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Abandoned forest ecosystem: Implications for Japan's Oak Wilt disease☆

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ABSTRACT

This study determined values for the ecosystem services of abandoned coppice forests that are threatened by a forest disease known as Japanese Oak Wilt. We applied a discrete choice experiment to value these ecosystem services. The results indicated that ecosystem services were highly valued in the order of biodiversity conservation, water and soil regulation, timber provision, and climate change mitigation. This study suggests that people expect abandoned coppice forests to be protected from Japanese Oak Wilt and to become rich in biodiversity. However, public preference for biodiversity conservation services had high heterogeneity among people. On the other hand, water and soil regulation services were widely ranked as important among people. Furthermore, traditional management method is most preferred than other forest-change scenarios in JOW countermeasures.

Introduction

The outbreak of an epidemic tree disease, Japanese Oak Wilt (JOW), has severely damaged coppice oak forests in many area of Japan since the 1980s (Ito et al., 1998; Kubono and Ito, 2002; Ito et al., 2009). JOW infections have been observed by Ida and Takahashi (2010) and, for over one hundred years, by the Forestry Agency (2013), although the geographic range was limited until several decades ago (e.g., Miyazaki, Kochi, Hyogo, and Yamagata prefectures). In the past, such outbreaks used to last for only five to ten years; however, recent outbreaks in large areas have continued for more than ten years (Ito and Yamada, 1998). In 2016, thirty prefectures were damaged by JOW (Forest Agency 2016). JOW damages in Akita and Nara prefectures were particularly higher than other prefectures (Forestry Agency, 2016).

This difference between earlier and recent infections can be traced to differences in Japan's forest management system. JOW infections were observed in trees with large trunk diameters, since the vector, *Platypus quercivorus*, a wood boring ambrosia beetle, prefers large-trunk trees (Kobayashi and Ueda, 2005). Oak coppice forests in Japan used to be frequently logged, and they were generally felled before they reached the size large enough for a beetle mass attack. Logging was frequent because the tree size required for charcoal and firewood was about 10–20 cm in diameter, which is much smaller than the size of the trees currently maturing. However, energy shifts to fossil fuels caused a drastic decrease in the demand for coppice woods from 1960 to 1970. As a result, many coppice forests were abandoned without management, and oak trees have grown to 40–50 cm in diameter, which is an attractive size for the disease vector.

The public lacks a clear incentive to protect these forests from infections because the forests have much less commercial value than they did several decades ago. However, a lack of protection has left the forests susceptible to forest degradation. The oak ecosystem damaged by JOW may lose a significant amount of its ecosystem services (the processes by which an environment produces natural resources) because these forests are sometimes degraded into scrub forests or bamboo grasslands without tall tree species (Ito et al., 2009, 2011). Such forests may then trap less carbon, suffer more erosion, or display less biodiversity than healthy forests. Therefore, to develop strategic measures against JOW, understand-

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Table 1
Attributes and levels of forest change scenarios in choice experiment questions.

Attributes	Levels
TYPE	TFM, BRF, PCF
SPECIES	+15%, +25%, +35%, +45%, −15%, −25%, −35%
CARBON	−10%, +0%, +10%
WATER	−10%, +0%, +10%
WOOD	+10%, +20%, +40%
COST (in 10,000 JPY)	0.1, 0.2, 0.5, 1

Table 2
Attributes and levels of status quo scenario in choice experiment questions.

Attributes	S1 level	S2 level	S3 level
SPECIES	+0%	−10%	−20%
CARBON	+0%	−45%	−90%
WATER	+0%	+10%	+20%
WOOD	+0%	+0%	+0%
COST (in JPY)	0	0	0

ing the value of ecosystem services that can be lost to this disease is important. This study estimates the values of ecosystem services in terms of protecting abandoned coppice forests from JOW.

