Fostering urban nature-positivity: *the Gohon no Ki* project

— An Urban Biodiversity Restoration Model Supporting Human–Wildlife Coexistence —

Where Nature Meets Happiness
「5本の樹」計画

SEKISUI HOUSE

Table of Contents

Foreword

Sekisui House has long embraced ***Love of Humanity*** as its fundamental philosophy, continuously seeking to improve the relationship between people and nature through housing development. A flagship initiative reflecting this philosophy is the *Gohon no Ki* project, launched in 2001 to promote a new vision of urban greenery through the planting of native tree species in residences.

Biodiversity loss driven by urbanization has emerged as a global challenge in our modern society. There is increasing attention towards concepts such as Nature-based Solutions (NbS), which harness ecosystem functions to address societal challenges and Nature Positive, which refers to a future of living in harmony with nature through restoration of biodiversity. It was decades before these concepts became part of the global sustainability agenda, when the *Gohon no Ki* project was launched to foster ecological restoration in cities by re-establishing relationships between native tree species and the diverse wildlife they support, in and around the place closest to people's daily lives—the home.

This white paper, developed in collaboration with Think Nature Inc., provides a scientific and quantitative assessment of the biodiversity restoration outcomes generated by the *Gohon no Ki* project over the past quarter century. It examines how the project's emphasis on the ecological quality of urban greenery over the mere provision of green space can contribute to the enhancement of ecological networks within urban landscapes.

This paper also explores the broader social and economic value created through urban ecological restoration, highlighting the fundamental role that nature plays in supporting resilient and livable cities. By quantitatively evaluating the continued efforts of the *Gohon no Ki* project, this paper explores how ecologically informed residential landscapes contribute to urban biodiversity and how biodiversity restoration can serve as a viable business opportunity for the private sector.

Executive summary

1. Background – international trends

Rapid urban expansion driven by global population growth has resulted in a substantial loss of green space adjacent to human settlements. In particular, the urban sprawl associated with the rapid economic growth between the 1950s and 1970s led to the conversion of agricultural land and forests in major metropolitan regions into built-up lands, accelerating the decline of biodiversity. In the 1990s, international concern over environmental issues intensified; however, it was not until the Kunming–Montreal Global Biodiversity Framework was adopted in 2022 that a comprehensive international agreement explicitly articulated the need for corporate engagement in biodiversity and nature conservation, including corporate disclosures and accountability measures.

The *Gohon no Ki* project, launched by Sekisui House in 2001, represents a voluntary, business-based approach to ecological restoration that preceded many of today's international action frameworks. By embedding nature recovery into commercial housing development, the initiative anticipated emerging global agendas such as the Kunming–Montreal Global Biodiversity Framework, particularly Target 12, which calls for the enhancement of green and blue spaces in urban areas to support human well-being and biodiversity. It also reflects early alignment with the principles of Nature-based Solutions (NbS), which seek to address both climate change and biodiversity loss through the integration of ecological functions into people's well-being.

2. The central proposition of the *Gohon no Ki*

The *Gohon no Ki* project is a proposal for garden and urban planning centered on native tree species that are well-suited to the local climate, environment, and wildlife, based on the principle of "Three for birds and two for butterflies, planting locally native trees", which voices the idea that small Japanese homes can be turned into biodiversity-rich habitats with well-designed landscapes. This is also an attempt to reintroduce the traditional Japanese *satoyama* landscape, a managed mosaic of ecosystems that has supported diverse biodiversity while providing people with a range of nature-based benefits, into contemporary urban environments.

To maximize the ecological benefits of greenery within the limited space of urban environments, this project emphasizes the selection of native tree species as a means of enhancing the quality of urban greenery rather than simply increasing green coverage. At the core of this design philosophy, birds and butterflies, both highly sensitive to environmental change, have been selected as indicators of habitat improvements. Belonging to different trophic levels, they are well suited to respond to ecological changes induced by urban landscape design.

Furthermore, Sekisui House has established a system that allows homeowners to select tree species themselves, based on the company's proprietary selection guidelines* that summarize the relationships between trees, birds, and butterflies. This flexibility allows for variation in the composition of tree species in individual gardens, resulting in a mosaic of heterogeneous habitat patches across urban areas. This in turn helps avoid homogeneity in planting schemes and supports richer ecological networks.

* Garden Tree Selection Book https://www.sekisuihouse.co.jp/gohon_sp/

3. Scientific bases and evaluation methods

The biodiversity that a given region can support is determined by the amount of available resources—that is, its environmental carrying capacity. In urban environments, where securing large areas of land for nature restoration is difficult, the *Gohon no Ki* project enhances resource availability per unit area by increasing habitat heterogeneity and vertical canopy structure, thereby improving the density of ecological resources, or habitat quality. To objectively evaluate this effect, this white paper adopts a scientific approach that models changes in the *Area of Habitat* (*AOH*) based on measurable environmental data.

Specifically, species distribution models estimated from more than two million occurrence records combined with environmental variables were used to identify native tree species around each residence, representing the local species pool. This local species pool was then integrated with a database of food resources for birds and butterflies, as well as species-specific canopy area data, to calculate changes in *AOH* induced by tree planting. This approach, when combined with an evaluation of pre-planting habitat conditions, enables the quantification of the net contribution of planted trees through pre-post comparisons.

4. Cumulative effects over 25 years and biodiversity net gain within property sites

Quantitative assessments presented in the current white paper consist of two parts: 1) cumulative biodiversity benefits and 2) pre-post comparison per residence.

1) Cumulative biodiversity benefits

- **Number of planted trees**: Over the 25-year period from 2001 to 2025, the cumulative number of planted trees reached over 20 million. Tree planting has been concentrated in Japan's three major metropolitan regions (Kanto, Chukyo, and Kansai).
- **Proportion of native tree species**: Of the species planted, approximately 60% are native to Japan, 45% are native to the corresponding prefecture, and 30% are native to the corresponding locality (5 km radius). The number of planted locally native tree species, as well as number of bird and butterfly species benefiting from the plantings, has shown a consistent upward trend over time.

2) Pre-post comparison of habitat quality within property sites based on sampling analyses

- **Changes in species richness:** Compared with pre-construction conditions, the total number of tree species within the property increased by 27%. In addition, the number of bird species benefiting from planted trees increased by 67%, while the number of butterfly species increased by 51%, resulting in an overall 49% increase in total species richness.
- **Changes in *Area of Habitat* (*AOH*):** A comparison of pre- and post-implementation conditions showed that the *AOH* of locally native plant species increased by 12%, while the *AOH* of benefiting bird and butterfly species increased by 28% and 20%, respectively. These results demonstrate that planting practices implemented by the *Gohon no Ki* project can create and expand on-site habitat area by approximately 20%.
- **Temporal trends:** Across Japan's three major metropolitan regions (Kanto, Chukyo, and Kansai), the average number of native tree species per property, as well as the number of benefiting bird and butterfly species, has shown a consistent growing trend over time. Likewise, the amount of habitat created through planting has steadily increased year by year.

5. Further business opportunities and way forward

Restoration of urban green spaces is not only a nature conservation effort but also an investment in green infrastructure that supports urban sustainability and economic value. Trees mitigate the urban heat island effect and reduce public health risks, thereby contributing to the maintenance of labor productivity and the containment of healthcare costs. Furthermore, it has been shown that daily contact with wildlife, such as birds and butterflies, enhances the mental well-being of urban residents and fosters a sense of psychological recovery. This represents a redefinition of the value of urban greening through the lens of the

One Health approach.

The value generated by the *Gohon no Ki* project cannot be measured simply by the number of trees planted or the improvement of urban scenery. Its broader significance lies in demonstrating that residential developments can function as drivers of biodiversity recovery. By introducing native plant species into urban environments, the project creates habitat for a wide range of organisms and strengthens the ecological functions that underpin ecosystem services in cities.

Going forward, Sekisui House aims to expand its scientific assessments beyond measuring biodiversity recovery itself to also quantify the benefits that restored biodiversity provides to people. Through this ongoing effort, Sekisui House seeks to redefine the relationship between cities, nature, and human well-being, and to help shape the future of sustainable urban development.

1. The *Gohon no Ki* project in the global context

1.1. Lost green spaces and the dawn of sustainable development

The world's population continues to grow rapidly, driving urban expansion across the globe. This trend is expected to continue through 2050 (United Nations Department of Economic and Social Affairs 2025). Population growth leads to the densification of housing and living infrastructure in cities, resulting in vegetation in human residential areas being converted into built-up lands. The decline in green spaces is a common trend worldwide (Derdouri et al. 2025; McDonald et al. 2020). Particularly from the 1950s to the 1970s, urban sprawl—driven by rapid post-World War II economic growth and population concentration—led to the intensified conversion of farmland and forested areas into urban areas in many metropolitan regions, resulting in the loss of vast tracts of green space (Foley et al. 2005).

Population growth and urban expansion have been accompanied by increasing resource consumption and environmental impacts globally. By the late 1980s, it had become widely recognized that environmental pressures associated with rapid economic growth, including deforestation and air and water pollution, posed a threat to the stability of the Earth system itself. Against this backdrop, the concept of sustainable development emerged and was formalized as a guiding framework for addressing these challenges, gaining momentum following the 1992 Earth Summit. These conceptual developments fostered a growing international recognition that economic development and environmental conservation, which had long been framed as competing objectives, should instead be integrated within the broader framework of sustainability (Figure 1). However, while international frameworks were beginning to emerge, they had not yet been translated into policy instruments, regulatory frameworks, or practical guidance for implementation at national and local levels. In particular, a comprehensive international commitment to the conservation and enhancement of biodiversity and nature's contribution to people, or *natural capital*, including the active involvement of the business sector such as mandatory disclosures of nature-related business risks and opportunities, was not formally articulated until the adoption of the Kunming–Montreal Global Biodiversity Framework in 2022.

The *Gohon no Ki* project represents an effort through which Sekisui House has translated the principles of sustainable development into practice well before they were formalized as international policy goals.

