In What Kind of Conditions Are Wild Species Used Sustainably? -Abundant Knowledge of Biology and the Effect of Biodiversity-

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Introduction

Even if people were to live in a "traditional" manner, there is no reason to expect that wild species would be used sustainably. Before modern times and even in the pre-agricultural age, human activities have brought extinctions of wild species. Although not impossible, through all ages and in all countries, it has been difficult to prioritize medium- or long-term profit for a group of people over short-term profit for an individual person. This is not always related to interfusion of money markets or to advancement or modernization.

This paper points out that in biodiversity-rich areas, if the people have a wealth of knowledge of biology, they will tend to use wildlife sustainably without any contradiction associated with short-term profit for individual persons.

Wild species use may be a typical case of the tragedy of the commons(2)(3). Assuming that there is a useful wild species, if the people harvest the species in a self-restrained manner with an attention to the reproductive capacity of the wild species, they are likely to be able to use it continually in the future. However, most of the people would want to collect a large quantity and consume it themselves. The people who put this into practice can take much more utility than those who collect self-restrainedly in view of future use. If many such people appeared, the wild species would be collected exhaustively and eventually become extinct.

In the use of wild species, there are three ways to avoid falling into the tragedy of the commons and to make usage sustainable. Firstly, extinction can be avoided because the quantity required is limited, even if the people consume the wild species as much as they want. In other words, the utility function is saturated at a lower level than the destructive collection intensity that brings the wild species to extinction.

In fact, this is the most familiar and very important way of being able to achieve sustainable use. Although researchers pay little attention to this reason due to its commonness, we must not overlook it. This is because the relative positions of the saturation point of the utility function (maximum collection intensity when the people try to use the wild species as much as they want) and the destructive collection intensity which brings the wild species to extinction can change under conditions where people are able to choose a certain kind of wild species out of several candidates.

In the case when the more that people collect a wild species, the more they achieve unlimited utility (for example, in a situation where they collect the wild species for sale in an external market), or when the collection intensity that causes the extinction of the wild species is at a lower level than the saturation point, some measures to avoid excessive use are needed.

If the useful wild species were plants or animals of scarce mobility, people would divide the common land, so as to manage useful wild species within one's own land. Such privatization of resources is the second way of being able to achieve sustainable use of wild species.

Thirdly, people can improve their social or political institutions to control the pursuit of an individual's short-term profit, for example by setting a hunting period, restricting hunting or fishing methods, or by setting a limit to the amount of collection per person. In previous studies on the sustainability of wild species use, the discussions were mainly focused on this third way of achieving sustainability. This is certainly an important way of achieving sustainability, but it is not the only way.

What is density-dependent resource selection?

Biodiversity provides redundancy in useful wild species. If there is an abundance of species, one useful species can be replaced by another that grows in the same place. In cases where one of the three conditions mentioned below is satisfied, people tend to use the most abundant species, choosing it from numerous interchangeable candidates. Then, when the chosen species becomes scarce, people replace it with other useful species. This phenomenon is described here as density-dependent resource selection.

(Condition 1) Skill that is particularized by species

With techniques like trapping or ambush, seen in hunting and fishing, it is essential for people to refine their skills according to the target animal's behavior pattern, home range, incentive method, etc(4). Thus, if a particular skill is required for collecting a particular species, people's targets would concentrate on a single and more abundant species. Then, if that species became scarce, they would refine another skill, in order to collect an alternative species which has similar utility but different behavior or distribution range.

(Condition 2) Quality unification

Materials often need to be collected in large amounts at a time, such as building materials (in Southeast Asia, large scale construction such as construction of a longhouse involving an entire village is common), bamboo and rattan for making tools, furniture and house walls, bark and vines as rope or fiber material, several kinds of roofing materials, resin, glue, dye, sap for sugar, seasoning and so on. Such collection might be impracticable unless the materials collected have the same qualities. In such situations, people choose the single most abundant species from among the candidates. If species collected becomes scarce, another will be adopted to ensure uniformity of the material collected.

(Condition 3) Weak habituation

There are quite a lot of effective herbal medicines for the same symptom. People always apply the herbal medicine that they are most accustomed to, as long as that species is abundant and accessible. However, if it decreased in abundance, another species would become the standard one to use.

