An HSI model of *Sasakia charonda* for SATOYAMA conservation activities

Yuri ASAMI＊，Akira TANAKA＊

Abstract

It is important for biodiversity conservation activities to target secondary ecosystems, and such activities are conducted actively. Many attempts fail, however, as it is difficult for workers without much ecological knowledge to properly handle conservation activities. Many workers do not understand the specificities of Satoyama ecosystems which are maintained by humans and require the adaptation of management practices according to the state of the ecosystem. There is a growing need to evaluate the effectiveness of the activities from the perspective of biodiversity. This study aimed to develop a quantitative evaluation method for the biological impacts of Satoyama conservation activities based on HEP. Utilizing the species *Sasakia charonda*, the Japanese national butterfly living in Satoyama, I found the relationship between its life requisites and conservation activities. Then, I constructed a Habitat Suitability Index (HSI) model which evaluates conservation activities that have strong influence on habitats. A hypothetical scenario was used to verify the functioning of HSI model. Preliminary results indicate that the HSI model can successfully evaluate the biological impacts of Satoyama conservation activities.

keywords：**HEP, HSI model, SATOYAMA conservation activities, *Sasakia charonda*,**

１．Introduction

Satoyama ecosystems are secondary ecosystems that have been established under the continuous influence of humans over the years. Satoyama ecosystems in Japan are in a critical condition due to both “overuse” and “underuse”. “Overuse” means loss of green space due to development projects. “Underuse” means transformation into wasteland due to lack of maintenance by humans (環境省，2012、田中，2010). Conservation activities by citizens are active, but economic demand for the resources obtained from Satoyama has been declining. And the traditional management methods are no longer effective for biodiversity conservation because the natural environment has already changed due to a neglect over a prolonged period(倉本，2004).

In order to Satoyama ecosystems, it is necessary to set the species being evaluated and maintain the life requirements for the species (田中，2016). However, it is difficult to take these conditions into account without ecological expertise (倉本，2019).

There is a study that attempted to develop a quantitative evaluation method for Satoyama management activities by applying Habitat Evaluation Procedure (HEP evaluates quantitatively the habitat of the species being evaluated in terms of "quality" × "space" × "time"). The study evaluated the activities with a simplified HSI model of *Luehdorfia japonica*, and suggested the possibility of the effectiveness of Satoyama conservation in a quantitative way. However, the HSI model was not linked to any specific activities. And ecological expertise is required to evaluate the activities and their results.

Therefore, this study aims to develop a method to evaluate activities biologically and quantitatively without the need for ecological expertise. Taking the Japanese national butterfly, *Sasakia charonda*, as an example, I developed a quantitative evaluation method for Satoyama conservation activities, focusing on the impacts on the habitat of *Sasakia charonda*.

２．Methods

２．１　Relationship between habitat variables and Satoyama conservation activities

Sasakia charonda is a species that is often found in Satoyama ecosystems (矢田，2007). Adults gather in the sap of *Quercus acutissima*. Then, females lay eggs on twigs and leaves. The larvae grow by feeding on *Celtis sinensis* leaves.In November, their body color changes

＊Graduate School of Environmental and Information Studies, Tokyo City University

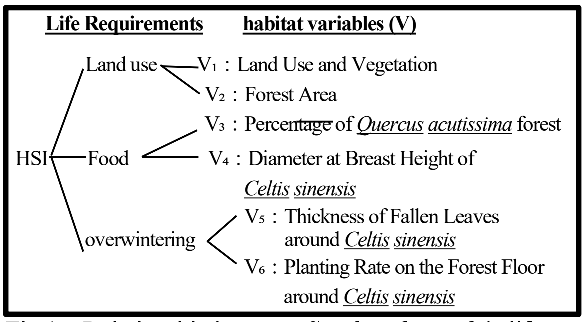

Fig.1 Relationship between Sasakia charonda's life requirements and habitat variables

from green to brown, the same color as dead leaves, and they descend the trunks to overwinter on the underside of the leaves near the roots. These larvae return to arboreal life in April, pupate on the underside of leaves in June, and hatch in about two weeks.

