YS (1998). Structure of Himalayan moist temperate cypress forest at and around Nainital, Kumaun Himalayas. Oecologia Montana 7:21-31.

Baduni NP, Sharma CM (1996). Effect of aspect on the structure of some natural stands of *Cupressus torulosa* in Himalayan moist temperate forest. Proceedings of Indian National Science Academy, B62 (5):345-352.

Bargali K, Bisht P, Khan A, Rawat YS (2013). Diversity and regeneration status of tree species at Nainital catchment, Uttarakhand, India. International J. Biol. Conserv. 5(5):270-280.

Bargali K, Joshi B, Bargali SS, Singh SP (2014). Diversity within Oaks. International Oaks 25:57-70.

Bargali K, Joshi B, Bargali SS, Singh SP (2015). Oaks and the Biodiversity They Sustain. International Oaks 26:65-76.

Bargali SS, Singh RP (1997). *Pinus patula* plantations in Kumaun Himalaya. I. Dry matter dynamics. J. Trop. For. Sci. 9(4):526-535.

Benton AH, Werner WE (1976). Field Biology and Ecology (New York) McGraw-Hill, Inc. 564pp.

Brown S (2002). Measuring, monitoring and verification of carbon benefits for forest-based projects. Phil. Trans. R. Soc. Lond. A360:1669-1684.

Champion HG, Seth SK (1968). A Revised Survey of the Forest Types of India, Manager of Publications, Government of India, New Delhi. 404 p.

Chaturvedi OP, Singh JS (1987).The structure and function of pine forest in Central Himalaya. I. Dry matter dynamics. Annals of Botany 60:237-252.

Cottam G, Curtis JT (1956). The use of distance measures in phytosociological sampling. Ecol. 35:451-460.

Curtis JT, McIntosh RP (1950). The interrelations of certain analytic and synthetic phytosociological characters. Ecol. 31:434-455.

Devi LS, Yadava PS (2006).Floristic diversity assessment and vegetation analysis of tropical semievergreen forest of Manipur, north east India. Trop. Ecol. 47: 89-98.

Good NF, Good RE (1972). Population Dynamics of Tree Seedlings and Saplings in Mature Eastern hardwood Forest. Bulletin of Torrey Botanical Club 99:23-34.

Jhariya MK, Bargali SS, Swamy SL, Kittur B, Bargali K, Pawar GV (2014). Impact of forest fire on biomass and Carbon storage pattern of Tropical Deciduous Forests in Bhoramdeo Wildlife Sanctuary, Chhattisgarh. Intl. J. Ecol. Enviro. Sci. 40(1):57-74.

Kershaw KA (1973). Quantitative and dynamic plant ecology. Edward Arnold Ltd. London. pp 308.

Kittur B, Swamy SL, Bargali SS, Jhariya MK (2014). Wildland Fires and Moist Deciduous Forests of Chhattisgarh, India: Divergent Component Assessment. J. Forestry Res. 25(4):857-866.

Khumbongmayum ADD, Khan ML, Tripathi RS (2006). Biodiversity conservation in sacred groves of Manipur north east India: population structure and regeneration ststus of woody species. Biodiv. Conserv. 15:2439-2456.

Knight DH (1975). A phytosociological analysis of species-rich tropical forest on Barro Coloraddo Island, Panama. Ecol. Monographs 45:259-284.

Margalef DR (1958). Information theory in ecology. General Systems Yearbook 3:36-71.

Misra R (1968). Ecology Work Book.Oxford Publishing Company, Calcutta.

Mueller-Dombois D, Ellenburg H (1974). Aims and methods of vegetation Ecology. Jhon Wiley and Sons.Inc.

Pande R, Bargali K, Pande N (2014). Impacts of Disturbance on the Population Structure and Regeneration Status of Tree Species in a Central Himalayan Mixed-Oak Forest, India. Taiwan J. Forest Sci. 29(3):179-192.

Phillips EA (1959). Methods of vegetation study. Henry Hill & Co. Inc., U.S.A.

Pielou EC (1966). The measurement of diversity in different types of biological collections. J. Theoret. Biol. 13:131-144.

Rana BS, Singh RP, Singh SP (1989). Carbon and energy dynamics of seven Central Himalayan forests. Trop. Ecol. 30:253-269.

Rawat YS, Singh JS (1988). Structure and function of Oak forest in central Himalaya. I. dry matter Dynamics. Annals of Botany 62:397-341.

Saxena AK, Singh JS (1982). A phytosociological analysis of woody species in forest communities of a part of Kumaoun Himalaya. Vegetatio 50(1):03-22.

Saxena AK, Singh JS (1984). Tree population structure of certain Himalayan forest associations and implications concerning their future composition. Vegetatio 58: 61-69.

Shahni KC (1990). Gymnosperms of India and addjacent countries. Bishan Singh and Mahendra Pal Singh Dehradun, India.

Shannon CE, Weaver W (1963). The Mathematical Theory of Communication. Urbana, USA: University of Illinois Press.

Simpson EH (1949). Measurment of diversity. Nature 163: 688.

Singh JS, Singh SP (1987). Forest Vegetation of the Himalaya. Botanical Rev. 53(1): 80-192.

Singh SP, Adhikari BS, Zobel DB (1994). Biomass, productivity, leaf longevity and forest structure in the central Himalaya. Ecological Monographs, 64(4):401-421.

Troup RS (1921). The Silviculture of Indian trees Vol. 1-111. Clarendon Press, Oxford.1195.

Valdiya KS (1980). Geology of Kumaun Lesser Himalaya. Wadia Institute of Himalayan Geology, Dehradun.

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Valuing the recreational benefits of wetland biodiversity

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Loss in biodiversity of wetlands is a worldwide problem in maintaining the ecosystem of the earth. Thus, environmental valuation studies have performed benefit calculations to show the value of biodiversity. Here, few studies use the revealed preference methods due to the lack of data on wetland biodiversity. To solve this issue, this paper presented an approach to create data using expert judgment. Data on total numbers of representative species (TNRS) which were selected by experts was employed as indicators of the biodiversity of wetlands, and data on wetland area (AREA) were also employed for analysis. Data on travel behaviors to eleven Ramsar wetlands in Hokkaido, Japan were applied in the repeated discrete choice model. The results indicate that the approach of this paper would be applicable for estimating the relationship between individual behaviors and the biodiversity of wetlands. Next, benefit calculations were performed under the hypothesis that the values of AREA and TNRS improves by 10, 50, and 90%. The benefits of increasing wetland areas ranged from JPY 1 (USD 0.01) per year to JPY 14,901 (USD 182.19) per year. Those of improving wetland biodiversity ranged from JPY 44 (USD 0.54) per year to JPY 3,190 (USD 39.00) per year. Two types of wetlands were revealed by calculations. The first type includes wetlands in which the benefits of AREA are larger than those of TNRS. The second type includes wetlands in which the benefits of TNRS are larger than those of AREA, and the feature of the second type is that the wetland area is smaller than the first type. It means that large wetlands should be protected, and the small one with high biodiversity. Consequently, the research on wetlands species is required. The result indicates that benefits are connected to recreational services of wetland ecosystems.

Key words: Benefit analysis, wetlands, biodiversity, travel cost method, JEL: D12, Q26, Q57.

INTRODUCTION

Wetlands are important natural resources for maintaining biodiversity (Uden et al., 2014). All over the world, however, many wetlands are in danger of decrease and/or disappearance due to developments of industries or agriculture (Turner et al., 2000). Thus, an intergovernmental treaty, the Ramsar Convention, has been established in order to provide the framework for national action and international cooperation for the conservation and wise use of wetlands (Maltby and Barker 2009; Matthews, 2013).

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In Japan, the Geospatial Information Authorities of Japan (hereafter GIS; http://www1.gsi.go.jp/geowww/lake/shicchimenseki2.html) researched a total area of wetlands and results indicated the area decreased from 2110.62 km^2 in the Meiji-Taisho era (between 1868-1926 years) to 820.99 km^2 in the Heisei era (between 1996-1999 years); 61.1% of the total area of wetlands in Japan disappeared. The region where there is drastic decrease of wetland area is in Hokkaido (Hokkaido Prefectural Government, 2014). In Hokkaido, 1771.99 km^2 wetland areas in the Meiji-Taisho era decreased to 708.67 km^2 in the Heisei era due to development of industries or agriculture, having caused losses in the biodiversity of wetlands (Kuriyama, 1998; Kamayama et al., 2001; Morino et al., 2005).

A cause of loss in the biodiversity of wetlands is that developers and policy makers have not recognized the values of wetlands and wetland biodiversity. Thus, benefit measurement methods have been developed to explain the values of wetland biodiversity. Here, however, there are two problems in valuing wetland biodiversity. The first problem is that most wetlands have little related to economic markets, leading to difficulty in collecting individual behavior data for measurements (Shrestha et al., 2002). In such instances, the stated preference methods (hereafter, SPM) such as the contingent valuation method (hereafter, CVM) and conjoint analysis (hereafter, CA) have been used. Since surveys on SPMs are implemented by asking respondents their monetary values of the benefits of wetland biodiversity directly in a questionnaire, individual behavior data is then not needed. In particular, the benefits calculated by using data obtained from respondents who have not visited wetlands (non-users) are called the non-use value of wetland biodiversity (Krutilla, 1967).