Furthermore for edible fruits, spice, side dishes, and natural ornamentation, people will use the same species repeatedly while they are abundant, demonstrating similar weak habituation to these species. But when the species become less abundant, the collectors shift to other species rather than collecting the original species excessively.

In contrast, in cases of strong habituation, a completely opposite effect is observed, and the species quickly run short. However, the continuance of wild species use rarely occurs, because wild plants with palatability such as tobacco, hemp, poppy, betel palm, betel, and durian are domesticated sooner or later due to their strong habituation.

Abundant knowledge of wildlife and effect of density-dependent resource selection

Let us consider which case enables sustainable use of wild species to be achieved easily; either when the density-dependent resource selection is practiced or not.

N stands for the total number of individuals of wild species having the same utility, and it is changeable with time. Individual numbers of each species having the same utility are n_1, n_2, ... ,n_k (at first, $n_1 > n_2 > ... > n_k$), which are also changeable with time.

$N = n_1 + n_2 + ... + n_k$

It is assumed that people use a total number of u individuals per hour.

Here, I consider three situations as follows;

(Case 1) Situation where a particular species is in use: This will occur when people do not have enough knowledge of useful wild species. In this case u individuals of single species h (invariable number) are used.

(Case 2) Situation where density-dependent resource selection is in effect: This will occur when the people have enough knowledge, and at least one of the three conditions mentioned earlier (skill which is particularized by species, quality unification, and weak habituation) is satisfied. In this case, among j (j =1,2, ... ,k) species, u individuals are used from species 1, and none is used from species 2 to k. However, when the order of numbers of individuals changes, u individuals of the species which newly occupies the first place will be used.

(Case 3) Situation where all species are in use without any distinction: This will occur when people have enough knowledge of useful wild species, but none of the three conditions for density-dependent resource selection is satisfied. In this case the individual number of species j that are taken is unj/N.」

Ecological study offers various mathematical models on community composition and population dynamics(5)(6). By applying the above cases to the mathematical models, we could examine in which conditions the extinction of wild species are most unlikely to happen. The details are due to be reported in another thesis, so here I will describe only the brief conclusion in qualitative terms without using mathematical formulas.

First, it is easily understood that extinction is most likely to happen in case 1. Although the biodiversity is high, extinction of species is caused easily when people do not have enough knowledge of useful wild species. So, the comparison between case 2 and case 3 comes into focus. Here, I will consider the issue in two distinct situations; one where species having the same utility are in competition over common resources such as food or space, and the other where there is no such relationship between the species.

Species with the same utility tend to have similar life style, and they are usually in a competitive relationship. When density-dependent resource selection is practiced (case 2), extinction is less likely to happen than when it is not practiced (case 3). Moreover, in case 2, the risk of extinction of rare species decreases compared to the natural state where there is no human use.

This reason is as follows. In case 2, the species with the highest competitive capacity declines under human impact, causing the number of individuals of suppressed species to increase. Therefore, human activities make the rare species in a natural state relatively resistant to extinction.

Resilience in number of individuals is the most important factor for the unlikeliness of extinction under the pressure of human use. From this viewpoint it is assumed that density-dependent resource selection automatically chooses the species most resistant to extinction. It is not that the people use a particular species intensively because they know it has high resilience. They are each pursuing individual profit based on one of the three conditions of density-dependent resource selection (ie; skill which is particularized by species, quality unification and weak habituation). The species most resistant to extinction is selected as a result.

Next is the situation where there is no competitive relationship between species having the same utility. For example, small grass species used for medicines or seasonings are not always competing within their community despite having the same utility or taste. In this situation, unlike the situation with a competitive relationship, extinctions of particular species will not decrease compared to the natural state. However, even in this situation, the process of the species with high resilience of number of individuals being automatically selected for standard use is almost the same as with the competitive relationship situation mentioned above. Therefore, extinction occurs less often in a situation where density-dependent resource selection is practiced (case 2) than in a situation where it is not practiced (case 3).

Where there is no competition, the initially dominant species is the one with high carrying capacity (expressed as an number of individuals K when the condition is stable enough and there is no human use). Because there is a trade-off between the carrying capacity K and the resilience in number of individuals (expressed as r), the initially dominant species tends to be a species without high value in r. Species with small values of r are not suitable for intensive use over the long term, but as a result of dominant species replacing each another as an effect of density-dependent resource selection, species with relatively high r come into standard use.