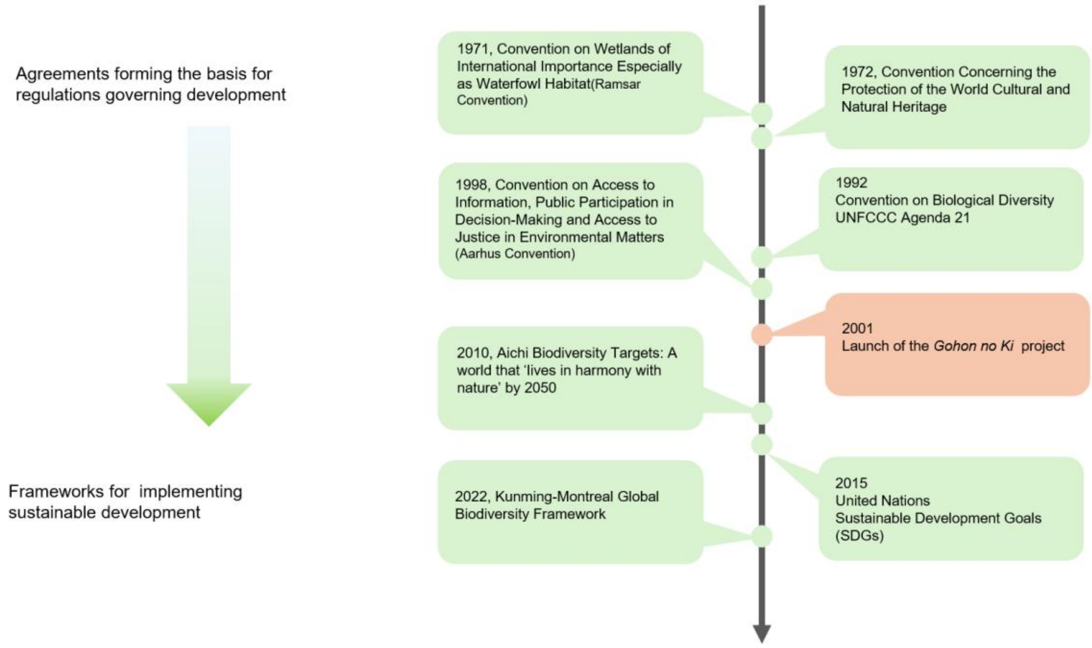

Figure 1 Progress in the international framework for sustainable development: from agreements serving as the basis for development regulations to agreements aimed at harmony with the global environment.

1.2. Evolving perspectives on urban green spaces and the progress of the *Gohon no Ki* project

Enhancing the abundance of urban green spaces and the benefits they provide is explicitly recognized in Target 12 of the Kunming–Montreal Global Biodiversity Framework, which calls for strengthening urban planning and access to green and blue spaces in support of biodiversity and human well-being. The emergence of urban nature as a central theme in efforts to promote coexistence between people and nature reflects decades of accumulated scientific evidence demonstrating its ecological and societal values.

Beginning in the late 1990s, growing concern over urban environmental challenges, including the urban heat island effect, air pollution, biodiversity loss, and impacts on human health, led to increasing recognition of the importance of nature in cities for both human well-being and biodiversity (Reyes-Riveros et al. 2021). Studies on biodiversity in urban green spaces have been increasing since 2000 (Zhao et al. 2022). However, in 2001, when the *Gohon no Ki* project was launched, green spaces were still primarily regarded as elements that supported human-centered urban planning, valued for maintaining visual attractiveness, providing recreational spaces for residents, and mitigating local heat conditions (Dempsey & Nam 2024).

By the mid-2000s, the concept of ecosystem services had become widely adopted in international policy and scientific discourse, following the publication of the Millennium Ecosystem Assessment (2005). Urban green spaces increasingly came to be viewed not merely as amenities within the urban landscape, but as infrastructure that provide a wide range of benefits, including carbon sequestration, disaster risk reduction, water purification, and improvements in mental health. In parallel with the growing recognition of this concept, research on urban green spaces and biodiversity increased rapidly after 2009 (Zhao et al. 2022).

In the 2020s, Nature-based Solutions (NbS) emerged as an integrative framework for addressing climate change, biodiversity loss and societal challenges in a harmonized manner. The concept further extended the role of urban green spaces as a core component of climate adaptation and improved wellness of people and nature. Accordingly, the role of urban nature is becoming increasingly embedded in urban policy, corporate strategies, and international sustainability agendas.

The 25-year history of the *Gohon no Ki* project can be seen as having consistently anticipated these broader societal trends. By planting native tree species, the project has helped restore biodiversity and delivered its associated benefits within residential environments under the spatial constraints of housing development. Furthermore, Sekisui House has presented a business approach based on NbS by defining planting plans that emphasize habitat functions as quality of greenery and its contribution to human well-being.

2. Core concept of the *Gohon no Ki* project

"Three for birds and two for butterflies, planting locally native trees." This succinct but poetic expression encapsulates the core idea of the *Gohon no Ki* project. The guiding principle derives from *satoyama*, Japan's traditional semi-natural landscape. In *satoyama*, human residences and wildlife habitats existed in close proximity, forming a mosaic of vegetation that supported a variety of native tree species through continuous human management. People benefited from the resources and ecosystem services provided by these landscapes, which in turn motivated their continued stewardship. The *Gohon no Ki* project is an effort to reestablish the connections between native biodiversity and local people within contemporary residential environments.

Native tree species adapted to local climatic and environmental conditions contribute to the multifunctionality of urban green spaces. Because they are well suited to local conditions, they are generally more resilient to environmental stress than introduced species. Moreover, having coexisted and interacted with other species in the region over long periods of time, they can provide ecological resources for a wide variety of local wildlife. In urban residential environments, where planting space is inherently limited, enhancing the ecological quality of green spaces requires careful consideration of how that space is designed. At the core of this approach is planting design centered on native tree species, which can simultaneously support both biodiversity and the benefits that nature provides to people.

In the *Gohon no Ki* project, the role of planted trees extends beyond mere scenic elements; they serve as habitats close to home that connect people and ecosystems. To make these benefits more perceptible, the *Gohon no Ki* project focuses on birds and butterflies as indicator groups. Because birds and butterflies are highly mobile, they can locate and utilize restored habitats relatively quickly. Gardens that attract a greater diversity of these species can be considered to provide higher habitat value. This is the essence of the guiding concept, "Three for birds and two for butterflies." This translates the ecological richness generated by planting into forms that people can interact with and appreciate in their daily lives.

This connection with nature is made even more tangible through the project's emphasis on personal choices. Homeowners can select tree species according to their own preferences from the Garden Tree Selection Book, a planting guide that introduces native tree species along with the birds and butterflies that they attract. Such a process facilitates an active involvement for residents to experience biodiversity in their everyday lives. When birds and butterflies visit a tree that they have chosen themselves, the biodiversity that has been restored through their planting efforts becomes more enjoyable in everyday life. Such experiences help revive the relationship between people and nature, which lies at the heart of the *Gohon no Ki* project.

This flexibility by design also has ecological significance. By allowing homeowners to select different combinations of native tree species, the project creates a diverse mosaic of habitat patches across residential landscapes. Heterogeneous habitats can support a wider variety of species regionally. This habitat heterogeneity contributes to improving the quality of the ecological network (e.g., Soga & Koike 2012; Graham et al. 2017; Ohlmann et al. 2024).

Planting native tree species not only contributes to biodiversity but also provides multifaceted benefits to residents. Because native tree species are well adapted to local environmental conditions, they generally require less intensive management and reduce the need for inputs such as chemical treatments, thereby lowering environmental impacts associated with maintenance. Such locally adapted compositions of planted trees are more tolerant of environmental stress and are likely to persist over the long term, while also allowing seasonal changes in planted vegetation to be more perceivable throughout the year. As green spaces mature over time, they enhance the attractiveness of residential environments and may contribute to increased property values at both the household and streetscape scales, which can be described as *keinen-bika* (gradual improvement in aesthetic attractiveness over time).

Moving beyond simple residential greening, the *Gohon no Ki* project is a continuous process of positioning individual gardens as ecological habitat patches and connecting them to form and maintain a rich, semi-natural landscape across the entire region. The project is structured to maximize habitat functionality within constrained urban spaces, creating a system that allows humans to directly enjoy the resulting ecosystem services (the benefits of nature). In modern society, where transitioning toward Nature Positive is a matter of utmost urgency, the *Gohon no Ki* project stands as a pioneering initiative. From a business perspective, it successfully embodies Target 12 of the Kunming–Montreal Global Biodiversity Framework, which calls for expanding green spaces in urban development and mainstreaming biodiversity.

Note: *Gohon no Ki* means "Five Trees" in Japanese. This does not imply that only five trees are planted in each home; rather, it reflects the idea of making the most of limited space in each individual home. This idea is captured in the phrase “Three for birds and two for butterflies...” from which the name *Gohon no Ki* (“Five Trees”) is derived, with five representing the sum of three and two. The phrase should not be interpreted as prescribing a fixed planting ratio. Instead, it conveys the principle of supporting birds and butterflies, which occupy higher trophic levels, through planting of native tree species that provide ecological resources underpinning local ecosystems.

3. Science behind the *Gohon no Ki* project

3.1. How does planting native tree species contribute to biodiversity restoration?

3.1.1. Resource availability: a fundamental factor driving carrying capacity for biodiversity

All species require resources for survival. The amount of biodiversity that a given area can support is determined by the availability of these resources, that is, its environmental carrying capacity. Carrying capacity is governed by both the extent of habitat available and its quality, defined as a per-unit ability of habitats to provide resources for species. Habitat restoration through planting can enhance carrying capacity and thereby support the persistence and recovery of populations across multiple species. Useful theoretical frameworks for linking population persistence to habitat dynamics include the theory of island biogeography proposed by MacArthur and Wilson in the 1960s (MacArthur & Wilson 1967) and metapopulation theory, further developed by Ilkka Hanski in the 1990s (e.g., Hanski et al. 2000).

Whether a species can persist in a specific region is determined by the density of resources required for its survival, such as food and nesting sites. If food resources are too sparsely distributed across the landscape, local populations cannot maintain reproductive rates that exceed mortality, leading to local extinction (Figure 2). The sets of resources utilized vary among species. Generalists, which can utilize a wide range of resources, and specialists, which depend on specific resources, differ in their capacity to persist under given environmental conditions. Butterflies that depend on specific tree species, for instance, will find it difficult to survive if densities of those trees decline. However, the underlying principle is common.

In ecosystems where populations of species are sustained, such as natural forests, abundant food resources enable many species to maintain populations above their persistence thresholds. In contrast, in urban environments, resources are often insufficient for some species to meet their survival threshold. Planting native tree species in urban and suburban areas increases both the total amount and density of resources. As a result, the population sizes of species that utilize resources provided by these trees increase. Furthermore, if enough trees are planted or a total area size of restored habitats is large enough, there is a possibility that species that were once regionally extinct may re-establish their local population. This means that resource density has exceeded the survival threshold for that species. In this way, increasing the resource of native tree species contributes to an increase in both population size and species richness—that is, to the restoration of biodiversity.

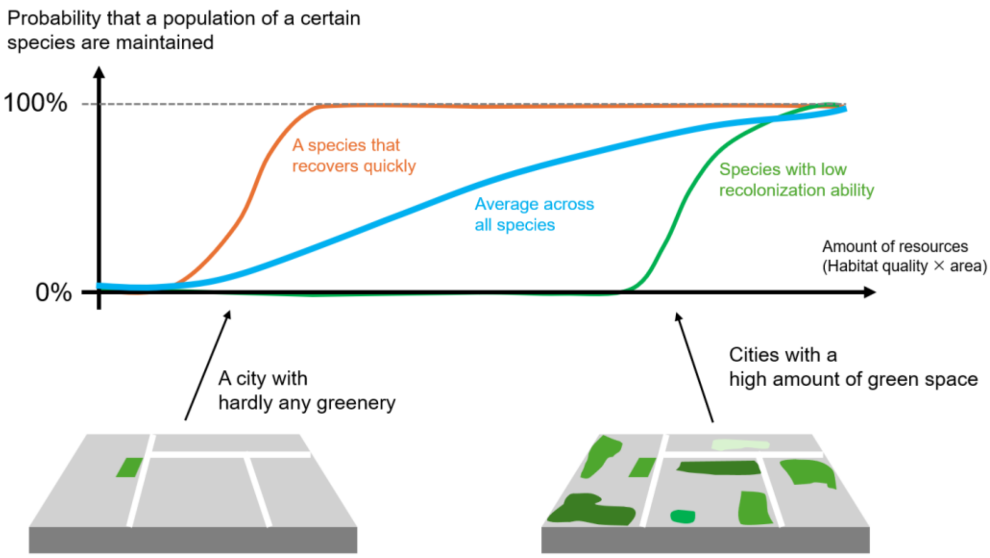

Figure 2 A conceptual diagram illustrating the process by which habitat restoration contributes to population recovery. In areas with poor vegetation cover, a majority of species fall below the threshold required for population maintenance, and most species cannot survive. When the number of available resources increases—either through the expansion of green space or improvements in habitat quality (resource abundance per unit area)—more species can reestablish local populations.