In previous studies on SPMs, Kosz (1996) estimates the benefits for conserving a wetland area and endangered species, etc. by the CVM with hypothetical development projects scenario, resulting that conserving wetlands in a natural state might be more economically efficient than developing the areas. Loomis et al. (1991) and Pate and Loomis (1997) estimates the benefits of (hypothetical) improvements of a wetland, contamination control techniques, and river/salmon, fining that geographical distance form respondents' homes to the objective area influences their benefit amounts. Hammit et al. (2001) and Amigues et al. (2002) estimate the benefits of improving water quality and habitats of waterfront wild fowls in wetlands.by designing hypothetical scenario of improving wetland qualities (e.g. water quality and number of waterfront wild fowls increase by 10%). Amigues et al. (2002) find that respondents' answers on the benefits differ when using different questionnaire formats in a survey. In the CVM surveys, researchers assess the benefit of a wetland quality, not quality by quality despite of existing several qualities in wetland amenities. The CA enables researchers to assess benefits of improving or preserving each quality at a single survey. A common technique is to design hypothetical (improvement or preservation) scenarios on wetland quality status. Morrison et al. (1999) evaluate the trade-off between the benefits of losing jobs and of preserving wetlands. Carlsson et al. (2003) estimated the benefits of the biodiversity of animals and plants in a wetland. Birol et al. (2006) and Birol and Cox (2007) estimates the benefits by designing alternative management scenarios on biodiversity status, open water surface area status and so on, resulting that wetland qualities have significant effects for human society. Hanley et al. (2006) estimates water quality improvement benefits by comparing the status quo and the hypothetical improvement status of ecology, aesthetics/ appearance, and river banks. Similarly, Carlsson et al. (2003) estimated the benefits of the biodiversity of animals and plants in a wetland, Milon and Scrogin (2006) estimated the benefits of a wetland’ s area and species, and Wang et al. (2007) estimated the benefits of numbers of plant species.

The previous studies indicate that not only wetlands but also its attributes have significant roles in both ecology and human society thought the benefit estimations. However, the validities of estimated values of the benefits rely on 1) the reality of hypothetical scenarios and 2) the respondents' cognitive abilities (Mitchell and Carson, 1989); whether hypothetical improvement levels and/or preservation projects are practicable as actual policies? Whether respondents certainly recognize the levels and/or the contents of hypothetically implemented projects? Thus, the estimated values of benefits would bias when respondents might misunderstand the contents of the CV or the CA questionnaires. Thus, most researchers prefer to use revealed preference methods (hereafter RPM). Data on individual real choices (decisions) is used in the RPMs, leading higher validity on the calculated values of benefits than those by using SPMs. The travel cost method (hereafter TCM) is a method of RPMs. It calculates the benefits of wetland biodiversity by estimating the relation between the number of visits to wetlands, travel costs, and wetland environmental qualities. The benefits calculated by the TCM are called as the use values since data on economic activities are used.

There are two type studies using the TCM for valuing wetlands. The first is the studies which employs no wetland quality data in estimations such as Grossmann (2011), while the second employs. As for the second type, Bockstael et al. (1987), Hanley et al. (2003), Phaneuf and Siderelis (2003), and Vesterinen et al. (2010) includes water quality (the biochemical oxygen demand or the chemical oxygen demand) as data for environmental qualities. Caulkins et al. (1986) includes the length of shoreline and lake depth. Yen et al. (2006) includes slope and width of beaches. As valuation studies on wetlands, Herriges et al. (2004) included the number of pheasants, Whitehead et al. (2009) employs wetland area, Carson et al. (2009) employs numbers of species of fish in fishing activities.

From previous studies on the TCM, data used as environmental quality were water quality indicators or geographic indicators such as area, slopes, and widths. Few studies estimated the relationship between the number of trips and the biodiversity (number of species) of wetlands (This fact is similar to the SPM). It is pointed out that the second problem in valuing wetland biodiversity was the lack of data on wetland biodiversity related to individual behavior. The supposed reason of this is that data on number of species would not be researched in most wetlands due to the huge numbers of species living there.

In valuing wetlands, the TCM would contribute to show 1) the higher valid benefits than those by the SPM due to the usage of individual actual behavior data (the result of individual decision making on comparison of the costs with the benefits in recreating) as discussed above, 2) the rapid assessments needed for decision making to prioritize important wetlands that need rehabilitation and more protection (Phaneuf and Siderelis, 2003; Herriges et al., 2004), and 3) the information on the benefit transfer method for valuing another important wetlands in which researchers could not perform surveys (Camacho-Valdez et al., 2014). Since the lack of data on biodiversity prohibit researchers from applying the TCM, then it is necessary to consider a way to construct data on biodiversity which is simple but broadly applicable for the TCM.

The purposes of this paper are to examine an operationally useful approach to construct data on wetland biodiversity, and to show the significance of valuing wetland biodiversity through benefit calculations. A significant contribution of this paper is to present a simple technique of constructing wetland biodiversity data which may be widely applicable for other case studies.

MATERIALS AND METHODS

A basic assumption of TCM is that the visitor makes a single site trip (that is, an individual visits a site and returns his/ her home). This means individuals see one level of environmental quality, so it is inadequate to estimate the relationship between the individual number of trips and the environmental quality. Thus, the repeated discrete choice (hereafter RDC) model, which is one of the random utility models, was used in this study. Morey et al. (1993), Needelman and Kealy (1995), Shaw and Ozog (1999), and Suwa (2008) are previous studies of the RDC. An advantage is flexibility on benefit calculations. The regression models were suitable for calculating benefits of environmental quality changes for a single site, but such models are not suitable for calculating benefits of quality changes for multi sites, for example, when an environmental quality in site A and site B simultaneously changes. Otherwise, the model structure of RDC allows us to calculate benefits even in the case of multi sites environmental quality changes.

The structure of RDC is as follows. Let *i* (i = 1,2,…,N) be an index for individuals, *j* (j = 0,1,2,…, M) and *k* (k = 1,2,…, M) be an index for sites. Here, j=0 means an individual *i* does not choose to travel to sites. Assume that an individual *i* has a fixed-choice occasion for a trip (T). In this study, T is designated as a maximum value of the respondents' total numbers of visits which is calculated from the observed data, T = 94. On each occasion, the individual is supposed to decide whether to visit a site and, if so, which one. Let v_i be individual *i*'s indirect utility, then the indirect utility function is given by Equation (1) if the individual *i* decides to visit site *j* and by Equation (2) if the individual *i* does not make the trip. Here, $m_i = Y_i / T$ where Y_i is the individual *i*'s household income per year. p_{ij} is the individual *i*'s travel cost per site *j*, z is a vector of the individual *i*'s socio-economic characteristics, q is a vector of site *j*'s environmental qualities. β_0 is a constant parameter, β_m is a parameter of *m*, $\boldsymbol{\beta}'_{\mathbf{z}}$ is a transposed vector of parameters of z, and $\boldsymbol{\beta}'_{\mathbf{q}}$ is a transposed vector of parameters of q. The disturbance term, ε_{ij}, from individual *i*'s visit to site *j*, is assumed to have an independent Gumbel distribution. Let Pr_{ij} be the probability that individual *i* will choose to visit site *j* on one occasion, and x_{ik} be individual *i*'s number of visits to site *k* on another occasion. Then, Pr_{ij} is defined as Equation (3), and individual *i*'s log likelihood, ll_i, is given by Equations (3) and (4).

$$v_{ij} = \beta_m (m_i - p_{ij}) + \mathbf{z_i}\boldsymbol{\beta}'_{\mathbf{z}} + \mathbf{q_j}\boldsymbol{\beta}'_{\mathbf{q}} + \varepsilon_{ij} \tag{1}$$

$$v_{i0} = \beta_0 + \beta_m m_i + \varepsilon_{i0} \tag{2}$$

$$\mathrm{Pr}_{ij} = \exp(v_{ij}) \Big/ \sum\nolimits_{j=0}^{M} \exp(v_{ij}) \tag{3}$$

$$ll_i = \left(T - \sum\nolimits_{k=1}^{M} x_{ik}\right) \ln\left(\mathrm{Pr}_{i0}\right) + \sum\nolimits_{k=1}^{M} x_{ik} \ln\left(\mathrm{Pr}_{ik}\right) \tag{4}$$

The procedure for benefit calculations using RDC is as follows. Let the indirect utility function be rewritten as $v_{ij}^{s} = \beta_m (m_i - p_{ij}) + \mathbf{z_i}\boldsymbol{\beta}'_{\mathbf{z}} + \mathbf{q}_{\mathbf{j}}^{s}\boldsymbol{\beta}'_{\mathbf{q}} + \varepsilon_{ij}$. Here, *s* is a superscript which indicates environmental qualities are changed by a project if *s* = *w*, and it is not if *s* = *wo*; A benefit generated from the change of site *j*'s environmental quality (hereafter *BQC*) is defined as Equation (5). Here, authors set $\beta_m = \beta'_m / 10{,}000$ for adjusting values of parameters. Thus, unit values of m_i and p_{ij} were set as ten thousand yen.

$$BQC_j = (T/\beta_m)\left(\ln\left(\sum\nolimits_{j=0}^{J} \exp(v_{ij}^{w})\right) - \ln\left(\sum\nolimits_{j=0}^{J} \exp(v_{ij}^{wo})\right)\right) \tag{5}$$

For comparisons on parameters, the ordinary least square regression (hereafter, OLS), the poisson regression (hereafter, PS) and the negative binomial regression (hereafter, NB) were employed followed by Cameron and Trivedi (2013). Most studies employ PS and/or NB for estimating travel demand functions, benefit calculations, or comparisons of signs of parameters such as in Shrestha et al. (2002), Heberling and Templeton (2009). Here, pooled data constructed from individual travel behaviors for wetlands and wetland environmental qualities were employed in estimations on OLS, PS and NB.