The effect of biodiversity

Rich biodiversity and poor biodiversity; in which situation can wild species use be sustainable? Following is the formulation of how species are used, in the situation of poor biodiversity.

(Case 4) Situation where biodiversity is poor: Suppose that there is only one species having some kind of utility, and its number of individuals is determined as N. As above, assume that people use u individuals per hour. The number of individuals N was previously divided into k species according to difference in competitive capacity, carrying capacity (K) and resilience in number of individuals(r), but here there should be no difference among N.

From this formulation, the ease of extinction can be compared with case 1 to case 3 above, all of which are situations in which biodiversity is rich. A detailed examination applying the various mathematical models on community composition and population dynamics is due to be reported in another thesis, so here, again, I will describe only the brief conclusion in qualitative terms.

The possibility of extinction occurrence, even in single species, is highest in case 1, where although biodiversity is rich, people's knowledge is poor. Of the rest, the next highest possibility of extinction occurring is with case 3, where although both biodiversity and people's knowledge are rich, density-dependent resource selection is not acting, followed by case 4, where biodiversity is poor and then case 2, where biodiversity is rich and the density-dependent resource selection is acting.

The reason why case 4 is lower than case 3 is that there are few individuals of each species, and in case 3, the species with low value in r, which is most likely to be extinct, is used continually. The reason why case 4 is higher than case 2 is that the species with high r is automatically selected as a standard use species in case 2, whereas in case 4 there is no such selection.

The possibility that usable species die out completely becomes lower in order from case 1, case 4, case 3, and then case 2. Here, in case 3, only species with a low value for r would become extinct, and species with a high value for r would be likely to remain alive, so case 3 replaces case 4 in the order.

Furthermore, the possibility that species potentially having value of use die out completely becomes lower in order from case 4, case 3, case 2, and then case 1. In case 1, species other than h are not used, so they are likely to survive.

Limitations of density-dependent resource selection

Species are less likely to become extinct and the risk of extinction may be even less than in the natural state (where there is no human use) when biodiversity is rich, people have enough knowledge of usable species, and at least one of three conditions for density-dependent resource selection (ie. skill which is particularized by species, quality unification and weak habituation) is satisfied. Looking over the examples mentioned above and limiting the discussion to self-sufficient resources, there are hardly any wild species resources that do not satisfy any of these three conditions for density-dependent resource selection.

From this viewpoint, there are two important conditions for likeliness of achieving sustainable resource use: (i) Usable resources have redundancy due to rich-biodiversity. (ii) The level of redundancy is not fixed, but can be enhanced by people having greater knowledge of useable species.

Lastly, the limitations of sustainable resource use through density-dependent resource selection should be considered. As I mentioned earlier, this paper discusses only the situation when the utility function is saturated. This is a quite general assumption if the wild species resources are used for subsistence. However, if the situation is that the more people collect wild species, the more they profit from high utility, then the assumption collapses completely, which means that density-dependent resource selection cannot contribute to the sustainability of resource use.

Such a situation (in which the utility function is not saturated) is assumed when the wild species resources became a target of commercialization. In this situation, either privatization of resources or communal management should be adopted to maintain sustainability of resource use. In fact, for example, fishermen who sell their catches have severe internal restrictions, and access to the resource by external persons is also limited. By contrast, there are few reports on communal resource management in collectives where diverse wild species are used for subsistence. I believe that communal management is not needed in such cases because density-dependent resource selection is available.

For maintaining biological knowledge

The idea of density-dependent resource selection is still new, so there is still a need to examine a lot of subjects both theoretically and verifiably. Although it seems risky to make many suggestions at this time, I would at least like to mention a certain point. For wild species use in biodiversity-rich area, commercial trade must be restricted but the collection and the use of species should not be excessively restricted. In such area rather they could be encouraged. People's abundant knowledge not only allows sustainable resource use, but also may result in some species having an even lower risk of extinction than in the natural state without human use. Such indigenous and abundant knowledge structures are only inherited and improved upon by continuing the habit of collecting and using the species. I would like to add that people's abundant knowledge of biology is valuable in various ways, and the aspect emphasized in this paper is just one aspect. The biodiversity, people's knowledge of biology, and their lifestyle of using abundant species, in which lies the basis of their knowledge, have to be conserved together, and this is in fact an efficient approach.

References

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