3.1.2. The value of improving habitat quality

The restoration of biodiversity is, at its core, the process of increasing the resources available to living organisms. In urban environments, however, it is difficult to secure large expanses of land for species habitats, as in natural ecosystems, and therefore simply expanding habitat area has clear limitations. Instead, within a constrained spatial extent, it becomes essential to enhance resource availability per unit area, that is, the *quality* of habitats. A key feature of the *Gohon no Ki* project lies in improving this ecological quality through the use of native tree species, thereby enhancing habitat quality in urban environments.

Habitat quality here refers to the extent to which resources available to species are densely distributed in space. For example, compared with a monotonous planting consisting only of canopy trees, environments that incorporate a multi-layered structure of canopy, sub-canopy, and understory vegetation generate more heterogeneous light and moisture conditions, and in turn produce a wider variety of resources such as leaves, flowers, fruits, bark, and leaf litter. As a result, such environments can support a broader range of species occupying different ecological niches. In this sense, increasing spatial heterogeneity and vertical stratification of vegetation is equivalent to increasing the density of usable resources per unit area.

Operationally, this concept can be defined as the extent to which a given area can provide habitat conditions usable by a large number of species. Its implementation rests on two main components. First is the formation of a vertically structured vegetation layer. A good combination of understory and canopy trees enables the coexistence of species with different resource requirements. This represents a qualitative improvement in habitat conditions that cannot be achieved simply by increasing the number of planted trees.

Second, planting design should be informed by the potential species pool of the locality, that is, the metacommunity, to maximize its ecological benefits. Because species differ in the resources they utilize, the composition of planted tree species shapes the resulting food-web structure. It is therefore important to consider geographical distribution of species and ecological interaction networks, and to select a set of trees that can provide resources for a wider range of locally native tree species. This goes beyond simple greening and instead represents a planting strategy aimed at restoring region-specific food webs and ecosystem functions.

BOX 1 Discussion on the concept of *habitat quality*

It is important to note that when referring to the *quality* of a habitat, there is no strictly defined, measurable amount or volume. Although the basic concept of "how desirable the habitat condition is for a species or a set of species" is shared, quality has been defined and operationalized in different ways depending on the research/implementation objectives and focus. One approach defines habitat quality in a bottom-up manner based on directly observed biological performance, such as survival rates, mortality rates, or individual traits (e.g., body size or health condition) (Johnson 2007). However, measuring such field-oriented indicators at broad spatial scales is often difficult in practice. Other approaches define habitat quality based on environmental conditions (Santos et al. 2008). In such cases, habitat quality is assessed by the presence or abundance of habitat attributes known to benefit target species or communities, such as presence of a certain tree species, vegetation structure, or naturalness.

In applied contexts, how *high-quality* habitat is defined is closely linked to operational decisions regarding conservation or restoration goals and how such outcomes are measured. It is also possible to include components such as carbon sequestration, which represent aspects of ecosystem function distinct from biodiversity itself. In this sense, what is included or excluded in the definition of *quality* depends on the purpose for which the concept is used. Such choices are therefore context-dependent and are not determined purely by scientific reasoning alone.

The evaluation of the *Gohon no Ki* project conducted in this paper defines *quality* of habitat specifically in terms of providing habitats for species, reflecting the project's objective of restoring urban biodiversity. Specifically, the analysis focuses on birds and butterflies and considers that planting that provides resources for more species per unit area has a higher *quality*. Regarding the decision to focus on specific taxonomic groups as a target of evaluation, refer to the discussion on surrogates in this paper.

3.2. <u>How to evaluate the effectiveness of the restoration action</u>

3.2.1. The need for models

Urban greening contributes to increasing the survival probability of species populations through the process of increasing the density of resources available to each species. Then, how should one quantify this effect? The most intuitive method would be to directly count the actual increase in population size or species richness. However, this method does not work well in practice. This is due to extinction debt, colonization lag, and the presence of stochasticity in population dynamics.

Changes in habitat conditions do not always translate immediately into changes in species community; instead, there is often a time lag before ecological responses become apparent. For example, when forests are lost and fragmentation progresses, a phenomenon known as *extinction debt* can occur. This refers to a situation in which resource densities have already fallen below the threshold required for population persistence, yet remnant populations do not disappear immediately and instead decline gradually toward extinction over a period of years to decades (Figure 3a). The length of this time lag until extinction varies substantially depending on the ecological characteristics of each species.

In contrast, even when habitats suitable for species increase, there is often a time lag before locally extinct species can re-establish. This delay is referred to as *colonization lag*. Its duration depends strongly on species-specific traits such as dispersal ability, as well as the distance to and size of source populations in surrounding areas, and landscape connectivity (Figure 3b). For a planting site to be occupied by species, a certain level of improvement in the surrounding environment is required, often through other complementary measures. It therefore takes time for improvements in habitat quality at individual sites to be reflected as detectable changes through field observation of species.

Furthermore, population fluctuations of species are greatly influenced by probabilistic factors, such as year-to-year climate variability and fluctuations in natural environmental productivity, such as variations in fruit yield. These uncertainties are referred to as stochasticity. Periodic population fluctuations observed between predators and prey are other factors that strongly influence population dynamics.

The presence of such uncertainties indicates that it is inherently difficult to evaluate the effectiveness of localized habitat restoration activities, such as tree planting, based solely on direct observations of species occurrences. Observed changes in population size are strongly confounded by time lags and stochastic variation operating at both broad and local spatial scales. Field surveys are costly to conduct, and whether a species is detected at a given site is heavily influenced by chance. As a result, direct observations of species presence are inherently unstable as a metric for evaluating the contribution of corporate restoration activities where cost-effectiveness is of particular relevance. Therefore, to obtain effective and reliable assessments of habitat restoration, it is essential to adopt an approach that models change in the availability of resources that can be utilized by species, based on measurable environmental features.

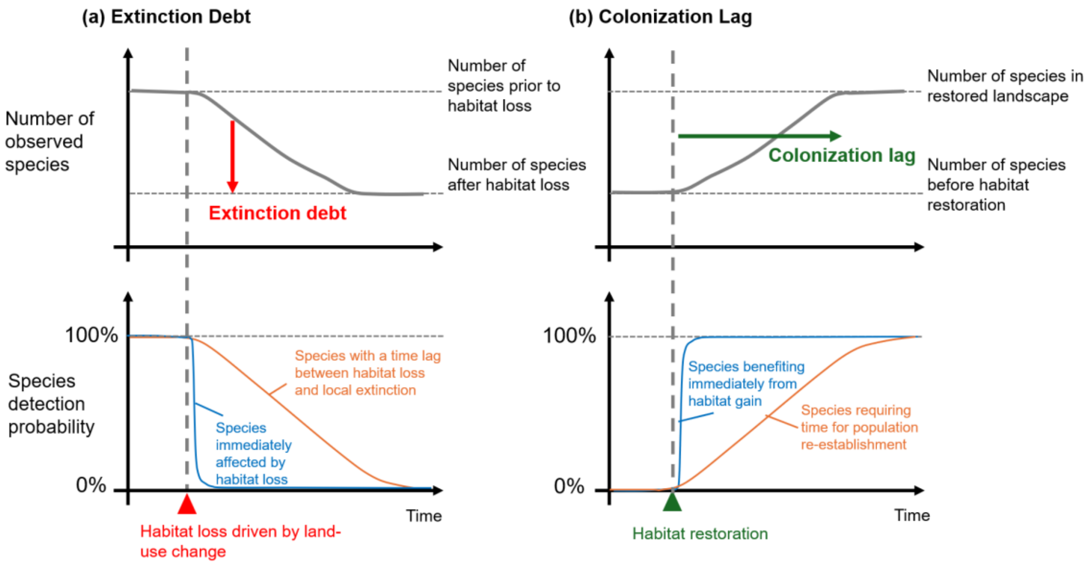

Figure 3 Conceptual diagrams of extinction debt (a) and colonization lag (b). Because habitat improvement takes time, a sequential time lag emerges between the initiation of habitat restoration and the eventual establishment of species.

3.2.2. Requirements for measurement models to quantify restoration effects

First, evaluation indicators must align with the objectives of the action. The urban planting targeted by the *Gohon no Ki* project promotes biodiversity restoration by enhancing habitat quality and connectivity within a limited area and increasing the amount of resources available to species. Indicators used to evaluate effectiveness must reflect these processes of resource increase and the recovery of ecosystem networks.

The extent to which restoration activity provides benefit for a range of species also matters in restoration projects of urban biodiversity, where per-area contribution to biodiversity is important. Interventions should not be assessed solely in terms of benefits to a small subset of focal species, but rather in terms of their potential to benefit a broader range of taxonomic groups. Accordingly, evaluation metrics need to incorporate the perspective of how well a restoration intervention can contribute to the restoration of overall ecological network structure.

Evaluation frameworks must clearly state the limitations of the targeted intervention. In an urban environment, there are groups of species and ecosystem functions that are difficult to restore due to constraints related to land use and human disturbance. For example, large mammals that require contiguous areas of forest for their habitats are difficult to restore through urban planting alone. Consequently, assessments of restoration effects must transparently indicate not only what they are effective for but also what they cannot sufficiently restore. Clearly articulating both the potential and the limitations of biodiversity restoration is crucial for scientific validity.

Another key consideration is that urban nature restoration is closely linked to social acceptability. Because urban spaces are settings in which human activities and natural environments coexist, the quantitative evaluation of restoration outcomes is closely tied to communication with citizens and processes of consensus building required for project continuity. Accordingly, evaluation metrics must be grounded not only in ecological validity, but also in their clarity and accessibility for non-specialist audiences, as well as their acceptability in societal contexts. Here, taxonomic groups such as birds and butterflies, which are familiar and easily recognized by the public, can more intuitively communicate the benefits of planting interventions. In this sense, the use of such groups as indicators has value in facilitating social sharing and understanding of biodiversity restoration outcomes in urban contexts. The *Gohon no Ki* project has recognized the significance of public acceptance, framing its concept as “Three for birds and two for butterflies, planting locally native trees” thereby presenting a form of urban ecological restoration that is understandable and widely acceptable to stakeholders including homeowners.