Research area

The decrease in wetland areas is an environmental problem in

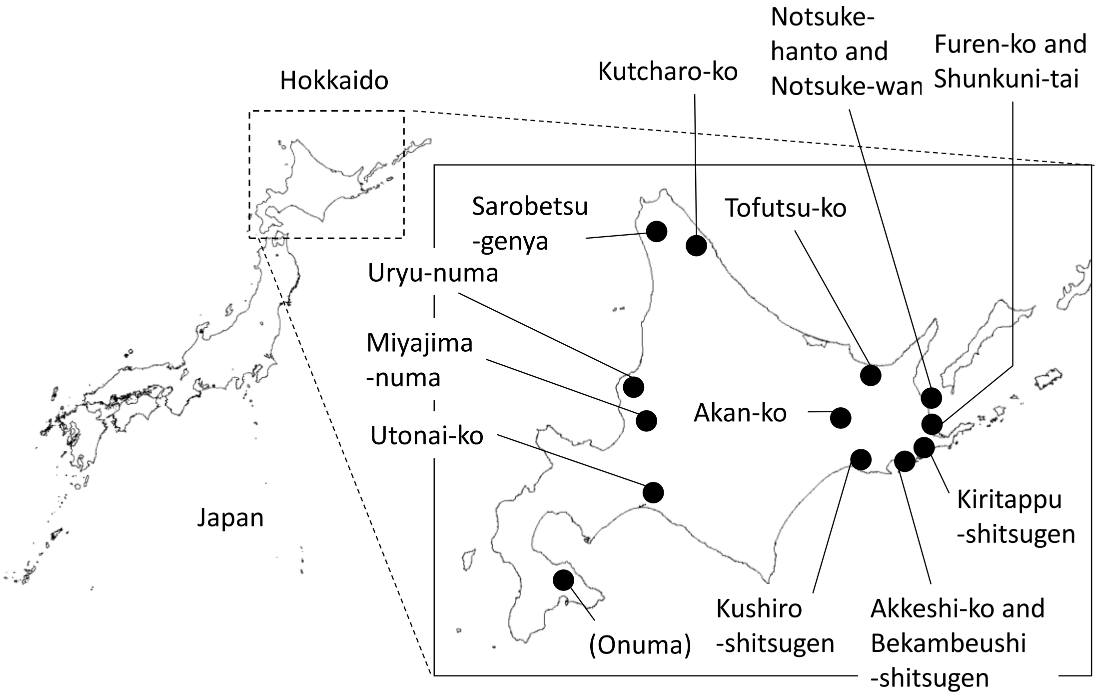

Figure 1. Locations of Hokkaido and Wetlands.

Figure 2. Recreation activities in Ramsar wetlands: The cases of Miyajima-numa and Sarobetsu-genya, Ministry of the Environment, Japan.

Japan. The Japanese government designed the National Biodiversity Strategy based on the Convention on Biological Diversity. The strategy requires to value the benefits of wetland biodiversity. Hokkaido is a main target area for the strategy due to the existence of numerous wetlands. Thus, the Hokkaido prefectural government has been proceeding with the registration of wetlands with national or international conservation programs. In particular, registrations with the Ramsar Convention have proceeded. In 2013, 13 wetlands have been registered in Hokkaido with the Convention (Hokkaido Prefectural Government, 2014). Their location is presented on the Figure 1 and the characteristics of the wetlands referred from Ministry of the Environment, Japan (2014) are described in Appendix 1: The zone of vegetation for Hokkaido is categorized from the cool-temperate zone to the subarctic zone. Various endangered birds, such as the red-crowned crane (add the scientific name), Blakiston's fish owl (add the scientific name), and white-tailed eagle (add the scientific name) use wetlands or adjacent areas as foraging habitats. Many people have visited there in order to enjoy tracking/walking, camping, observing, canoeing, or fishing each season (Figure 2).

The objective areas are the following eleven sites; Miyajima-numa, Uryunuma-shitsugen, Sarobetsu-genya, Kutcharo-ko,

Table 1. Wetland areas and reduction rates

Site names	Base (km^2)[a]	Period A (km^2)[b]	Period B (km^2)[c]	Reduction rates (%)
Miyajima-numa area	0.41	3536.05	37.66	98.93
Uryunuma-shitsugen area	6.24	N.D.	195.13	N.D.
Sarobetsu-genya area	25.6	12250.36	6042.78	50.67
Kutcharo-koarea	16.07	4534.52	459.41	89.87
Utonai-koarea	5.1	8178.13	1350.42	83.49
Kushiro-shitsugen area	78.63	33738.97	22656.13	32.85
Tofutsu-ko area	9	1534.77	155.96	89.84
Akkeshi-ko and Bekambeushi-shitsugen area	52.77	10743.61	12192.68	-13.49
Kiritappu-shitsugen area	25.04	2558.19	2977.04	-16.37
Furen-ko andShunkuni-tai area	61.39	409.56	373.19	8.88
Notsuke-hanto and Notsuke-wan area	60.53	N.D.	N.D.	N.D.
All Japan	-	2110.62	820.99	61.1

[a] Values (km^2) of the part of wetland area protected with the Ramsar Convention, [b] the values during the Meiji-Taisho era (1868-1926), [c] the values during the Showa-Heisei era (1996-1999); N.D. means no data.

Utonai-ko, Kushiro-shitsugen, Tofutsu-ko, Akkeshi-ko and Bekambeushi-shitsugen, Kiritappu-shitsugen, Furen-ko and Shunkuni-tai, Notsuke-hanto and Notsuke-wan. The Akan-ko wetlands were excluded from our research and estimations due to the lack of data on an environmental quality. The Onuma wetlands were also excluded because it was not registered with the Ramsar Convention during the research period.

Data on environmental qualities

Previous studies have made use of various indicators of environmental quality in monitoring wetlands (Caulkins et al., 1986; Hanley et al., 2003; Carson et al., 2009; Vesterinen et al., 2010). In this study, both wetland area (Table 1) and biodiversity were employed because the former is the only data published as standard geographic information and the latter is a target in this study. Firstly, the data on wetland areas is described. Table 1 shows the data. The row for "Base" shows values (km^2) of the part of wetland area protected with the Ramsar Convention. The row for "Period A" shows the values during the Meiji-Taisho era (1868-1926), and "Period B" shows the values during the Showa-Heisei era (1996-1999) that were researched by the GIS. "N.D." means there were no data because the areas were not included in the GIS research.

In this paper, the values of Base were used for estimations, and the data set in Base is denoted as AREA. The values of Period A and B were used for setting hypothetical scenarios described in benefit calculations. "Reduction rates" shows percentages of reduction rates of wetland areas calculated from the values of Periods A and B. One reason for negative values in reduction rates (increment rates) of the Akkeshi-ko area, the Bekambeushi-shitsugen area and the Kiritappu-shitsugen area is that new areas were added due to a change in map-making process when research on Period B was performed.

Secondly, the data on wetland biodiversity was described. First of all, let biodiversity in a wetland be defined as the total number of species in the wetland. Because of the difficulty of counting huge number of species, previous studies rarely employ the one in valuations by RPMs. A solution for this issue is simply to limit the number of species in counting. Actually, the purpose of visitors in a wetland would be to enjoy observing not all species in the wetland but *representative* species in which visitors are interested.

Two selection methods were considered; the one is research for visitors and the other is expert judgment. The expert judgment was employed in this study. The experts were officers of the Hokkaido Institute of Environmental Sciences, and the Japan Science and Technology Agency (hereafter, HIESJSTA). HIESJSTA (2004) presents a "BirdBase (http://birdbase.hokkaido-ies.go.jp/rdb.html)" and provides names of representative species (plants, wild birds, insects, mammals, fishes and shellfishes, amphibians and reptiles) living in objective wetlands. By counting the names, Table 2 shows the numbers in each category and the total number of representative species (hereafter TNRS).

Survey and individual behaviors

Data on travel behaviors was obtained through an internet survey from Hokkaido residents in March of 2011. E-mails sent to 2,754 respondents registered by the internet research company, and 2,300 respondents answered questionnaires about their travel behaviors for eleven wetlands during the past year. On the web site of the internet research company, respondents were questioned regarding the number of visits to Ramsar wetlands, their postal codes, their interests in species, and their socio-econometric information. Here, data for 44 respondents out of 2300 were excluded due to their incorrect postal code numbers. Table 3 shows definitions of variables.

In the question on the number of visits, a matrix type of answer format was used. Wetland names were displayed in the first row, and alternatives of number of visits were displayed in the first column. The alternatives were A: one time (1), B: two times (2), C: three to five times (4), D: six to ten times (8), E: eleven to fifteen times (13), F: sixteen to twenty times (18), G: over twenty one times (21), H: did not go (0). Numbers in the parentheses were used for estimations. In the results of all answers (11 x 2,256), there were fourteen answers selected for alternative G. Although true values for the fourteen answers would be over 21 times, it is thought that this has little influence on estimation results due to the small response rates. The number of visits, represented by the variable VISIT, is modeled as a dependent variable in the OLS, PS, and NB regressions, and modeled as x_{ij} in the RDC model.

The research type of this paper is off-site sampling survey,

Table 2. Numbers of representative species in wetlands

Site names	Plants	Wild birds	Insects	Mammals	Fish and shellfish	Amphibian and reptiles	Total number of species
Miyajima-numa	8	18	0	0	7	0	33
Uryunuma-shitsugen	17	6	14	0	0	0	37
Sarobetsu-genya	18	8	0	5	0	6	37
Kutcharo-ko	18	17	9	5	10	0	59
Utonai-ko	18	18	12	3	10	1	62
Kushiro-shitsugen	16	18	8	6	9	6	63
Tofutsu-ko	18	17	0	0	7	0	42
Akkeshi-ko and Bekambeushi-shitsugen	23	26	0	7	2	0	58
Kiritappu-shitsugen	17	19	12	2	5	0	55
Furen-ko and Shunkuni-tai	30	25	5	7	9	2	78
Notsuke-hanto and Notsuke-wan	31	22	9	7	0	0	69

Table 3. Definitions of variables used in models.