Many studies have been conducted on the valuation of forest ecosystem services. The Science Council of Japan (2001) used the replacement-cost approach to value all Japanese forests, and reported that the value of the CO_2 storage function was JPY 1,239 billion and that the flood water mitigation function was JPY 6,468 billion. Meyerhoff et al. (2009) value benefits from changed levels of biodiversity due to nature-oriented silviculture in Lower Saxony, Germany using a choice experiment. They value habitat for endangered and protected wildlife, wildlife diversity, forest stand structure, and landscape diversity. Juutinen et al. (2011) value different trade-offs between biodiversity and recreational services that emerged in national park development scenarios in Oulanka National Park (Finland) using a choice experiment. Tyrväinen et al. (2014) value enhanced forest amenities, in particular landscape values and biodiversity, in private forests in the Ruka-Kuusamo tourism area in northern Finland using a choice experiment. Mogas et al. (2009) use a contingent valuation and choice experiment to estimate non-market values from alternative afforestation programs in the Northeast of Spain, in particular recreation value, sequestered CO_2, and erosion. Chang et al. (2011) estimate the willingness to pay (WTP) for conserving forests from insect outbreaks using the contingent valuation method and compare forest types (recreational, ecological, and productive forests) to determine which type should be conserved in New Brunswick and Saskatchewan, Canada. Shoyama et al. (2013) use a choice experiment to estimate WTPs for managing natural forests, wetlands, productive forests, and agricultural land in Kushiro, Japan. However, few studies have valued abandoned coppice forests degraded forest disease.

This study evaluated four forest ecosystem services, including biodiversity conservation, climate change mitigation, water and soil regulation, and timber provision, all over the abandoned secondary growth forests threatened by JOW in Japan. To value these ecosystem services, this study used four quantitative indicators: “number of wildlife species in forests”, “CO_2 storage of forests”, “amount of flood water”, “forestry benefits”. This study addresses the following two questions:

Q1: What ecosystem services are highly valued in Japanese abandoned coppice forests?
Q2: What types of management methods are highly valued in JOW countermeasures?

This study is structured as follows. Section 2 explains the empirical methods, Section 3 reports the results, Section 4 provides a discussion, and Section 5 presents the conclusion.

Methods

Survey design

To value abandoned coppice forests, we applied discrete choice experiment. Discrete choice experiments are a kind of questionnaire surveys on modelling preferences for goods, where goods are described in terms of their attributes and the levels they achieve (Kumar, 2010). Respondents are presented a choice set including alternatives for goods, differentiated by their attribute levels, and are asked to choose one of the alternatives. By analyzing the results of the questionnaire surveys, researchers can obtain values for the attributes of the goods.

Our questionnaire comprised three sections. The first section explained JOW and asked respondents about their perspectives on JOW. The second section conducted discrete choice experiments and the third section asked the socioeconomic status of a respondent. In the second section, we provided each respondent the following hypothetical situation, before the discrete choice experiments:

(1) Abandoned coppice forests are, and will be, threatened by JOW. Forest ecosystem services will deteriorate by JOW.
(2) To conserve forest ecosystem services, it is necessary to manage abandoned coppice forests.
(3) However, management of abandoned coppice forests require public donation.
(4) Respondents were asked to choose their most preferred scenario from each scenario set four times. Donation for the management of the forests is only a one-time payment.

A choice set in discrete choice experiment comprised three forest-change scenarios and a status quo scenario. The forest-change scenarios are those that convert current forests (all forests vulnerable to JOW) into new types of forests (forests tolerant against JOW). The status quo scenario is the scenario that does not apply any measure to forests. The attributes of these scenarios are “forest management type” (TYPE), “number of wildlife species in forests” (SPECIES), “CO_2 storage of forests” (CARBON), “amount of flood water” (WATER), “forestry benefits” (WOOD), and “cost of scenario per person” (COST). The attribute TYPE represents kinds of forest-change scenarios. The attribute TYPE are (a) the traditional forest management (TFM) scenario, which converts current forests into forests following the traditional management system with periodical logging for charcoal and firewood, (b) the biodiversity-rich forest (BRF) scenario, which converts current forests into biodiversity rich forests escaping disturbance by outside forces like storms, disease or logging and (c) the productive conifer forest (PCF) scenario, which converts current forests into plantations of more commercially important conifer trees. The attributes SPECIES, CARBON, WATER, WOOD represent the level of ecosystem services of forests. The levels of these attributes are represented as a percentage change compared with current attribute levels. The attribute COST represents amount of donation for a forest-change scenario. The level of COST is represented in JPY. Respondents choose one preferred scenario from these four by comparing their attributes. An example of a choice set is presented in Fig. 1.

The levels of forest-change scenarios were assigned from Table 1. However, the level of SPECIES was determined by the level of TYPE. When TYPE was TFM, SPECIES was one of +15%, +25%, or +35%. When TYPE was BRF, SPECIES was one of +25%, +35%, or +45%. When TYPE was PCF, SPECIES was one of −15%, −25%, or −35%.