I conducted a literature review and interviewed Mr. Jiken Atobe, director of the Hokuto City Omurasaki Center in Hokuto City, Yamanashi Prefecture, regarding satoyama conservation activities.

Based on the fig. 1, I organized the relationships among the habitat variables, and satoyama conservation activities.

２．２ Creating HSIa* model to evaluate Satoyama conservation activities

I developed an HSIa model based on the identified relationship. The letter 'a' indicates an HSI model built for the evaluation of conservation activities.

２．３ A hypothetical evaluation

To verify the functioning of HSIa model, I created a three-year activity scenario and evaluated hypothetically by HSI model of Sasakia charonda and HSIa model. Evaluated site is Tsubaki TC Satoyama Bank, the first biodiversity bank in Japan.

３．Results

３．１ Relationship between habitat variables and Satoyama conservation activities

In fig. 2, the left-hand side is the HSI model of Sasakia charonda with six habitat variables and The right-hand side connects it with the activities that affect the habitat variables. It was identified that there are four main types of habitat maintenance activities: cutting the grass, thinning, logging in order by area, and fallen leaves management.

３．２ Creating HSIa model to evaluate Satoyama conservation activities

ａ）Grass cutting (SIa1) model

Cutting keeps deciduous broadleaf forests bright, protect young Celtis sinensis from undergrowth and prioritize its growth, and also maintain overwintering habitat. That is to say cutting affects 3 habitat variable, Land use and vegetation (V_1), Diameter at Breast Height of Celtis sinensis (V_4) and Planting Rate on the Forest Floor around Celtis sinensis (V_6).

Therefore, SIa1 value is set to 1.0 when all three of these activities are performed. ①To maintain a bright deciduous broadleaf forest, cut Shrubs and grasses over 20 cm high once in winter, ②To protect juvenile Celtis sinensis and Quercus acutissima, cut shrubs and grasses around Celtis sinensis and Quercus acutissima less than 2 m twice each in summer and autumn, ③ Less than 20 cm of herbaceous vegetation, etc. is left in an Celtis sinensis perimeter of more than 2 m. When one of the three activities is not performed, the value is 0.5 or 0.7. If cutting is not performed every year, the value is 0.0.

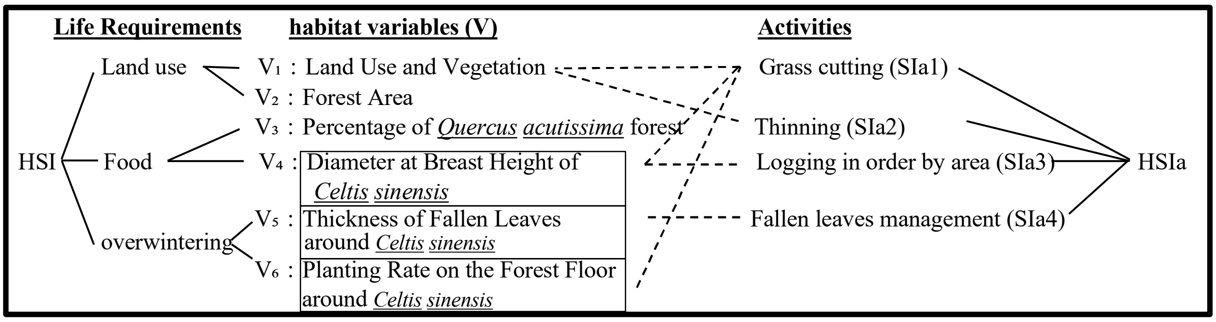

Fig.2 Relationship between Habitat Variables of Sasakia charonda and conservation activities