Variable	Explanations
VISIT	Number of visit to Ramsar wetlands in past a year
PRICE	Round trip travel cost from the individual *i*'s home to wetlands (ten thousand yen)
GND	1, if the individual *i* is male, 0 otherwise
AGE	The individual *i* 's actual age (years)
MAR	1, if individual *i* was married, 0 otherwise
ICM	The individual *i* 's household income (tax included) per past a year (ten thousand yen)
SCAPE	1, if the individual *i* is interested in wetlands' landscapes, 0 otherwise
WILD	1, if the individual *i* is interested in the wetlands' wild birds and/or animals, 0 otherwise
PLANT	1, if the individual *i* is interested in the wetlands' plants, 0 otherwise
AMPH	1, if the individual *i* is interested in the wetlands' amphibians and/or reptiles, 0 otherwise

resulting to collect 613 visitors and 1,643 non-visitors data sets. Thus, both data sets from 2,256 and from 613 respondents were employed for estimations by the RDC model.

Respondents' travel costs to wetlands were calculated as follows. A respondent *i*'s distances (d_{ij}) and travel times (t_{ij}) from the respondent's home to j^{th} wetlands were calculated by using the respondent *i*'s postal code and PC software, Zenrin Professional 7. Respondents' average gas bill during 2011 was set at 138 yen per liter from data of Oil Information Center, Japan. Respondents' average gasoline mileage was set at 17.8ℓ／km from data of the Ministry of Land, Infrastructure, Transport and Tourism. The opportunity cost was set at 24.98 yen per minute per person. The respondent *i*'s travel cost to j^{th} sites was calculated as $p_{ij} = 2 \times \{138 \times (d_{ij}/17.8) + 24.98 \times t_{ij}\}$. The travel costs, represented by variable PRICE, are modeled as an independent variable of the OLS, PS, and NB regressions, and the p_{ij} of the RDC model.

Other independent variables in the model include individual interests in biodiversity and socioeconomic characteristics. Independent variables concerning the individual interests include the following variable; SCAPE if an individual *i* was interested in wetland landscapes, WILD if the individual *i* was interested in wild birds and/or animals living in wetlands, PLANT if the individual *i* was interested in plants growing in wetlands, AMPH if the individual *i* was interested in amphibians and/or reptiles living in wetlands.

The socioeconomic characteristics include the individual *i*'s gender (GND), age (AGE), income (ICM), and MAR if the individual *i* was married. Here, ICM equals to Y_i in the RDC model; the variable of m_i was denoted as TICM. The positive sign of the parameter of income allows us to calculate benefits from quality changes under the concept of compensating variation (Morey et al., 1993). The signs of AREA and TNRS are supposed to be positive following Whitehead et al. (2009) and Carson et al. (2009). Signs of other parameters were confirmed by estimations.

RESULTS

Socioeconomic characteristics

The descriptive statistics of individual travel behaviors and socioeconomic characteristics are presented from

Table 4. Descriptive statistics of numbers of visits of sites

Site name	Mean	Std. Dev.	Minimum	Maximum
Miyajima-numa	0.06383	0.51445	0	13
Uryunuma-shitsugen	0.06294	0.51197	0	13
Sarobetsu-genya	0.07402	0.46645	0	8
Kutcharo-ko	0.07314	0.59597	0	21
Utonai-ko	0.25532	1.26156	0	21
Kushiro-shitsugen	0.21720	1.29258	0	21
Tofutsu-ko	0.05541	0.58589	0	21
Akkeshi-ko and Bekambeushi	0.07181	0.67003	0	21
Kiritappu-shitsugen	0.06959	0.57827	0	13
Furen-ko and Shunkuni-tai	0.07004	0.65888	0	18
Notsuke-hanto and Notsuke-wan	0.10461	0.76836	0	21
ALL	0.10163	0.77206	0	21

Std.Dev., standard deviation; Number of observation is 2,256 from Miyajima-numa to Notsuke-hanto and Notsuke-wan; Number of observation is 2,256 x 11 in ALL.

Table 5. Descriptive statistics on travel costs

Site name	Mean	Std. Dev.	Minimum	Maximum
Miyajima-numa	0.93933	0.78323	0.0536	3.9937
Uryunuma-shitsugen	1.28042	0.70268	0.3267	4.0069
Sarobetsu-genya	2.84760	0.68934	0.5228	5.1291
Kutcharo-ko	2.53952	0.65003	0.4496	4.8786
Utonai-ko	0.83261	0.80624	0.0409	4.2404
Kushiro-shitsugen	3.25923	0.94093	0.2076	5.5402
Tofutsu-ko	2.74752	0.81657	0.0744	5.3671
Akkeshi-ko and Bekambeushi	3.53618	0.95323	0.5262	5.8503
Kiritappu-shitsugen	3.66914	0.96266	0.4176	6.003
Furen-ko and Shunkuni-tai	3.83959	0.96683	0.1081	6.3673
Notsuke-hanto and Notsuke-wan	3.58522	0.93958	0.2942	6.2805
ALL	2.64330	1.36540	0.0409	6.3673

Std.Dev., Standard deviation; Number of observation is 2256 from Miyajima-numa to Notsuke-hanto and Notsuke-wan; Number of observation is 24,816 in ALL

Tables 4 to 6. ALL in the column of Site names in Tables 4 and 5 means descriptive statistics calculated from pooled data. Table 4 shows values of VISIT by wetland. The mean value of ALL is about 0.10163 times per person. The maximum value in the mean values of VISIT is the value of Utonai-ko; the minimum value is the value of Tofutsu-ko. Table 5 shows the values of PRICE. The mean value of ALL is about 2.64330 ten thousands yen. The maximum value in the means of PRICE is the value of Furen-ko and Shunkuni-tai, the minimum value is the value of Utonai-ko. From Table 4 and Table 5, it is supposed that there are some elements, other than the prices, that influence the number of visits for wetlands. The mean value of PRICE for Kushiro-shitsugen (or Notsuke-hanto and Notsuke-wan) is over the mean of PRICE of ALL, otherwise, the mean value of VISIT of Kushiro-shitsugen is over the mean value of VISIT of ALL. In short, the demand level for Kushiro-shitsugen is high despite the high level of the price. Finally, Table 6 shows socioeconomic characteristics. The result shows that respondents are interested in SCAPE the most. The order of degree of influences of the variables for demands was confirmed by estimations.

Assumptions of signs of estimated parameters are as follows; the sign of PRICE is supposed to be negative because natural environments are considered to be normal goods in general economic theory. The sign of TICM is supposed to be positive because an increment of an individual income leads to an increase of the individual demand.

Estimation results

Table 7 shows the estimation results using OLS, PS, NB,

Table 6. Descriptive statistics of individual characteristics and interests

Variable	Mean	Std. Dev.	Minimum	Maximum
GND	0.55408	0.49718	-	-
AGE	43.40736	10.17062	16	81
MAR	0.37101	0.48318	-	-
ICM	528.72340	327.52091	150	1600
SCAPE	0.36436	0.48136	-	-
WILD	0.16312	0.36956	-	-
PLANT	0.04610	0.20975	-	-
AMPH	0.01950	0.13832	-	-

Std.Dev., Standard deviation; Number of observation is 2,256.

Table 7. Estimation results.

Parameter	OLS	VIF	PS	NB	RDC_ALL	RDC_VIS
CONT	-0.12383^a (0.03388)		-5.55293^a (0.15479)	-5.99600^a (0.27395)	9.99138^a (0.15103)	8.34951^a (0.15550)
PRICE	-0.03812^a (0.00443)	1.58	-0.36402^a (0.01785)	-0.25345^a (0.03408)	-	-
ICM/TICM	0.00001^d (0.00001)	1.13	0.00018^a (0.00005)	0.00042^a (0.00011)	0.36710^a (0.01796)	0.33065^a (0.01784)
GND	0.04005^a (0.00986)	1.04	0.48730^a (0.04640)	0.49288^a (0.07881)	0.51427^a (0.04690)	0.44754^a (0.04715)
AGE	0.00079^d (0.00052)	1.21	0.01066^a (0.00214)	0.00456^d (0.00393)	0.01037^a (0.00216)	0.01633^a (0.00215)
MAR	0.03225^a (0.01121)	1.27	0.36843^a (0.04745)	0.41611^a (0.08702)	0.33547^a (0.04623)	0.43267^a (0.04711)
SCAPE	0.18274^a (0.01035)	1.07	2.12488^a (0.05928)	2.38988^a (0.08292)	2.16525^a (0.05937)	1.02768^a (0.06006)
WILD	0.12196^a (0.01391)	1.14	0.82348^a (0.04558)	1.36777^a (0.08679)	0.86002^a (0.04626)	0.45771^a (0.04696)
PLANT	0.21184^a (0.02446)	1.13	0.56278^a (0.05799)	0.69423^a (0.13865)	0.62047^a (0.05952)	0.50725^a (0.06083)
AMPH	0.29556^a (0.03532)	1.03	0.78145^a (0.07168)	0.51813^b (0.20600)	0.87545^a (0.07534)	0.75176^a (0.07647)
AREA	0.00090^a (0.00029)	2.50	0.00893^a (0.00107)	0.00401^c (0.00216)	0.00914^a (0.00107)	0.00735^a (0.00107)
TNRS	0.00219^a (0.00048)	1.96	0.02052^a (0.00191)	0.02281^a (0.00364)	0.02029^a (0.00190)	0.02040^a (0.00192)
Max. LL	-28326.55766		-8070.01463	-5549.34759	-17505.08355	-15681.99182
AIC	56679.11532		16164.02926	13102.09590	35032.16711	31385.98366
MR^2	0.01617		0.21343	0.12192	0.11283	0.04403
N	24,816		24,816	24,816	2,256	613

Numbers of parentheses are standard errors of the coefficients; the super scripts of coefficients "a" means the coefficient significant at $p < 0.1$, "b" means $p < 0.5$, "c" means $p < 0.1$, "d" means $p > 0.1$, respectively.

and RDC. The RDC model was used for estimating two set of data. The column of RDC_ALL shows estimated parameters from the data of 2,256 respondents and RDC_VIS shows estimated parameters from 631 respondents who went to at least one wetland one time during the past year. VIF shows values of the Variance Inflation Factor were small, confirming the less influences of multicollinearity in parameters. Here, Appendix 2 shows the results of estimating different models with the ones in Table 7

Signs of all parameters of variables (without constants) are the same in OLS, PS, NB, and RDCs. The signs of PRICE are negative and the significant levels are $p < 0.01$ across models. These results are consistent with previous studies. The signs of ICM are positive across models and the significant levels are $p < 0.01$ in PS, NB, RDCs. As a reference, the value of the residual deviance/ the degree of freedom is 0.53823 in PS.