BOX 2 The use of surrogate in biodiversity measurement

All decision-making regarding biodiversity must accept the principle that it is impossible to measure and quantify everything in nature. Therefore, it is necessary to establish simplified metrics appropriate for specific purposes, which are referred to as surrogates. The purposes of surrogates vary, and in many cases, the optimal choice depends on the specific circumstances.

One context in which surrogates become necessary is spatial conservation planning. Because it is not possible to obtain complete information on the distribution of all components of biodiversity (i.e., habitats, species, and genetic diversity), conservation strategies are often designed to maximize benefits by using a subset of species or habitats as proxies for entire biodiversity.

In this context, different types of surrogate species may be selected, including indicator species, which are empirically known to reflect ecosystem conditions; umbrella species, whose large habitat or resource requirements imply the presence of many other species; and flagship species, which attract high public attention and serve as symbols for conservation efforts (Caro & O'Doherty 1999). In addition, surrogates may also be based on land use patterns or the spatial structure of habitats.

An important point is that the meaning of surrogates differs between conservation planning and the evaluation of biodiversity restoration actions. The former corresponds to *management surrogates*, while the latter corresponds to *indicator surrogates* (Hunter et al. 2016). *Management surrogates* refer to specific species or structural features of ecosystems that are used in management decisions in conservation planning and resource allocation. *Indicator surrogates*, in contrast, are proxy measures used to assess ecosystem condition. For example, indicator species or indicator taxonomic groups may be used to represent changes in habitat quality resulting from restoration actions.

The surrogates used to quantitatively evaluate the effects of the *Gohon no Ki* project correspond to *indicator surrogates*. It is important to note that the use of surrogates is not necessarily based on direct observation. As discussed in relation to extinction debt and colonization lag, habitat evaluation based on field observations of species presence is not always practical in urban environments. In this paper, for birds and butterflies used as surrogates, the benefits of planting actions are quantified in terms of the increase in potentially suitable habitat area generated by planted trees.

In summary, to quantify biodiversity restoration outcomes, it is essential to define appropriate surrogates based on multiple operationally important dimensions, including the objectives of the intervention, measurability, and ecological validity.

3.2.3. Measuring effects using birds and butterflies as indicators

In the quantitative evaluation of the *Gohon no Ki* project presented in this paper, the amount of habitat for birds and butterflies restored through tree planting is used as an indicator of biodiversity restoration effects. As noted above, even when the total planted area is the same, the set of species that can utilize a site varies depending on the combination of planted tree species. For example, larvae of butterflies that depend on specific host plants cannot survive in the absence of their corresponding plant species. Similarly, bird species differ in the resources they rely on, including fruits, insects, and tree cavities (Beninde et al. 2015). Therefore, quantifying an increase in green cover alone is insufficient to capture the effect of planted trees; the composition of tree species determines the resulting food-web structure and the set of species that benefit from planted trees. Based on this perspective, planting designs that provide resources for a larger number of species per unit area are defined here as higher-quality habitat restoration. In other words, higher habitat quality refers to planting designs that increase the area of suitable habitat for a greater number of bird and butterfly species.

Referring to birds and butterflies as indicators has two main advantages. First, these groups occupy different trophic positions and can therefore reflect changes in ecological network structure at multiple levels (Figure 4). Thus, green volume generated by native trees indirectly captures benefits for other taxa that also utilize habitats created by these trees. In this sense, an integrated evaluation framework based on trees and higher-level taxa such as birds and butterflies can represent the overall structure of restored urban biodiversity. Such multi-trophic approaches are also used in spatial conservation planning at national scales in Japan (Kubota et al. 2017; Lehtomäki et al. 2019). Second, both groups are highly mobile, making them responsive to changes in habitat conditions resulting from urban planting (Blair 1999; Cooper et al. 2024) (Figure 5). This characteristic not only supports their ecological validity as indicators but also enhances their practical utility for detecting the effects of urban greening interventions. In addition, birds and butterflies are well studied in terms of their ecology and distribution, which improves the reliability of the underlying data.

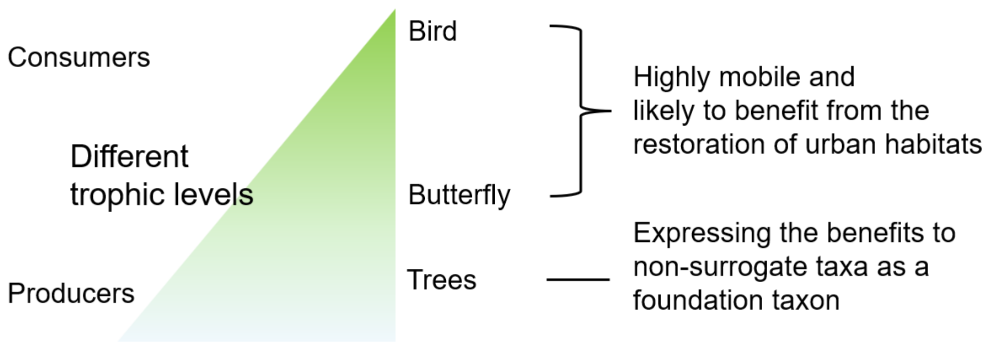

Figure 4 Multi-trophic approach for evaluation of biodiversity restoration.

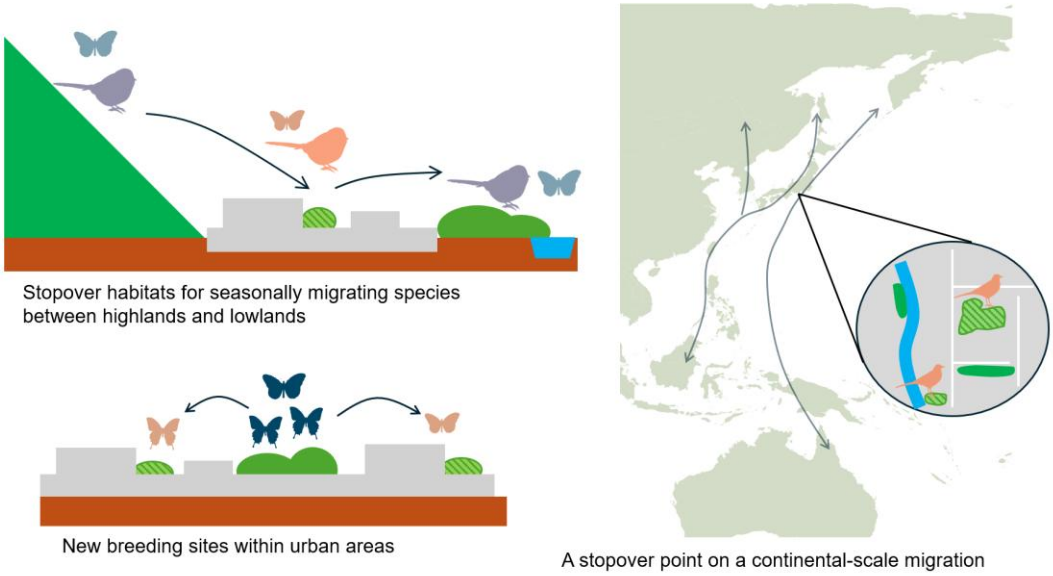

Figure 5 Birds and butterflies are mobile and thus likely to benefit from improvements in small habitats.

3.2.4. Formulation of habitat gain

In locations where a species potentially occurs—either because local population exists in the vicinity or because the species regularly passes through the area—planting tree species that provide usable resources for that species increases the total amount of resources available to it. This increase can be reasonably quantified in terms of green volume contributed by individual trees. Although the effect of a single tree is very small, it accumulates and becomes substantial as the number of planted trees increases. In this paper, the increase in available resources is measured as changes in canopy area resulting from planting and expressed as changes in habitat area. Using area as the unit of quantification has the advantage of improving comparability across cases and making the magnitude of the effect easier to interpret. The canopy area gained per planted tree is estimated using data that parameterizes canopy expansion over time as a function of tree growth.

The set of species that potentially occur in a given place is referred to as the species pool. This is a key concept linking macro-scale processes of species dispersal and evolution with local community composition (Cornell & Harrison 2014). Planting benefits accrue to those species within the local species pool whose resource availability is enhanced by the planted vegetation. In the quantitative evaluation of the *Gohon no K*i project presented here, this local species pool is derived using species distribution models (SDMs) (Box 3).

BOX 3 Obtaining local species pools using species distribution models

The concept of a *species pool* allows us to address the hierarchical nature of the processes involved in the formation and maintenance of biodiversity. A species pool refers to the totality of species that potentially occur in a given location, although the scale varies depending on the phenomenon under consideration. This includes species not currently observed directly at that location—that is, locally extinct species or species that are difficult to observe due to low population densities. When a species occurs in a certain location, this is driven not only by the current environment but also by long-term, wide-scale processes spanning tens of millions of years. For example, the Japanese population of rock ptarmigan (*Lagopus muta japonica*), which is distributed in the alpine zones of the Chubu region, is a species that dispersed from the continent to Honshu during the glacial periods hundreds of thousands of years ago.

Therefore, to identify species that can occur in a locality, it is necessary to use methods capable of capturing broader patterns of biodiversity, rather than relying solely on observational records from that specific locality. Species distribution modeling (SDM) has proven effective in addressing these challenges (Murphy & Smith 2021). SDM allows for the visualization of species' ranges by integrating various types of information based on observation records and empirical knowledge. Typically, such modelling methods are applied on spatial resolutions ranging from a few kilometers to tens of kilometers, which are suitable for modeling the effects of a species' adaptation to its environment and its dispersal history.

To map species distribution ranges on a large spatial scale, various information sources—such as species observation records, habitat information, and expert knowledge—are utilized, and each method has its own advantages and disadvantages (Elith & Leathwick 2009). Among these, the approach that links observational data and environmental variables through statistical learning offers the advantages of a reproducible analytical process, transparency due to the ability to quantitatively evaluate model performance, and the ease of modeling the effects of environmental variability. In evaluating the effectiveness of the *Gohon no Ki* project, species distribution models for Japanese plants and vertebrates created by Lehtomäki et al. (2019) were used to obtain local species pool across Japan. In this study, more than two million species occurrence records were combined with a wide range of environmental variables, including climate, soil, geology, topography, and geographic information, to map species distribution probabilities at a 1 km grid resolution. The predictions were generated using a statistical learning method known as the Maximum Entropy Model (MaxEnt) (Phillips et al. 2006). In addition, the resulting outputs were refined using regional checklists at the level of prefectures and islands, producing spatially explicit distribution datasets that map the potential range of individual species.

By combining the resulting estimates of local species pool with changes in habitat area at finer spatial scales, it is possible to calculate species-specific habitat area, referred to as *Area of Habitat* (*AOH*). This metric can be interpreted as being proportional to the amount of resources available to a given species. Although it does not directly represent population size, it can be used as an indicator of trends in biodiversity change (e.g., Crawford et al. 2024). In this paper, biodiversity change is quantified based on the same idea, using species-specific areas of habitat as the core indicator.

Within a local species pool, which species benefit from which planted trees can be explicitly defined by listing the species that utilize each candidate tree species as a resource. In the quantitative evaluation of the *Gohon no Ki* project, such lists include bird species that feed on fruits, as well as butterfly species that visit flowers for nectar or use leaves as host plants. This information can be compiled by integrating multiple data sources, including field guides for birds and butterflies, reference books documenting plant–animal interactions, and individual observational records. In practice, Sekisui House has compiled such information into the *Garden Tree Select Book* and provides it to customers.