Fig. 3 Grass cutting (SIa1) model

Grass cutting	Value of SIa1
・To maintain a bright deciduous broadleaf forest, cut shrubs and grasses over 20 cm high (once in winter) ・To protect juvenile *Celtis sinensis* and *Quercus acutissima*, cut shrubs and grasses around Celtis sinensis and Quercus acutissima less than 2 m (twice each in summer and autumn) ・Less than 20 cm of herbaceous vegetation, etc. is left in an *Celtis sinensis* perimeter of more than 2m	1.0
・To protect juvenile *Celtis sinensis* and *Quercus acutissima*, cut shrubs and grasses around Celtis sinensis and Quercus acutissima less than 2 m (twice each in summer and autumn)	0.7
・To maintain a bright deciduous broadleaf forest, cut shrubs and grasses over 20 cm high (once in winter) ・Without identifying *Celtis sinensis* and *Quercus acutissima*, cut the young *Celtis sinensis*, *Quercus acutissima* and the shrubs and grasses around the *Celtis sinensis*	0.5
・Cut the grasses less than once a year	0.0

Fig. 4 Thinning (SIa2) model

Thinning	Value of SIa2
・Maintain a distance of at least 2 meters between trees ・Protect *Celtis sinensis* and *Quercus acutissima*	1.0
・Maintain a distance of at least 2 meters between trees ・Do not protect *Celtis sinensis* and *Quercus acutissima*	0.3
・Do not maintain a distance of at least 2 meters between trees ・Do not protect *Celtis sinensis* and *Quercus acutissima*	0.0

Fig. 5 Logging in order by area (SIa3) model

Logging in order by area	Value of SIa3
・Conduct partial logging every few years that does not change the land use of the forest area ・Protect *Celtis sinensis* and *Quercus acutissima*	1.0
・Conduct partial logging every few years that does not change the land use of the forest area ・Do not protect *Celtis sinensis* and *Quercus acutissima*	0.3
・Do not conduct partial logging every few years that does not change the land use of the forest area ・Do not protect *Celtis sinensis* and *Quercus acutissima*	0.0

Fig. 6 Fallen leaves management (SIa4) model

Fallen leaves management	Value of SIa4
Do not move any fallen leaves from November to April (Ground is obscured by fallen leaves)	1.0
Sweep up the fallen leaves from November to April (Few fallen leaves and the ground is visible)	0.0

$$HSIa = \left\{ SIa1 \times \left(\frac{SIa \times SIa}{2}\right) \times SIa4 \right\}^{\frac{1}{3}}$$

Formula HSIa model

b) Thinning (SIa2) model

Thinning affects Land use and vegetation (V_1). In order to maintain the bright deciduous broadleaf forests, the trees should be at least 2 meters apart. However, care must be taken to avoid inadvertently cutting down *Celtis sinensis* and *Quercus acutissima*. So, the highest value of 1.0 is given only to the case where the distance between trees is maintained at 2m or more while also protecting *Celtis sinensis* and *Quercus acutissima*.

c) Logging in order by area (SIa3) model

Logging in order by area means that the forest is divided into a number of plots, and each plot is cut down in turn each year. And by the time the cycle is complete, the cleared forest is regenerated.

Logging in order by area affects Diameter at Breast Height of *Celtis sinensis* (V_4). Diameter at Breast Height of *Celtis sinensis* (SI4) model evaluates SI4 value of 1.0 for a diameter at breast heigh of 15 cm or greater. On the other hand, small *Celtis sinensis* must be present to prepare for the situation where large *Celtis sinensis* die out. Since

Celtis sinensis tends to grow at forest edges, it is necessary to conduct activities to improve the germination and growth environment of *Celtis sinensis*. This can be achieved through tree rotation in which some of the forest area is cut down without changing the land use of deciduous broad-leaved forests.

The highest value of 1.0 is given in the presence of both logging in order by area and protection of *Celtis sinensis* and *Quercus acutissima*.

ｄ）Fallen leaves management (SIa4) model

Fallen leaves management affects thickness of fallen leaves around *Celtis sinensis* (V_5). As the larvae overwinter on the underside of fallen leaves, it is important not to rake up or move fallen leaves.

ｅ）HSIa model

In HEP, the arithmetic mean method is used when all of the SIs are not necessarily needed at the same time, and any one of them can function as a habitat in its own right. If one of the SI's is zero, the value of the habitat is zero, then the geometric mean method is used (田中，2016).