The results of GND and MAR are positive and the significant levels are $p < 0.01$ across models. The results suggest that males and persons who were married are likely to visit wetlands. The results of AGE are positive across models. The significant levels are $p < 0.01$ in PS and RDCs, but $p > 0.1$ in OLS and NB. The results of AGE suggest that older persons are more likely to visit wetlands. The results of SCAPE, WILD, PLANT and AMPH are positive and the significant levels are $p < 0.01$ across all models. Finally, the results of AREA are positive across models, and are consistent with Whitehead et al. (2009). The significant levels are $p < 0.01$ in OLS, PS, RDC_ALL, and RDC_VIS, but $p < 0.1$ in NB. Although the significant level in NB was not

Table 8. Benefits of increasing of wetland areas

Increment rates	10%		50%		90%	
	ALL	VIS	ALL	VIS	ALL	VIS
Miyajima-numa	1 (0.01)	5 (0.06)	6 (0.07)	26 (0.32)	12 (0.15)	47 (0.57)
Uryunuma-shitsugen	21 (0.26)	83 (1.01)	111 (1.36)	428 (5.23)	206 (2.52)	791 (9.67)
Sarobetsu-genya	76 (0.93)	310 (3.79)	422 (5.16)	1,726 (21.10)	849 (10.38)	3,470 (42.43)
Kutcharo-ko	53 (0.65)	206 (2.52)	283 (3.46)	1,104 (13.50)	546 (6.68)	2,127 (26.01)
Utonai-ko	26 (0.32)	93 (1.14)	133 (1.63)	474 (5.80)	244 (2.98)	872 (10.66)
Kushiro-shitsugen	814 (9.95)	3,338 (40.81)	5,720 (69.94)	23,459 (286.82)	14,901 (182.19)	61,043 (746.34)
Tofutsu-ko	20 (0.24)	85 (1.04)	107 (1.31)	443 (5.42)	201 (2.46)	828 (10.12)
Akkeshi-ko and Bekambeushi-shitsugen	272 (3.33)	1,134 (13.86)	1,702 (20.81)	7,102 (86.83)	3,890 (47.56)	16,243 (198.59)
Kiritappu-shitsugen	66 (0.81)	278 (3.40)	368 (4.50)	1,547 (18.91)	737 (9.01)	3,101 (37.91)
Furen-ko and Shunkuni-tai	409 (5.00)	1,664 (20.34)	2,659 (32.51)	10,832 (132.44)	6,346 (77.59)	25,854 (316.10)
Notsuke-hanto and Notsuke-wan	398 (4.87)	1,627 (19.89)	2,579 (31.53)	10,550 (128.99)	6,127 (74.91)	25,073 (306.55)

Table 9. Benefits of improving wetland biodiversity

Improvement rates	10%		50%		90%	
	ALL	VIS	ALL	VIS	ALL	VIS
Miyajima-numa	51 (0.62)	154 (1.88)	272 (3.33)	813 (9.94)	522 (6.38)	1,539 (18.82)
Uryunuma-shitsugen	58 (0.71)	179 (2.19)	315 (3.85)	949 (11.60)	608 (7.43)	1,808 (22.11)
Sarobetsu-genya	49 (0.60)	159 (1.94)	262 (3.20)	843 (10.31)	507 (6.20)	1,604 (19.61)
Kutcharo-ko	88 (1.08)	274 (3.35)	495 (6.05)	1,501 (18.35)	1,000 (12.23)	2,959 (36.18)
Utonai-ko	146 (1.79)	414 (5.06)	820 (10.03)	2,274 (27.80)	1,666 (20.37)	4,504 (55.07)
Kushiro-shitsugen	279 (3.41)	910 (11.13)	1,569 (19.18)	4,996 (61.08)	3,190 (39.00)	9,900 (121.04)
Tofutsu-ko	44 (0.54)	144 (1.76)	238 (2.91)	769 (9.40)	464 (5.67)	1,476 (18.05)
Akkeshi-ko and Bekambeushi-shitsugen	131 (1.60)	434 (5.31)	730 (8.93)	2,370 (28.98)	1,470 (17.97)	4,662 (57.00)
Kiritappu-shitsugen	65 (0.79)	219 (2.68)	363 (4.44)	1,191 (14.56)	728 (8.90)	2,332 (28.51)
Furen-ko and Shunkuni-tai	227 (2.78)	736 (9.00)	1,319 (16.13)	4,139 (50.61)	2,769 (33.85)	8,409 (102.81)
Notsuke-hanto and Notsuke-wan	198 (2.42)	644 (7.87)	1,129 (13.80)	3,572 (43.67)	2,324 (28.41)	7,152 (87.44)

enough to prove the relationship between individual behaviors and wetland areas, AREA was used in benefit calculations for comparisons.

Benefit calculations

Benefits calculations by Equation 5 were performed. Let BQC^{h}_{area} be benefits for increasing wetland areas, and BQC^{h}_{bio} be benefits for improving wetland biodiversity. The super script *h* means that benefits calculated by using parameters of RDC_ALL when *h* = *ALL*, RDC_VIS when *h* = *VIS*, respectively. Values in parentheses were USD values calculated by using the average exchange rate of USD1 = JPY81.79 in March, 2011 from the Bank of Japan. Hypothetical improvements of environmental qualities for benefit calculations were designed from reduction rates in Table 1. Reduction rates in Table 1 ranged from 8.88 to 98.93%, designing the hypothetical improvement rates as 10%, 50%, and 90% for wetland areas (AREA) in Table 1 and biodiversity (TNRS) in Table 2.

Table 8 shows the benefits for increasing in wetland areas (BQC^{h}_{area}). BQC^{ALL}_{area} ranges from JPY 1 (USD 0.01) per year to JPY 14,901 (USD 182.19) per year; BQC^{VIS}_{area} ranges from JPY 5 (USD 0.06) per year to JPY 61,043 (USD 746.34) per year. Results show that the values of BQC^{VIS}_{area} are larger than those of BQC^{ALL}_{area}. The minimum value is the values in Miyajima-numa and the maximum value is the ones in Kushiro-shitsugen.

Table 9 shows benefits for improving in wetland biodiversity (BQC^{h}_{bio}). BQC^{ALL}_{bio} ranges from JPY 44 (USD 0.54) per year to JPY 3,190 (USD 39.00) per year; ranges from JPY 144 (USD 1.76) per year to JPY 9,900 (USD 121.04) per year in VIS, respectively. Results also show that BQC_{BIO} calculated from RDC_VIS are larger than those from RDC_ALL. The minimum values of benefits are those for the Tofutsu-ko and maximum values are the ones of Kushiro-shitsugen.

DISCUSSION

A problem in valuations on wetland biodiversity by the revealed preference methods is the lack of data on it. This paper examined a simple approach on works for constructing data on wetland biodiversity, and to confirm the availability though estimations and benefit calculations. The discussion and conclusion are as follows.

The validity of approach

The approach of this paper was to select representative species in wetlands by expert judgment, using the total number of them for estimations. The estimation results show this approach enables researchers to estimate relationships between individual behaviors and wetland biodiversity by the revealed preference methods. Because of this simplicity on the data creation, this approach would be widely available for valuing other natural environments in the world.

Here, there is a second approach that is a (preliminary) survey to ask respondents about their favorite species. An advantage of the second approach is that researchers would research representative species whether experts exist or not. Note that there are possibilities to outcome more or less similar results if only a richness specie data would be used as the biodiversity variable if a researcher used the approach of this paper. If possible, the second approach would be useful to know the tourists' complete preferences for wetland biodiversity. In particular, the indigenous species (or subspecies) would attract tourists (naturalists) more (building the data is needed for performing further analyses) A disadvantage, however, is that the survey would take much time and money when the number of target wetlands increases or the survey carries on during years. Consequently, the approach of this paper would present more rational research process for researchers (if experts exist) than the second approach.

Parameter estimations

In Table 7, a reason for the positive signs of GND and MAR is thought to be that males have more opportunities for family trips, making bike trips with friends, or touring on bicycles than females. Hokkaido is one of the most famous areas where people enjoy driving or touring, and males living in Hokkaido have more leisure time to enjoy outdoor recreation.

Secondly, the reason for the positive signs of AGE may be that older persons have more leisure time than younger persons. Otherwise, this result indicates younger persons have less opportunity to visit wetlands (although young people who have high income might visit wetlands more often than those who have low income). Thus, policy makers should create changes to generate younger person interest in wetlands by extracurricular activities in schools or announcing volunteer activities in wetlands. Thirdly, the positive signs of SCAPE, WILD, PLANT and AMPH suggest that persons who were interested in wetland landscapes, wild birds and / or animals, plants and amphibians and/or reptiles are likely to visit wetlands. This indicates that increments of individual interests in biodiversity lead to increases of visitors for wetlands and may generate economic impacts for regions surrounding wetlands due to recreational activities. Finally, the positive signs of AREA suggest that individuals prefer to visit larger wetlands. A reason for such results was thought to be that lager wetlands often have more long-walking and/or tracking courses with beautiful landscapes, rare birds and animals than smaller wetlands. The results for TNRS are positive, and consistent with Carson et al. (2009), and the significant levels are $p < 0.01$ across models. The positive signs of TNRS also suggest that individuals prefer to visit ecologically richer wetlands. The results show that variety of species entertains visitors. The results of AREA and TNRS may indicate that policy makers maintain wetland areas and biodiversity for visitors in order to achieve a state of “wise use” for wetlands (Maltby and Barker, 2009).