By formalizing the relationship between native tree species and the species that benefit from them, it becomes possible to quantify how much benefit each species receives from the increase in green volume generated by a given planting scheme (Figure 6).

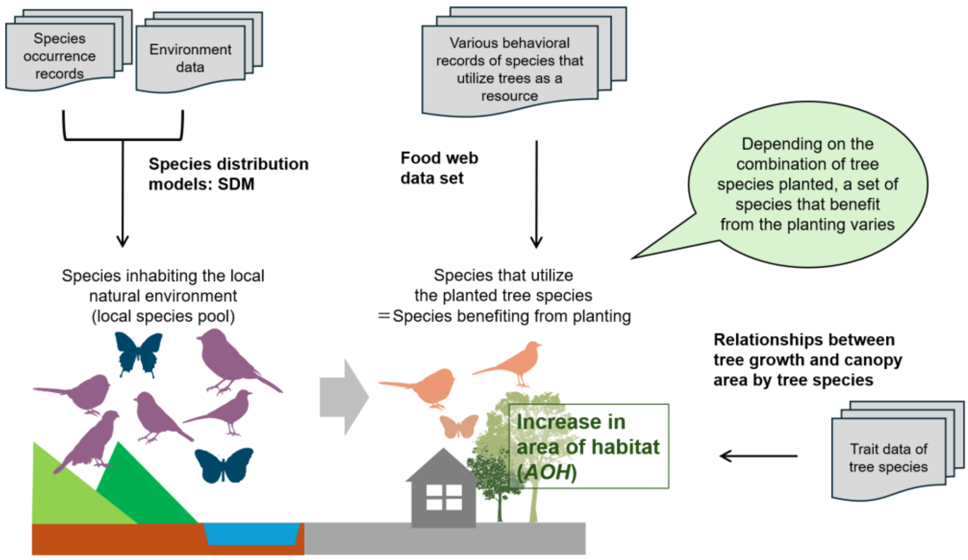

Figure 6 Data integration approach to quantify an increase in Area Of Habitat by planted trees.

3.3. In what context should biodiversity gain be claimed?

Evidence that a given restoration initiative has contributed to biodiversity gain can be scientifically demonstrated through the amount of habitat gained. However, interpreting what such an increase means is not straightforward.

Biodiversity restoration actions may be implemented as part of larger projects, including compensatory measures for biodiversity losses. In such cases, the goal may be to achieve no net loss or net positive outcomes. In other cases, however, such actions are undertaken primarily as standalone initiatives for communication or demonstration purposes and are not necessarily framed within a strict compensation context. These differences can be summarized as a question of what the assessment of biodiversity gain is intended to achieve. A central issue along this dimension is how the outcomes of an intervention are related to biodiversity losses elsewhere. This can be framed in terms of whether the nature-friendly action is aligned with the mitigation hierarchy (Moilanen & Kotiaho 2018).

When biodiversity gains from habitat restoration are compared against losses in corporate biodiversity accounting, several perspectives need to be considered. First, there is the question of how gains and losses are quantified. If the purpose is simply to demonstrate that conservation or restoration activities generate biodiversity gains, there is considerable flexibility in the choice of indicators. However, when gains are explicitly compared with losses, the indicators used must be consistent with those used to quantify losses. Second, the spatial and organizational boundaries used to assess gains and losses strongly influence the evaluation. Losses may be assessed at the project level, but they may also be aggregated across all operational sites where a company has direct impacts. Furthermore, incorporating biodiversity losses occurring at different stages of the supply chain allows for a more comprehensive comparison. In some cases, a project may appear to generate net gain locally, while a broader accounting of corporate activities reveals substantial net losses. Third, the choice of baseline against which biodiversity gains are evaluated is critical. An inappropriate baseline can undermine the validity of the entire assessment. It is therefore necessary to quantify biodiversity change relative to a counterfactual scenario, namely what would have happened in the absence of intervention, and to evaluate how much more favorable the observed outcome is. An additional issue concerns how gains and losses in biodiversity should be compared. For example, it is generally not justifiable to offset the loss of wetlands caused by land development with the restoration of forest habitats through planting, since wetlands are often more irreplaceable ecosystems that support a higher number of rare and specialized species.

Estimating biodiversity gains and losses as the product of habitat area and habitat quality provides one reasonable approach for comparing gains and losses. Whether no net loss or net positive outcomes have been achieved is defined by the balance between these two components. Even if high-quality green spaces are created, the overall balance remains negative (net loss) if the initial loss associated with development exceeds the gains. It is not justifiable to ignore this total loss and selectively highlight only the gained components in order to claim net positive outcomes. Conversely, even in cases where the area of loss is substantial, it is theoretically possible to achieve a net positive outcome if the pre-development habitat was of very low quality and the post-development condition results in a substantially higher-quality green space. This is particularly relevant in urban redevelopment contexts, where there is often significant scope to improve both the quantity and quality of green spaces relative to previous conditions. As a result, net positive outcomes may be more readily achievable. However, claims that a very small area of restoration offsets losses over a much larger area may raise questions about the underlying assumptions and analytical premises.

However, the choice of temporal scale and baseline for evaluating gains and losses inevitably involves subjective judgment. When an organization restores habitats in areas it previously altered, such actions can be evaluated as on-site efforts to improve environmental conditions. Conversely, claims of having achieved net positive outcomes are often not persuasive if they disregard the losses previously caused by the same organization in the same place. In contrast, when an organization acquires land that has been subject to habitat-destructive development by other organizations and undertakes restoration, claims of net positive outcomes based on a before-and-after comparison are in some cases more readily accepted.

The extent to which such comprehensiveness is taken into account determines how far nature-friendly activities conducted by companies can be justified and articulated. For example, the fact that a single development project has achieved net gains in biodiversity does not *per se* justify the conclusion that the company's overall activities result in net positive biodiversity outcomes. In general, it is extremely difficult for voluntary conservation and restoration actions alone to fully offset biodiversity losses generated across corporate activities. For this reason, corporate reporting of biodiversity outcomes requires a careful balance. Overly positive representations that exceed the underlying evidence are scientifically misleading and may lead to accusations of *greenwashing*. Conversely, excessively restrictive reporting may fail to support continued investment, external recognition, or brand value creation, thereby undermining the long-term sustainability of such initiatives. Accordingly, it is important to explicitly define the scope of activities and impacts included in the assessment, while contextualizing the results to be both scientifically defensible and accessible to external stakeholders.

BOX 4 Biodiversity restoration effects of the *Gohon no Ki* project

The quantitative assessment of biodiversity restoration effects presented in this paper for the *Gohon no Ki* project evaluates changes in habitat area the project has produced as of 2026. For residential plots where planting has been conducted, a before-and-after comparison is conducted to quantitatively evaluate what has been gained and what has been lost. This study presents results for residential plots where the *Gohon no Ki* project has been implemented and does not entirely cover Sekisui House's business activities.

The *Gohon no Ki* project is not designed to strictly comply with the mitigation hierarchy in a formal sense. It is not intended as a compensatory measure for biodiversity impacts arising from Sekisui House's operations, but rather as a voluntary contribution to biodiversity restoration through business activities.

Consistent with this framing, the objective of this study is to quantify within-project net gains based on a before-and-after comparison. Accordingly, when the pre-intervention condition corresponds to forest, a reduction in tree cover resulting from planting is accounted for as a loss of tree cover. The analysis includes habitat losses that cannot be compensated within the scope of the *Gohon no Ki* project itself, such as the conversion of paddy fields or reservoirs into residential areas, which cannot be restored through tree planting. However, losses occurring outside the boundary of the project's activities, including impacts embedded in upstream supply chains or biodiversity losses associated with housing construction prior to the introduction of the project, are not included in the assessment.

Thus, the biodiversity restored through the *Gohon no Ki* project represents only a subset of the overall biodiversity impacts associated with Sekisui House's business activities. Nevertheless, demonstrating the restoration effects of native tree planting remains highly meaningful. The significance of this study lies in showing that biodiversity restoration is feasible even within corporate business activities. Furthermore, by empirically substantiating these effects based on scientific evidence, it provides a practical basis for integrating biodiversity restoration into corporate decision-making and business strategy. These insights may contribute to the broader promotion of biodiversity restoration initiatives across diverse business activities.

4. Quantitative evaluation of the *Gohon no Ki* project: analytical methods and quantified effects

4.1. Structure of this section

This section first describes the biodiversity-related data used to quantify the biodiversity restoration effects of planting (4.2). Data on species distribution and ecological information (4.2.1 and 4.2.2) are introduced first, followed by the conceptual framework for quantification (4.2.3), the compilation of planting history data (4.2.4), and the approach used for pre–post comparison and scenario analysis (4.2.5). The results are then presented in 4.3, beginning with changes in the number of planted species (4.3.1), followed by per-site contributions (4.3.2), temporal trends across all sites (4.3.3) and magnitude of habitat loss associated with the project (4.3.4). Finally, a scientific approach for further improving the biodiversity contributions of planting, based on these results, is introduced (4.4).

4.2. Background data and quantitative approaches

4.2.1. Species distribution data and definitions for native tree species and for species potentially benefiting from planted trees

An overview of species distribution modeling was provided in the previous section and Box 3. Here, a brief description of the data used in the analysis is presented. Figure 7 shows the modelled distributions of the Azure-winged magpie (*Cyanopica cyanus*), the Spangle (*Papilio protenor*), and Chinese bayberry (*Myrica rubra*) in Japan. For species that undergo seasonal movements, occurrence records from all seasons were incorporated into the distribution modeling. This approach makes it possible to identify species that may use a given location as habitat at some point during the year. The distribution models were developed at a spatial resolution of 1 km (Figure 7).

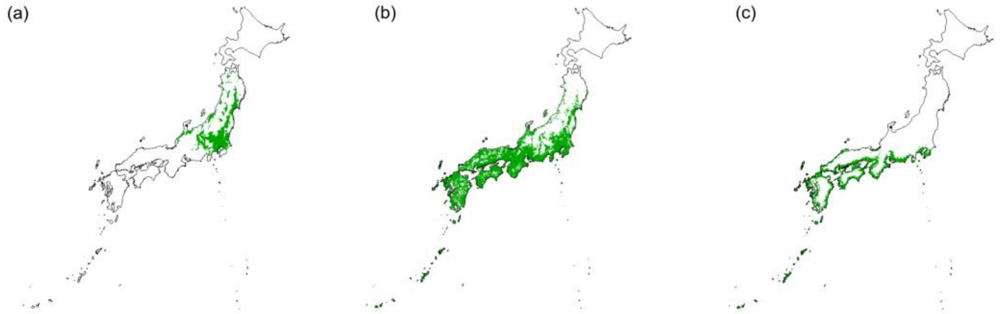

Figure 7 Native distribution ranges of (a) Azure-winged magpie (*Cyanopica cyanus*), (b) the Spangle (*Papilio protenor*), and (c) Chinese bayberry (*Myrica rubra*) in Japan mapped by species distribution modeling (green areas indicate distribution ranges).