HSIa value is calculated as the geometric mean of SIa1, SIa4 and the arithmetic average of the SIa2 and 3 because Thinning (SIa2) and Logging in order by area (SIa3) do not necessarily have to be performed at the same time.

３．３　A hypothetical evaluation

ａ）Evaluated site

The chosen site was Tsubaki TC Satoyama Bank located in Shisui-mathi, Chiba Prefecture, Kanto Region of Japan. The target area is 43 hectares. The light green color in the vegetation map (Fig. 9) on the right is deciduous broadleaf forest.

ｂ）Activity scenario

The deciduous broadleaf forest before the activity was overgrown with grass and bamboo, making it difficult to see ahead and impossible for people to enter. I made a conservation activities scenario for three years for this forest. Activities and frequency are shown in fig. 10 and fig. 11. Daily number of people is 2, and activity hours is 8 hours.

ｃ）A hypothetical evaluation results

Fig. 12 shows the result of the three-year activities by the HSI model of Sasakia charonda, and Fig. 13 shows the result by the HSIa model. These results are same trend, with THU increasing after two years of conservation activities.

Fig. 7　Tsubaki TC Satoyama Bank in Shisui-matchi, Chiba Prefecture, Kanto Region

Fig. 8　Tsubaki TC Satoyama Bank

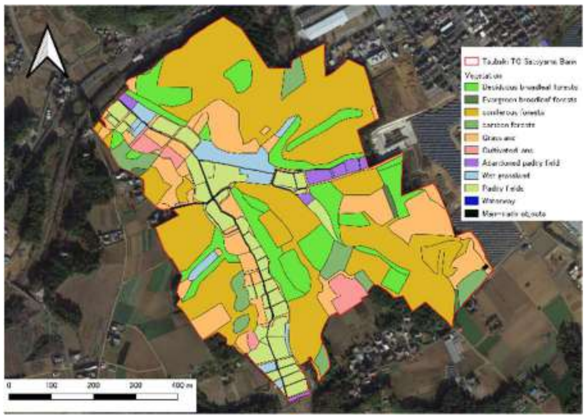

Fig. 9　Vegetation map of Tsubaki TC Satoyama Bank

Fig. 10　Activity Scenario

Year	Activities
1	Grass and bamboo cutting in the entire area
2	① Logging in order by area, Planting *Quercus acutissima* ②Grass cutting around *Celtis sinensis* and *Quercus acutissima* less than 2 m ③Grass cutting in the entire area
3	②Grass cutting around *Celtis sinensis* and *Quercus acutissima* less than 2 m ③Grass cutting in the entire area

Fig. 11　Activity Frequency

Year	Frequency
1	6 days a week (5 months from November~March)
2	①2 days a week (4 months from March~June) ②Twice a year (one day each in spring and winter) ③Once a year (one day in winter)
3	②Twice a year (one day each in spring and winter) ③Once a year (one day in winter)

Fig. 12　Evaluation results from HSI model of Sasakia charonda

Fig. 13　Evaluation results from HSIa model

４．Discussion

In this study, I organized the habitat variables and the activities that affect them, and found that an activity can affect multiple habitat variables.

HSIa model evaluates habitat indirectly by assessing activities rather than directly by assessing the state of the natural environment. It was suggested that HSIa model is a quantitative evaluation method that can be utilized without specialized knowledge and does not require much time for evaluation. HSI model evaluates the biological situation as a habitat, the survey methods are specialized. On the other hand, HSIa model evaluate activities themselves. So, anyone can reliably and quickly produce evaluation results.

And, I think citizens can active quickly and effectively to conserve Satoyama ecosystem by using HSIa model. The HSI model represents the life requirements. Activist must come up with their own activities to maintain those states, and it is difficult without ecological expertise to develop an activity plan from the information in the HSI model. On the other hand, HSIa model is structured by activity, so you can quickly identify the activities you need to do. In addition, it is easy to understand the cares to be taken for each activity.

Future work will be to evaluate actual conservation activities and verify HSIa model's functionality in the habitat of *Sasakia charonda*.

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