The valuing of wetland biodiversity

The results in Table 9 show the order of the value of benefits in each increment rate are maintained, illustrating the values of BQC_{area}^{ALL} and BQC_{bio}^{ALL} in the case of the 10% increment rate in Figure 3. Figure 3 indicates that there are two types of wetlands. The first type in which the values of BQC_{area}^{ALL} are larger than those of BQC_{bio}^{ALL} are as follows: Sarobetsu-genya, Kushiro-sitsugen, Akkeshi-ko and Bekambeushi-shitsugen, Kiritappu-shitsugen, Furen-ko and Shunkuni-tai, Notsuke-hanto and Notsuke-wan. The second type in which the values of BQC_{bio}^{ALL} are larger than those of BQC_{area}^{ALL} are as follows: Miyajima-numa, Uryunuma-shitsugen, Kutcharo-ko,Utonai-ko, Tofutsu-ko. A feature of wetlands in the second type is that the wetland areas is smaller than those of the first type. A mean value of area for the second type is about 7.4 km^2, and for the first type is about 50.7 km^2. The facts indicate that an economic valuation of biodiversity of wetlands is important for showing the values of small wetlands rather than large wetlands. The reason is thought that the biodiversity of a wetland would not be always related to the wetland area, leading the economic valuation on biodiversity in the wetland to be performed for conserving small wetlands.

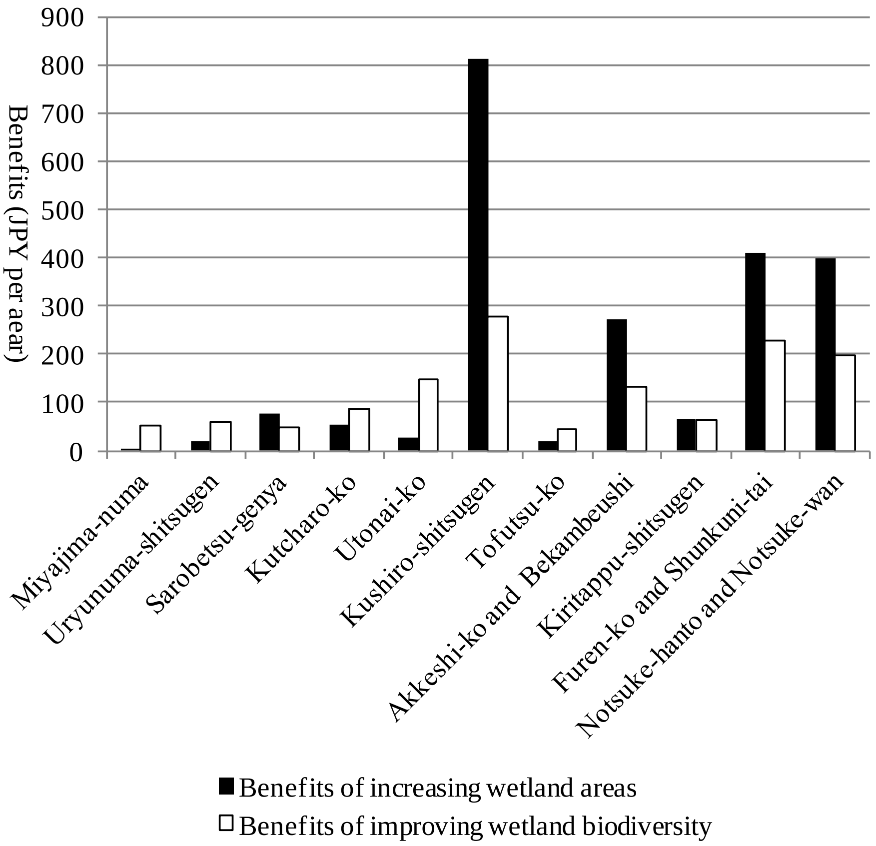

Figure 3. Benefits of wetland areas and biodiversity in the case of 10 % increment rate.

Political implications

It is thought that there are two frames for an improvement in biodiversity in this study. Considering conservations, the first frame is to increase the number of new individual favorite species living in a wetland. If so, policy makers plan to recover animals and/ or plants which do not live in the wetlands at present. Considering uses, the second frame is to increase the number of species which influence individual behaviors. If so, policy makers plan to enhance individual interest in the wetland biodiversity. Estimation results show that individual interest in biodiversity in WILD, PLANT, and AMPH, have a positive influence on individual travel behaviors and the value of benefits. Since it takes much time for policy makers to recover a variety of species in the wetland, the results indicate that policy makers would like to implement a short term policy to raise non-visitor interests in wetlands, and simultaneously implement a long term project to recover the numbers of species in order to achieve the state of wise-use of wetlands.

Since few studies have been performed to calculate benefits of improving wetland biodiversity by revealed preference methods, it is a future task of this study to confirm the validity for calculated values of benefits; by using the contingent behavior method or the combined method including revealed and stated preference data as in Whitehead et al. (2000, 2009) and Grossmann (2011).

Achievements of this paper

In previous studies, valuing wetland biodiversity are mainly performed by the stated preference data with an anxiety for the biases on estimated benefits. The method of this study would enable researchers to value wetland biodiversity, not only in Japan but also in the world, without the anxiety. A crucial finding of this study is that the improvements of biodiversity in small wetlands are more important than large wetlands. The finding would help to prevent small wetlands in natural status from (economic) developments. The result would indicate that the improving and preserving wetland biodiversity - even small wetlands - give the higher welfare status for human society.

Conflict of interests

The authors have not declared any conflict on interests.

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Author contributions

Tadahiro Okuyama undertook the survey, was responsible for the econometric models and analysis, and was involved in manuscript development and review. The guarantor for the overall content of the manuscript is Tadahiro Okuyama.

REFERENCES

Amigues JP, Boulatoff C, Desaigues B, Gauthier C, Keith JE (2002). The benefits and costs of riparian analysis habitat preservation: A willingness to accept/willingness to pay contingent valuation approach. Ecol. Econ. 43(1):17-31.

Birol E, Cox V (2007). Using choice experiments to design wetland management programmes: The case of Severn Estuary Wetland, UK. J. Environ. Plan. Manage. 50(3):363-380.

Birol E, Karousakis K, Koundouri P (2006). Using a choice experiment to account for preference heterogeneity in wetland attributes: The case of Cheimaditida wetland in Greece. Ecol. Econ. 60(1): 145-156.

Bockstael NE, Hanemann WH, Kling CL (1987). Estimating the value of water quality improvements in a recreational demand framework. Water Resour. Res. 23(5):951-960.

Burnham KP, Anderson DR (2002) Model selection and multimodel inference−A practical information-theoretic approach. Springer.

Camacho-Valdez V, Ruiz-Luna A, Ghermandi A, Berlanga-Robles CA, Nunes PALD (2014). Effects of land use changes on the ecosystem service values of coastal wetlands. Environ. Manage. 54(4):852-864.

Cameron AC, Trivedi PK (2013). Regression analysis of count data (second edition). Cambridge University Press, Cambridge, UK.

Carlsson F, Frykblom P, Liljenstolpe C (2003). Valuing wetland attributes: An application of choice experiments. Ecol. Econ. 47(1):95-103.

Carson RT, Hanemann WM, Wegge TC (2009). A nested logit model of recreational fishing demand in Alaska. Mar. Resour. Econ. 24:101-129.

Caulkins PP, Bishop RC, Bouwes NW Sr. (1986). The travel cost model for lake recreation: A comparison of two methods for incorporating site quality and substitution effects. Am. J. Agric. Econ. 68(2):291-297.

Grossmann M (2011). Impacts of boating trip limitations on the recreational value of the Spreewald wetland: A pooled revealed/contingent behavior application of the travel cost method. J. Environ. Plan. Manage. 54:211-226.

Hammit JK, Liu JT, Liu JL (2001). Contingent valuation of a Taiwanese wetland. Environ. Dev. Econ. 6:259-268.

Hanley N, Bell D, Alvarez-Farizo B (2003). Valuing the benefits of coastal water quality improvements using contingent and real behavior. Environ. Resour. Econ. 24(3):273-285.

Hanley N, Wright RE, Alvarez-Farizo B (2006). Estimating the economic value of improvements in river ecology using choice experiments: An application to the water framework directive. J. Environ. Manage. 78(2):183-193.

Heberling MT, Templeton JJ (2009). Estimating the economic value of national parks with count data models using on-site, secondary data: The case of the Great Sand Dunes national park and preserve. Environ. Manage. 43(4): 619-627.

Herriges JA, Kling CL, Phaneuf DJ (2004). What's the use? Welfare estimates from revealed preference models when weak complementarity doesn't hold. J. Environ. Econ. Manage. 47: 55-70.

HIESJSTA (2004). Wetland lists. BirdBase. Hokkaido Institute of Environmental Sciences, and Japan Science and Technology Agency. URL: http://birdbase.hokkaido-ies.go.jp/1_eng/rdb_shicchi.html, Accessed at June 4, 2014.

Hokkaido Prefectural Government (2014). Ramsar conservation and wetlands (in Japanese). URL: http://www.pref.hokkaido.lg.jp/ks/skn/environ/wetland/shitsugen.htm, Accessed at May 2, 2015.

Kamayama S, Yamagata Y, Nakamura F, Kaneko M (2001). Development of WTI and turbidity estimation model using SMA - application to Kushiro Mire, eastern Hokkaido, Japan. Remote Sens. Environ. 77(1):1-9.

Kosz M (1996). Valuing riverside wetlands: The case of the "Donau-Auen" national park. Ecol. Econ. 16 (2): 109-127.

Krutilla JV (1967). Conservation reconsidered. Am. Econ. Rev. 57(4):777-786.