Using species distribution data developed at a 1-km grid resolution, tree species were classified into the following nested categories. A species was classified as a locally native if at least one occupied grid cell occurred within 5 km of the property. A species was classified as a native to a prefecture if at least one occupied grid cell occurred within the prefecture where the property was located, excluding records restricted to oceanic islands such as the Izu and Ogasawara Islands. A species was classified as a native to Japan if at least one occupied grid cell occurred anywhere within Japan. Further, because Sekisui House designates native tree species with particularly strong associations with birds and butterflies as the *Gohon no Ki* species, these tree species were identified separately in the analysis. Next, a species was considered a potential beneficiary of a planting if it met two conditions:

(1) the species was known to utilize the planted tree species as a resource, and (2) its distribution included at least one occupied grid cell within 5 km of the property. Such species were assumed to be capable of utilizing the planting and therefore to benefit from the resulting increase in habitat availability.

4.2.2. Criteria for identifying species benefiting from planted trees

Studies on the ecology of birds and butterflies have documented their use of certain tree species. For example, based on a survey conducted in Kochi Prefecture, Sato and Sakai (2001) reported that the seed dispersers of *Toxicodendron sylvestre* in their study area comprised five species: *Turdus pallidus*, *Turdus eunomus*, *Hypsipetes amaurotis*, *Phoenicurus auroreus*, and *Lanius bucephalus*. This information indicates that these five bird species feed on *Toxicodendron sylvestre* berries. Similarly, Kato (1981) reports that *Papilio helenus* gather on *Clerodendron trichotomum* to feed on nectar. A database was developed linking bird and butterfly species to tree species known to provide resources for them through a comprehensive review of the available literature (example provided in Table 1). Here, beneficiary species were defined as bird species that feed on the fruits of a given tree species and butterfly species that use the tree species as a larval host plant or nectar source.

Table 1 Birds and butterflies associated with *Celtis sinensis* (excerpt)

Taxonomic group	Species name
Birds	*Eophona personata*
	Cyanopica cyanus
	Streptopelia orientalis
	Coccothraustes coccothraustes
	Hypsipetes amaurotis
	Sturnus cineraceus
	Zosterops japonicus
Butterflies	*Sasakia charonda*
	Nymphalis xanthomelas
	Hestina persimilis

4.2.3. Compilation of database of planted trees by Sekisui House

Planting records from 80,616 sites that implemented the *Gohon no Ki* project between 2001 and 2025 were compiled and standardized with the following procedures. Geographic coordinates were first derived from site address information to determine the location of each site. Information on the species planted and the number of individuals at each site was then extracted. Prior to 2015, the number of planted trees was recorded only as branch-level or company totals. Species-level planting records for individual sites were therefore reconstructed using the species composition observed in site-level records available from 2015 onward. Species taxonomies were then standardized following *BG Plants Japanese–Scientific Name Index (YList)* (Yonekura & Kajita 2003-) in species-level.

4.2.4. Estimating Area of Habitat (AOH) from tree growth data

The increase in habitat area resulting from planting was quantified by modeling the expansion of tree canopy area as trees grow over time. Throughout the remainder of this paper, habitat area is referred to as *Area of Habitat (AOH)* when treated as a quantitative metric in the analysis. Three factors were considered: (1) the maximum height typically maintained for a planted tree, (2) the growth rate in tree height following planting, and (3) the relationship between tree height and crown spread (canopy area).

For factor (1), data on the height at which each tree species is typically maintained in planting settings were compiled from sources including the Japan Greenery Research and Development Center's *Greening Tree Supply Capacity* database. For example, this database indicates a maximum supplied height of 4.5 m for Griffith's ash (*Fraxinus griffithii*) and 0.7 m for the Satsuki azalea (*Rhododendron indicum*), values that broadly correspond to the heights at which these species are commonly maintained as garden trees. For factor (2), tree growth was modeled under the assumption that planted trees reach the height specified in (1) within five years, following the typical interval before pruning occurs. Information for factor (3) was assembled from a range of published sources. For example, Osaka City (2008) provides data describing the relationship between tree height and crown spread for multiple planted tree species. These relationships make it possible to estimate changes in canopy areas following planting. For species lacking direct data, canopy area was estimated from the general relationship between tree height and crown width. To reflect the fact that garden trees are regularly pruned, canopy cover was capped at 4 m.

Using the estimated canopy area of each tree species, the increase in *AOH* for each bird and butterfly species was defined as the sum of the canopy areas contributed by planted tree species known to provide resources for that species based on the aforementioned database linking bird and butterfly species to tree species (Figure 8). Consequently, the total AOH may exceed the area of the planted land. This can be interpreted as meaning that the planting generated more resources due to the hierarchical structure of the tree crowns.

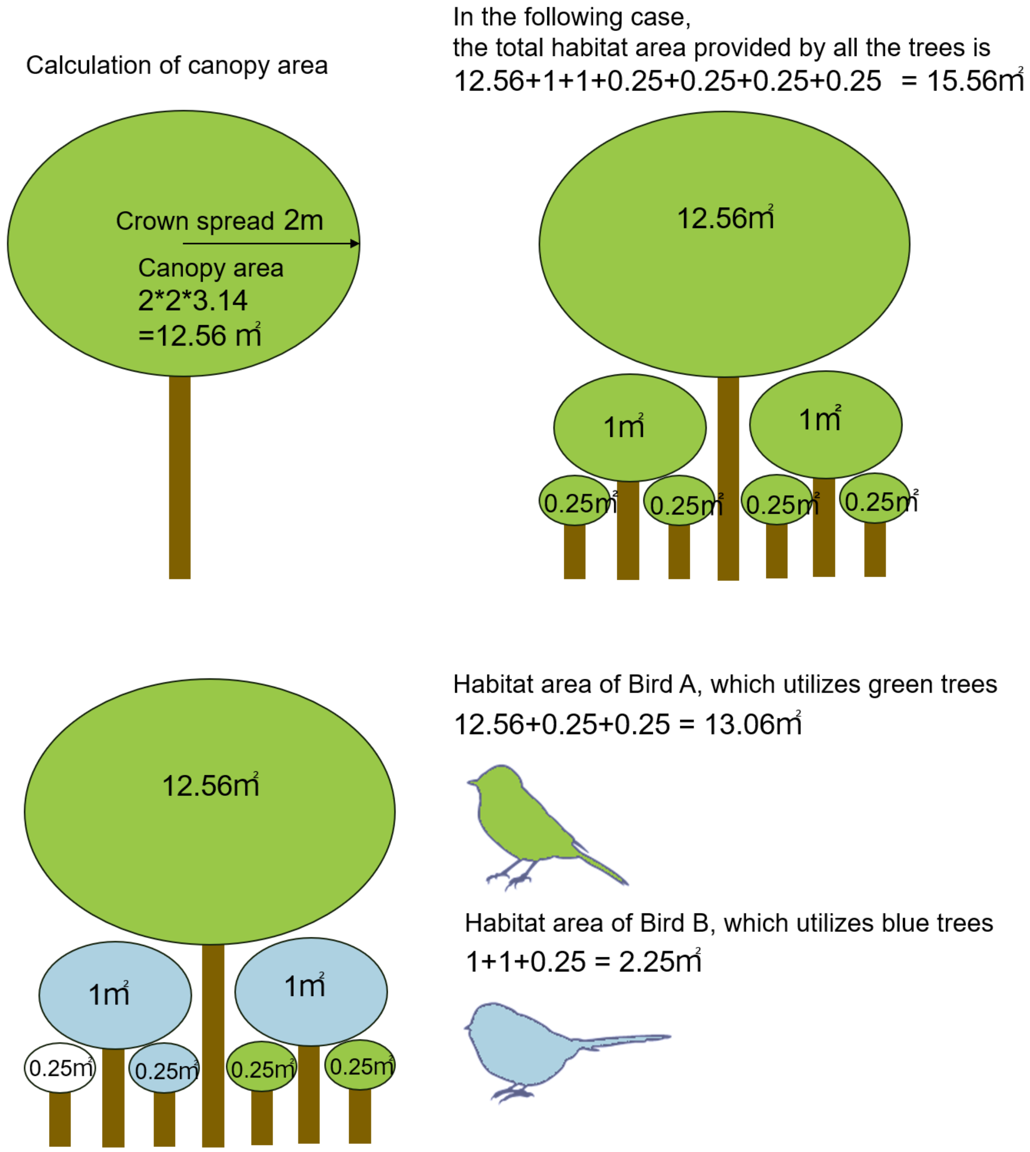

Figure 8 Illustrated procedures for calculation of Area Of Habitat increase by planted trees.

4.2.5. The sampling approach for a pre-post comparison of AOH

Direct information on the tree species composition that existed prior to planting was not available for all residential sites included in the assessment. Therefore, the previous land-use type was identified for a random sample of 282 residential sites selected from planting locations across Japan. This approach provides an estimate of the average pre-planting condition of residential sites. The proportions of different previous land-use types within the sample, together with their confidence intervals, are presented in Table 2.

For sites whose pre-planting land use was residential, the tree species present before planting were identified using *Google Street View* imagery. The accuracy of this procedure was evaluated separately using an independent reference dataset. Validation against sites for which actual planting records were available revealed a systematic underestimation of approximately 25%, largely because some planted species were not visible or identifiable in the available Street View imagery. To account for this bias, the estimated pre-planting species richness was adjusted upward by 25% before comparison. Specifically, species that were not identified through image interpretation were supplemented from among the most frequently planted species until the estimated 25% shortfall was corrected.

Table 2 Proportions of pre-planting land-use types and their 95% confidence intervals based on a sample survey of 282 sites

Land types	Number of cases	Sample proportion	95% confidence interval based on the Wald method
Residential land	188	66.7%	61.2%–72.1%
Parking lot	34	12.1%	8.8%–16.4%
Vacant lot	27	9.6%	6.2%–13.0%
Cropland	17	6.0%	3.3%–8.8%
Forest	10	3.5%	1.4%–5.7%
Paddy field	4	1.4%	0.0%–2.8%
Reservoirs	2	0.7%	0.0%–1.7%

This sampling-based approach allowed an estimation of the expected gain or loss of habitat for species associated with a single residential site under the *Gohon no Ki* project. Net change of *AOH* was then quantified by comparing habitat availability before and after implementation and expressed as the relative change in habitat area observed within the sampled sites (Figure 9).

When the land cover prior to implementation of the *Gohon no Ki* project was woodland or residential land, changes in *AOH* can be interpreted naturally as changes in the amount of habitat available to tree-associated species. In contrast, when lands other than forest or residential land were converted to residential sites, development caused the loss of non-forest habitats that could not be compensated for through tree planting. The extent of these losses was therefore quantified separately and presented, providing a comprehensive account of both habitat gains and losses associated with the *Gohon no Ki* project (Figure 9).

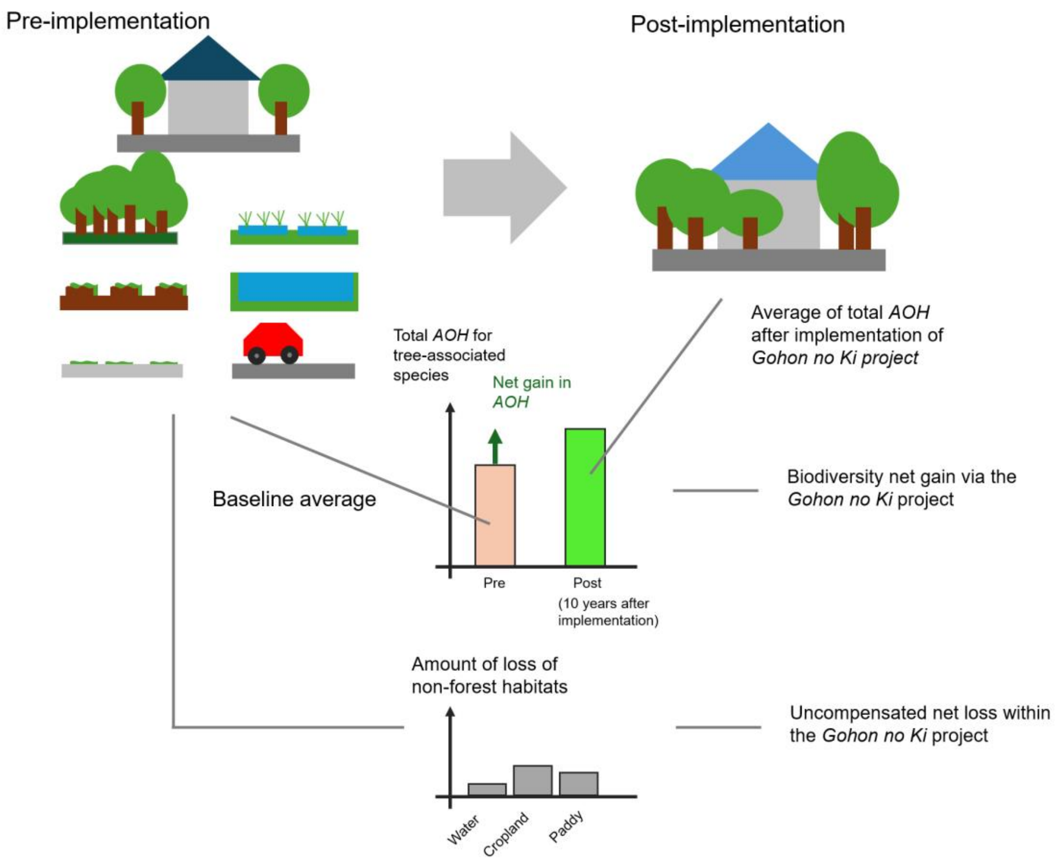

Figure 9 Illustrated procedures for calculating net change in *Area Of Habitat* (*AOH*) at residential sites where planting was implemented.

By integrating the estimated habitat condition prior to implementation of the *Gohon no Ki* project with planting records across all implemented sites, the cumulative effects of habitat restoration by the *Gohon no Ki* project were visualized. Specifically, for each implemented site, one of the pre-implementation land types was allocated in proportion to each land type's share. If the allocated condition was residential land, a pre-implementation condition was then assigned by sub-sampling one site from residential sites with a size similar to the targeted site, in order to calculate the pre-implementation *AOH* of the residence (Figure 10).

For relatively recent developments, tree canopy cover may not yet have fully developed. To account for canopy maturation over time, adjustments were applied to post-planting forest area estimates. Analysis of the relationship between planting year and canopy area indicated that canopy expansion stabilizes after approximately 10 years, reaching about 1.6 times the area at the time of planting. Based on this result, all post-planting canopy area estimates were standardized to values corresponding to 10 years after planting.

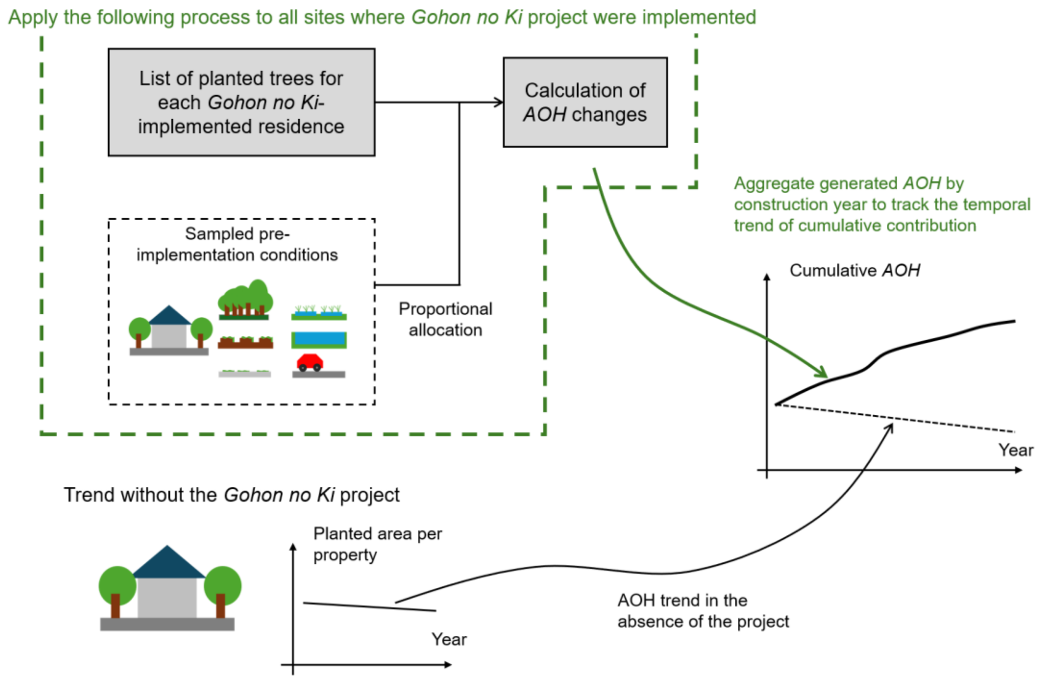

Figure 10 Method for estimating the habitat-gain effect against baseline by integrating sampled pre-implementation conditions with the planting species lists across all sites

4.3. Quantitative results of the analysis

4.3.1. Number of planted trees and temporal trends of beneficiary species

Over the 25-year period from 2001 to 2025, the cumulative number of trees planted exceeded 21 million. Planting activity was particularly concentrated in Japan's three major metropolitan regions—the Kanto, Chukyo, and Kansai areas—where planting densities sometimes exceeded 100,000 trees per 100 km². The composition of planted trees remained relatively consistent over time, with approximately 60% classified as native to Japan, 45% as native to the prefecture in which they were planted, and 30% as native to the locality. These percentages are not mutually exclusive, as locally native species are a subset of species native to prefectures, which are themselves a subset of species native to Japan. The proportion of native tree species planted varies geographically. In particular, lower proportions of species native to prefectures and regions were observed in the Kansai, Shikoku, and Kyushu regions (Figure 11).

The average number of locally native tree species planted per 1-km grid cell has increased over time across Japan. Correspondingly, the average number of bird and butterfly species expected to benefit from these plantings has also shown an increasing trend (Figure 12).

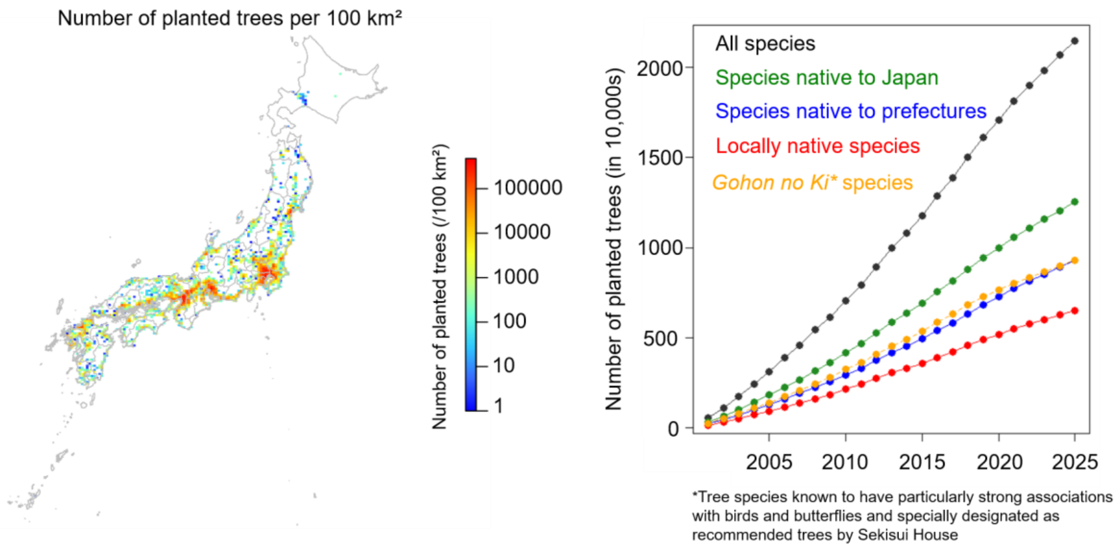

Figure 11 Cumulative number of planted trees under the *Gohon no Ki* project.

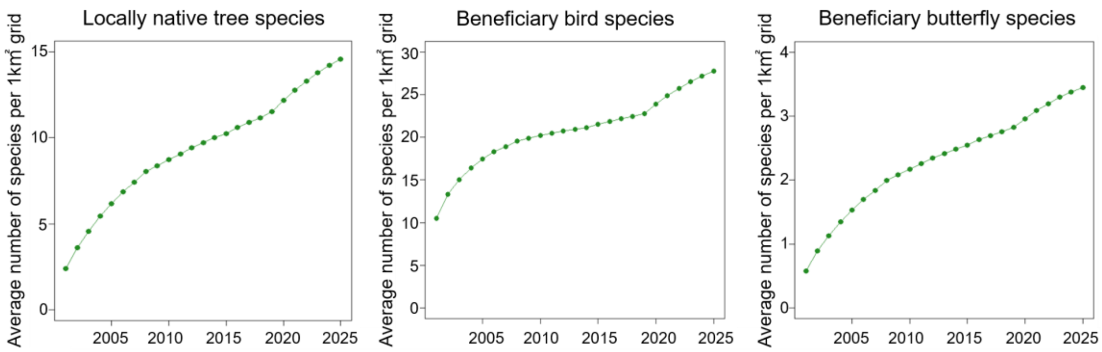

Figure 12 Temporal trends in the number of locally native tree species planted and the number of bird and butterfly species benefiting from those plantings (mean values per 1-km grid cell).

4.3.2. Changes in AOH before and after implementation of the Gohon no Ki project based on sample-based assessments

To conduct a direct before–after comparison, 282 residential sites were randomly selected from previously developed properties, and polygon data describing site boundaries and forested areas before and after development were compiled. The analysis showed that the area of forest cover within residential sites decreased by 31% following the implementation of the *Gohon no Ki* project. This reduction reflects the substantial loss of pre-existing forest at a subset of sites where forested land was converted to residence. When post-planting canopy growth was taken into account, the net reduction was estimated to be 17%.