Kuriyama K (1998). Contingent valuation study of recreational value in Kushiro wetland (in Japanese). J. Forest. Econ. 44(1):63-68.

Loomis J, Hanemann WM, Kanninen B, Wegge T (1991). Willingness to pay to protect wetlands and reduce wildlife contamination from agricultural drainage. In: Dinar A, Zilberman D (eds.) The economics and management of water and drainage in agriculture. Kluwer Academic Publishers. Boston. MA.

Maltby E, Barker T (Eds.) (2009). The Wetland handbook. Willey-Blackwell, Chichester; Millennium ecosystem Assessment, 2005. Ecosystems and human well-being: wetlands and water. Synthesis. Washington, DC. Island Press.

Matthews GVT (2013). The Ramsar convention on wetlands: its history and development. The Ramsar Convention Secretariat. URL: http://www.ramsar.org/sites/default/files/documents/pdf/lib/Matthews-history.pdf. Accessed at May 26, 2015.

Milon JW, Scrogin D (2006). Latent preferences and valuation of wetland ecosystem restoration. Ecol. Econ. 56(2): 162-175.

Ministry of the Environment, Japan (2014). Ramser sites in JAPAN, URL:http://www.env.go.jp/en/nature/npr/ramsar_wetland/pamph/index.html, Accessed at June 14, 2014.

Mitchell RC, Carson RT (1989). Using surveys to value public goods: The contingent valuation method. Resources for the Future. Washington DC. US.

Morey ER, Rowe RD, Watson M (1993). A repeated nested-logit model of Atlantic salmon fishing. Am. J. Agric. Econ. 75(3): 578-592.

Morino K, Yoshino K, Furuya H, Ishioka Y (2005). Evaluation of the environmental values of ecosystems of Akkeshi Lake-Bekanbeushi wetlands by using conjoint analysis (in Japanese). Trans. JSIDRE. 73(4): 337-344.

Morrison M, Bennett J, Blamey R (1999). Valuing improved wetlands quality using choice modeling. Water Resour. Res. 35(9): 2805-2814.

Needelman MS, Kealy MJ (1995). Recreational swimming benefits of New Hampshire lake water quality policies: An application of a repeated discrete choice model. Agric. Resour. Econ. Rev. 24 (1):78-87.

Pate J, Loomis J (1997). The effect of distance on willingness to pay values: a case study of wetlands and salmon in California. Ecol. Econ. 20:199-207.

Phaneuf DJ, Siderelis C (2003). An application of the Kuhn-Tucker model to the demand for water trail trips in North Carolina. Mar. Resour. Econ. 18:1-14.

Shaw WD, Ozog MT (1999). Modeling overnight recreation trip choice: Application of a repeated nested multinomial logit model. Environ. Resour. Econ. 13(4):397-414.

Shrestha RK, Seidl AF, Moraes AS (2002). Value of recreational fishing in the Brazilian Pantanal: A travel cost analysis using count data models. Ecol. Econ. 42(1-2):289-299.

Suwa T (2008). Estimation of the spatial substitution effect of national park trip demand: An application of the Kuhn-Tucker model. Environ. Econ. Pol. Stud. 9(4):239-57.

Turner RK, van den Bergh JCJM, Soderqvist T, Barendregt A, van der Straaten J, Maltby E, van Ierland EC (2000). Ecological-economic analysis of wetlands: scientific integration for management and policy. Ecol. Econ. 35:7-23.

Uden DR, Hellman ML, Angeler DG, Allen CR (2014). The role of reserves and anthropogenic habitats for functional connectivity and resilience of ephemeral wetlands. Ecol. Appl. 24(7):1569-1582.

Vesterinen J, Pouta E, Huhtala A, Neuvonen M (2010). Impacts of changes in water quality on recreation behavior and benefits in Finland. J. Environ. Manage. 91(4):984-994.

Wang X, Bennett J, Xie C, Zhang Z, Liang D (2007). Estimating non-market environmental benefits of the conversion of cropland to forest and grassland program: A choice modeling approach. Ecol. Econ. 63(1):114-125.

Whitehead JC, Groothuis PA, Southwick R, Foster-Turley P (2009). Measuring the economic benefits of Saginaw Bay coastal marsh with revealed and stated preference methods. J Great Lakes Res. 35(3):430-437.

Whitehead JC, Haab TC, Huang JC (2000). Measuring recreation benefits of quality improvements with revealed and stated behavior data. Resour. Energy Econ. 22(4):339-354.

Yeh CY, Haab TC, Sohngen BL (2006). Modeling multiple-objective recreation trips with choices over trip duration and alternative sites. Environ. Resour. Econ. 34(29):189-209.

Appendix 1. Summaries on Ramsar wetlands in Hokkaido.

Site names	Summary
Miyajima-numa	Major Type: Freshwater lake, Summary: Miyajima-numa is a round lake in Bibai City, located 50 km northeast of Hokkaido's capital city, Sapporo. It is a shallow lake with an average depth of 1.7 m. An astounding number of waterfowl including geese, ducks and swans visit this lake every autumn and spring. The Miyajima-numa is one of the most important stopover points in Japan. Especially, the number of white-fronted geese (*Anser albifrons*) exceeds 50,000, constantly accounting for more than 1% of the species population in East Asia. Main plants are *Trapa bispinosa var. iinumai, Zizania latifolia, Phragmites communis,* etc.; Main birds are *Anser albifrons, Cygnus cygnus, Cygnus columbianus*, etc.; Main fish and shellfish are *Cyprinus carpio, Tribolodon hakonensis, Phoxinus percnurus sachalinensis*, etc.
Uryunuma-shitsugen	Major Type: High moor, Summary: The Uryunuma-shitsugen is located at 70km north of Sapporo, Hokkaido. Diverse vegetation of approximately 150 species of plants is observed in the Uryunuma wetland in its pristine condition, including the spatterdock (*Nuphar luteum)*, peat moss (*Sphagnum* ssp.) and *Moliniopsis japonica*. The summer months (June-September) are an excellent season to appreciate the flower garden of Broad Dwarf Day-Lily, Arctic Iris and Plantain Lily. Main plants are *Nymphaea tetragona association, Menyanthes trifoliata community, Veratrum stamineum - Calamagrostis canadensis var. langsdorffii community*, etc.; Main birds are *Anas platyrhynchos, Gallinago hardwickii, Lanius bucephalus*, etc.
Sarobetsu-genya	Major Type: High moor, intermediate moor, low moor, and fresh-water lake, Summary: The Sarobetsu-genya is a vast peat land located approximately 40km south of Wakkanai City, a northernmost city in Japan. From spring to autumn, the Sarobetsugenya is covered with colorful flora with more than 100 species of plants including cranberry (*Vaccinium macrocarpon*), Hare's tail cotton grass (*Eriophorum vaginatum*), bog rosemary (*Andromeda polifolia*) and broad dwarf day-lily. The two lakes in this wetland are important habitats for breeding waterfowls and migratory birds. They constantly support 1% of the species' population of middendorf's bean goose (*Anser fabalis middendorffi*), and tundra swan (*Cygnus Columbianus*) in East Asia. Main plants are *Ledum palustre subsp. diversipilosum var. yesoense, Empetrum nigrum var. japonicum*, *Chamaedaphne calyculata*, etc.; Main birds are *Motacilla flava taivana, Emberiza aureola*, *Emberiza schoeniclus*, etc. Main mammals are *Sorex minutissimus hawkeri, Myotis daubentoni, Myotis mystacinus*. Main amphibian and reptiles are *Lacerta vivipara, Elaphe climacophora, Elaphe quadrivirgata*.
Kutcharo-ko	Major Type: Freshwater lake, low moor, Summary: The Kutcharo-ko is one of the northernmost lakes in Japan. The lake is surrounded by a northern forest of firs and spruces, and has a reed community on the shore. A variety of unique aquatic plants such as *Ruppia occidentalis* are found here. It also is a ground for commercial fishing for shrimps, clams and smelts. The area is an important staging ground for migratory waterfowl, where 290 species of birds, mainly Anatidae, have been recorded. This area is included in the Flyway Site Network under the Partnership for the East Asian-Australasian Flyway. Main plants are *Phragmites communis, Typha latifolia, Scirpus lacustris subsp. creber*, etc. Main birds are *Anas platyrhynchos, Anas penelope, Aythya marila*, etc. Main insects are *Lestes dryas, Sympetrum striolatum imitoides, Sympetrum flaveolum flaveolum*, etc. Main mammals are *Sorex minutissimus hawkeri, Myotis daubentoni, Myotis mystacinus*, etc. Main fish and shellfish are *Oncorhynchus masou masou, Salvelinus leucomaenis, Hypomesus nipponensis*, etc.
Utonai-ko	Major Type: Freshwater lake, low moor, Summary: The Utonai-ko is a freshwater lake in southwestern Hokkaido. The area is one of the most important stopover sites and wintering grounds for migratory birds. Tens of thousands of birds including the white-fronted goose (*Anser albifrons*), bean goose (*Anser fabalis*), whooper swan (*Cygnus cygnus*), etc. visit every year. More than 260 bird species are recorded. The marshland around the lake serves as an important breeding ground for siberian rubythroat (*Luscinia calliope*), and yellow-breasted bunting (*Emberiza aureola*), and the forest is a winter habitat for white-tailed sea eagle (*Haliaeetus albicilla*) and Steller's sea eagle (*European Storm-petrel*). Main plants are *Phragmites communis, Calamagrostis canadensis var. langsdorffii, Carex middendorffii*, etc. Main birds are *Anas platyrhynchos, Anas penelope, Anas acuta*, etc. Main insects are *Lestes dryas, Anax parthenope julius, Sympetrum parvulum*, etc. Main mammals are *Vulpes vulpes schrencki, Tamias sibiricus, Lepus timidus ainu*. Main fish and shellfish are *Cyprinus carpio, Carassius auratus, Tribolodon hakonensis*, etc. Main amphibian and reptiles are *Rana pirica*.

Appendix 1. Contd

Kushiro -shitsugen	Major Type: Low Moor, Freshwater Lake, River, Summary: The Kushiro-shitsugen located in eastern Hokkaido, and is the largest marshland in Japan. Approximately 80% of the peat land is a low moor dominated by a reed and sedge community and alder forest. The plant community in the wetland has a variety of species including marsh jacob's ladder, a relict of the ice age, etc. This wetland is blessed with rich fauna including 26 species of mammals and 170 species of birds. It also is home of the internationally endangered Japanese crane (*Grus japonensis*), white-tailed sea eagle (*Haliaeetus albicilla*), and Steller's sea eagle (*European Storm-petrel*). This is the only habitat in Japan for the unique amphibian Siberian Salamander. Main plants are *Phragmites communis, Alnus japonica, Carex lasiocarpa subsp. occultans*, etc. Main birds are *Grus japonensis, Gallinago hardwickii, Alauda arvensis*, etc. Main insects are *Sympetrum flaveolum flaveolum, Lestes dryas, Leucorrhinia intermedia ijimai*, etc. Main mammals are *Mustela vison, Mustela itatsi itatsi, Clethrionomys rufocanus bedfordiae*. Main fish and shellfish are *Pungitius pungitius pugitius, Chaenogobius laevis, Hucho perryi, Lethenteron reissneri*, etc. Main amphibian and reptiles are *Salamandrella keyserlingii, Hynobius retardatus, Elaphe climacophora,* etc.
Tofutsu-ko	Major Type: Brackish lake, Summary: The Tofutsu-ko located in the northeast Hokkaido, and is an important habitat for more than 60,000 ducks and geese, supporting more than 1% of East Asian regional population of bean goose (*Anser fabalis*), whooper swan (*Cygnus cygnus*), wigeon (*Anas penelope*), smew (*Mergus albellus*) and red-breasted merganser (*Mergus serrator*). A salt marsh has developed in the low area along the shore with aquatic communities such as seaside arrowgrass (*Triglochin maritima*) and marsh arrowgrass (*Triglochin palustris*). In Particular, the communities of common glasswort (*Salicornia europaea*) in beautiful red autumn color attracts many tourists to the lakes along the coast of the Sea of Okhotsk. Main plants are *Phragmites communis, Typha latifolia, Scirpus lacustris subsp. creber*, etc. Main birds are *Anas platyrhynchos, Anas penelope, Anas strepera*, etc. Main fish and shellfish are *Hypomesus nipponensis, Cyprinus carpio, Carassius auratus*, etc.
Akkeshi-ko and Bekambeushi -shitsugen	Major Type: Brackish lake, salt marsh, low moor, high moor, and river, Summary: The Akkeshi-ko and Bekambeushi-shitsugen located in eastern Hokkaido. The Akkeshi-ko is a brackish water lake, plant communities of saline environment are found in some places in the salt marsh along the shore, including common glasswort (*Salicornia europaea*). Approximately 200 species of birds have been recorded. As it does not completely freeze over in winter, the Akkeshi-ko is an important wintering ground for the whooper swans (*Cygnus cygnus*). In addition, almost 300 Steller's sea eagles (*European Storm-petrel*) and white-tailed sea eagles (*Haliaeetus albicilla*), winter here. Main plants are *Glaux maritima var. obtusifolia, Carex subspathacea, Triglochin maritimum*, etc. Main birds are *Ardea cinerea, Anas crecca, Anas penelope*, etc. Main fish and shellfish are *Salangichthys microdon, Eleginus gracilis*.
Kiritappu -shitsugen	Major Type: Salt marsh, brackish lake, river, high moor, and low moor, Summary: The Kiritappu-shitsugen located in eastern Hokkaido and is bound with snow and ice in winter. In spring and autumn, a number of migratory birds stop over the site. The marshland is an important habitat for Japanese cranes (*Grus japonensis*), and thus is included in the Flyway Site Network under the Partnership for the East Asian-Australasian Flyway. From May to September, a number of colorful wetland flowers such as the Japanese rose (*Rosa rugosa alba*), Hare's tail cotton grass(*Eriophorum vaginatum*), Arctic Iris (*Iris setosa*), and Broad Dwarf Day-lily adorn the wetland, making it the site of visitors from all over the country. Main plants are *Molinia japonica, Phragmites communis, Alnus japonica*, etc. Main birds are *Grus japonensis, Podiceps grisegena, Ardea cinerea*, etc. Main insects are *Cordulia aenea amurensis, Coenagrion ecornutum, Aeshna nigroflava*, etc. Main mammals are *Mustela vison, Vulpes vulpes schrencki*. Main fish and shellfish are *Salvelinus leucomaenis, Tribolodon hakonensis, Platichthys stellatus*, etc.
Furen-ko and Shunkuni-tai	Major Type: Brackish lake, seagrass/seaweed bed, sandbar, low moor, and tidal flat, Summary: The Furen-ko and the Shunkuni-tai located in eastern Hokkaido, and an area to embrace sand dunes, grasslands, forests, salt marshes, and tidal flats. In particular, the Sakhalin spruce (*Picea glehnii*) forest on the sand dunes has attracted international attention for its uniqueness. Furen-ko's ecosystem diversity includes approximately 280 species of birds including shorebirds, swans and geese. The lagoon is one of the most popular places for national/international visitors to observe rare species such as the white-tailed sea eagle(*Haliaeetus albicilla*), Steller's sea eagle (*European Storm-petrel*), black woodpecker (*Dryocopus martius*), Blakiston's Fish Owl (*Bubo blakistoni*), etc. all the year round. Main plants are *Triglochin maritimum, Glaux maritima var. obtusifolia, Scirpus lacustris subsp. creber*, etc. Main birds are *Grus japonensis, Anser fabalis, Cygnus cygnus*, etc. Main insects are *Libellula quadrimaculata asahinai, Procrustes kolbei aino, Limenitis populi jezoensis*, etc. Main mammals are *Sorex unguiculatus , Clethrionomys rufocanus bedfordiae, Clethrionomys rutilus mikado*, etc. Main fish and shellfish are *Tapes japonica, Corbicula japonica, Eleginus gracilis*, etc. Main amphibian and reptiles are *Rana pirica, Hyla japonica*.

Appendix 1. Contd

Notsuke-hanto and Notsuke-wan	Major Type: Shallow marine water, tidal flat, seagrass/seaweed bed, salt marsh, low moor, sandspit, Summary: The Notsuke-hanto and the Notsuke-wan located in eastern Hokkaido. Because of the diverse natural wetland environment, it is an important stopover site visited by more than 20,000 migratory birds every spring and autumn. The Notsuke-wan is the inner bay surrounded by the peninsula of Notsuke-hanto. The bay has one of the largest seagrass beds in Japan. The sea grass bed of eelgrass (*Zostera marina*) is a rich repository of fishery resources because it serves as a good spawning and nursery ground for various fish and shellfish. Main plants are *Iris ensata var. spontanea, Sanguisorba tenuifolia form. alba, Hemerocallis dumortierii var. esculenta*, etc. Main birds are *Gallinago hardwickii, Tringa totanus, Grus japonensis*, etc. Main insects are *Sympetrum flaveolum flaveolum, Coenagrion lanceolatum, Libellula quadrimaculata asahinai*, etc. Main mammals are *Clethrionomys rufocanus bedfordiae, Clethrionomys rutilus mikado, Sorex unguiculatus*.

Appendix 2. Additional estimation results for selecting independent variables.

Model	**RDC_ALL**		**RDC_VIS**	
CONT	8.10758^a (0.11168)	8.99707^a (0.12287)	6.44673^a (0.11611)	7.34899^a (0.12810)
PRICE	-	-	-	-
ICM/TICM	0.17638 ^{a}(0.01436)	0.17378^a (0.01447)	0.16176^a (0.01470)	0.16323^a (0.01472)
GND	0.82053^a (0.04621)	0.52030^a (0.04688)	0.52640^a (0.04664)	0.44509^a (0.04710)
AGE	0.02590^a (0.00207)	0.00930^a (0.00217)	0.01911^a (0.00209)	0.01567^a (0.00217)
MAR	0.08551^c (0.04553)	0.33347^a (0.04629)	0.39268^a (0.04657)	0.44547^a (0.04718)
SCAPE	-	2.16045^a (0.05941)	-	1.01246^a (0.05992)
WILD	-	0.85554^a (0.04625)	-	0.44874^a (0.04683)
PLANT	-	0.61238^a (0.05938)	-	0.50428^a (0.06074)
AMPH	-	0.92477^a (0.07459)	-	0.81082^a (0.07586)
AREA	-	-	-	-
TNRS	-	-	-	-
LL	-19375.04631	-17714.63551	-16219.02965	-15866.24628
AIC	38760.09262	35447.27102	32448.05930	31750.49256
MR2	0.01807	0.10222	0.01130	0.03281
N	2,256	2,256	613	613

Numbers of parentheses are standard errors of the coefficients; the super scripts of coefficients "a" means the coefficient significant at $p < 0.1$, "b" means $p < 0.5$, "c" means $p < 0.1$, "d" means $p > 0.1$, respectively. Appendix 2 shows the results of RDC models omitted some variables in Table 7. Here, the values of AIC and MR2 of the RDC model in Table 7 were 35032.16711 and 0.11283 for RDC_ALL, 31385.98366 and 0.04403 for RDC_VIS, respectively. The values of AIC and MR2 in Appendix are higher than these values in Table 7, indicating that the models in Table 7 are suitable for estimations. However, the result also might indicate the possibility of lacking important independent variables because the values of AIC of RDC_ALL and RDC_VIS reach the minimum values when using all variables. See Burnham and Anderson (2002) for the details on the model selection.

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