Despite a decrease in canopy area, a comparison of conditions before and after implementation of the *Gohon no Ki* project revealed a 27% increase in the number of planted tree species (Figure 13). When restricted to locally native tree species, a slight decrease of 5% was observed. In contrast, the number of bird species expected to benefit from the plantings increased substantially by 67%, while butterfly species increased by 51%. Taken together, the total number of species considered in this analysis (locally native tree species, and bird and butterfly species expected to benefit from the plantings) increased by 49%.

The increase in species benefiting from the plantings despite a slight decline in locally native tree species suggests that the tree species selected under the *Gohon no Ki* project provide high resource value for birds and butterflies, thereby contributing to an increase in resource density per unit area, i.e., *habitat quality*.

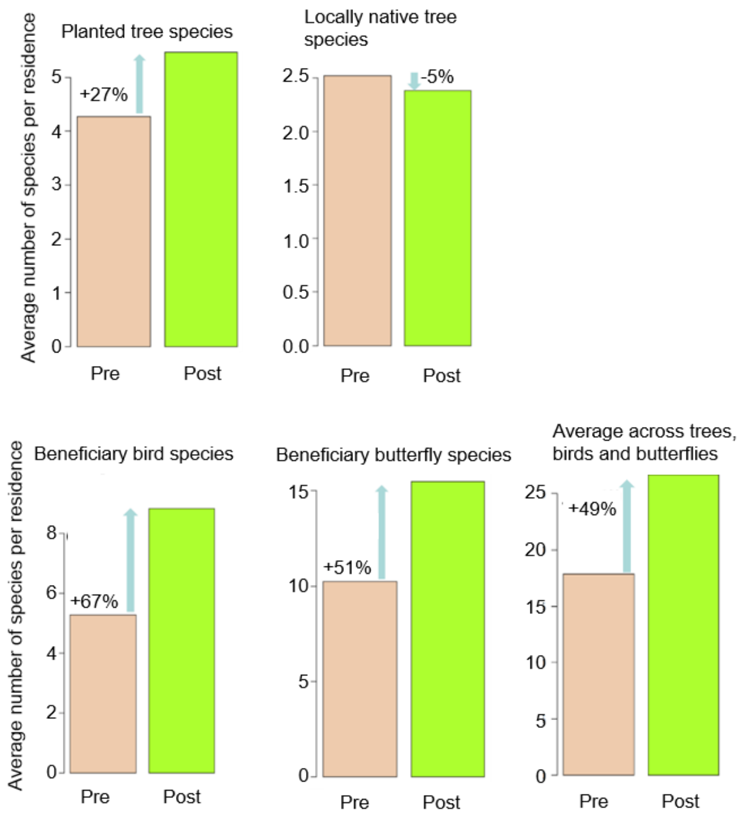

Figure 13 Changes in the number of planted tree species and the number of bird and butterfly species benefiting from the plantings before and after implementation.

In terms of habitat area, canopy area produced by locally native tree species showed a 12% increase. Likewise, total *AOH* of bird species expected to benefit from the plantings increased by 28% and butterfly species by 20% on average across the sampled residence (Figure 14). This indicates a clear increase in the amount of resources available to birds and butterflies in residential sites developed under the *Gohon no Ki* project.

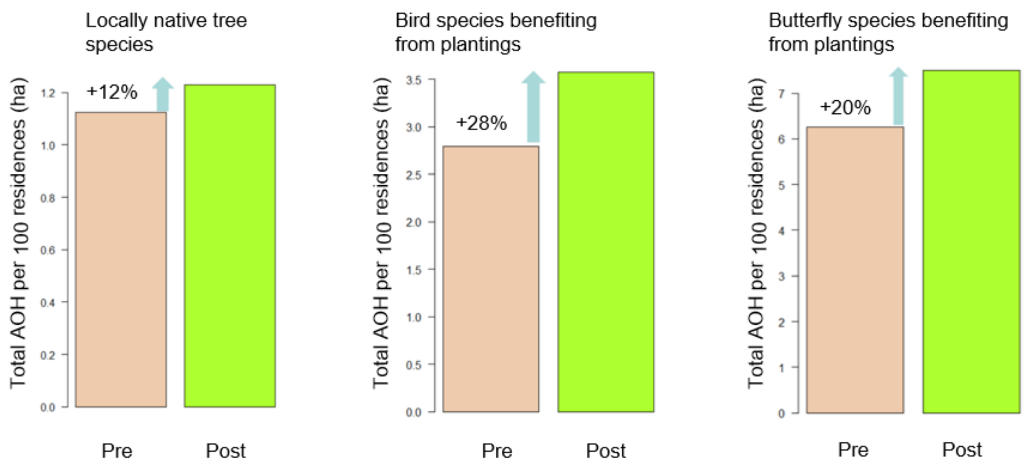

Figure 14 Pre-post changes in *AOH* (per 100 residential sites)

4.3.3. Time-series analysis of biodiversity restoration effects

The temporal trends in the number of locally native tree species per site, as well as in the number of bird and butterfly species benefiting from the plantings, exhibit a long-term increasing trend across taxonomic groups (Figure 15).

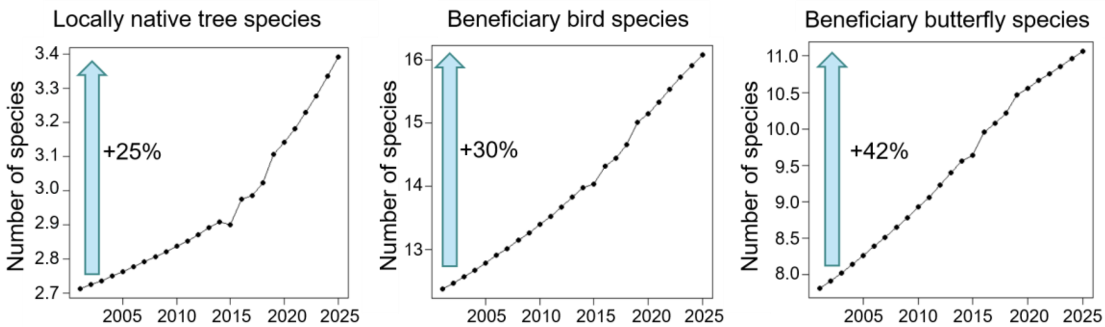

Figure 15 Temporal growth in per-site richness of locally native tree species and beneficiary bird and butterfly species per residence.

Similarly, in Japan's three major metropolitan regions—the primary implementation areas of the project—trends in the total *AOH* summed across species for birds and butterflies exhibited a consistent increase over time (Figure 16). In butterflies in particular, *AOH* more than doubled over the study period. The projected *AOH* trajectory under a hypothetical scenario without implementation of the *Gohon no Ki* project shows a declining trend. This declining baseline reflects a broader trend of decreasing tree cover within residential properties in Japanese urban areas. Figure 17 shows *AOH* trends per species. Overall, the growth in number of beneficiary species by planted trees and clear increase in their *AOH* indicates that the *Gohon no Ki* project has created high-quality (densely resourced) habitat in urban areas, where availability of space limits habitat restoration opportunities. The native-tree-species-oriented planting promoted by the *Gohon no Ki* project proved to be an ecologically effective initiative for biodiversity restoration, aligned specifically with the urban context.

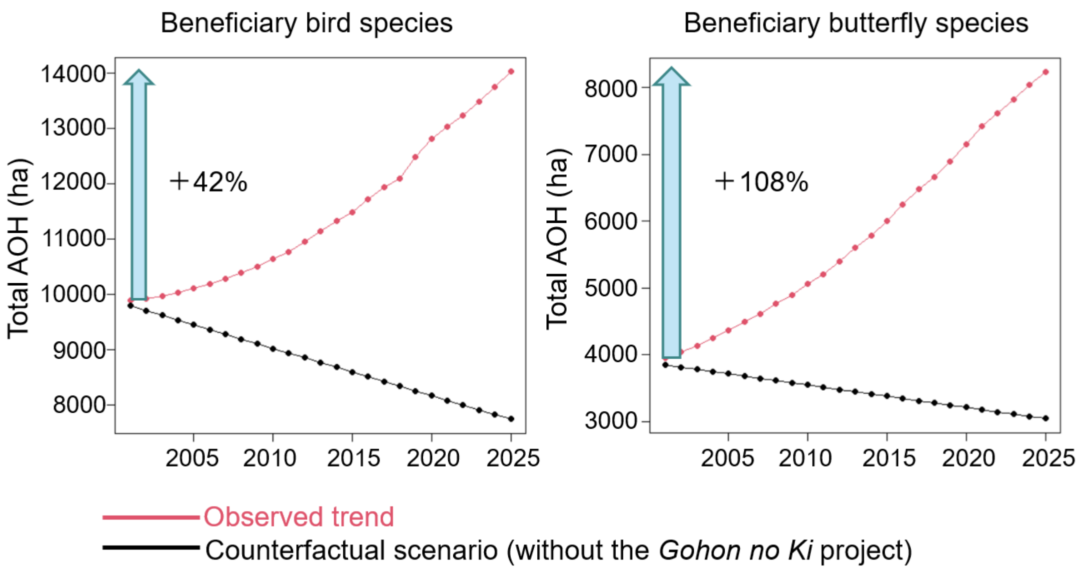

Figure 16 Time-series changes of total AOH for birds and butterflies.

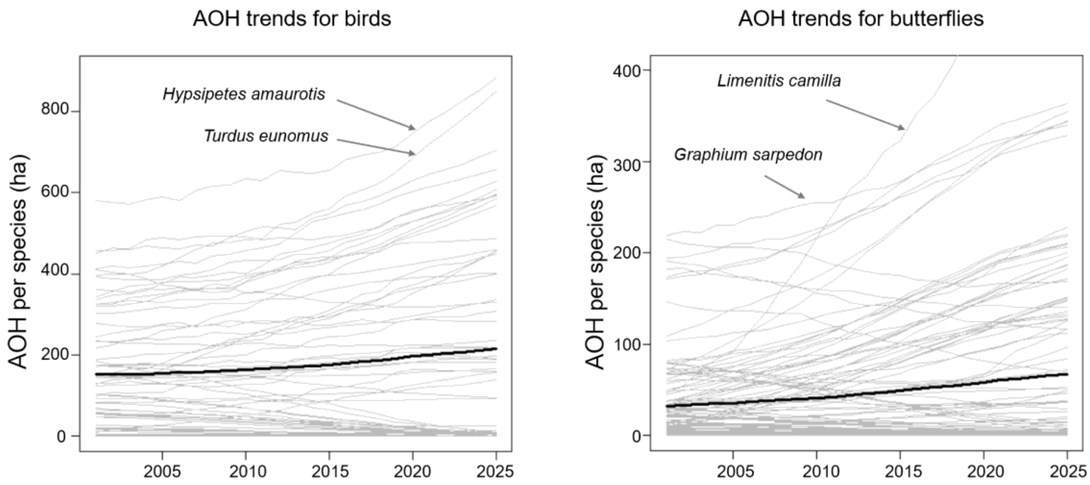

Figure 17 Time-series changes of total AOH for birds and butterflies per species.

4.3.4. Habitat loss due to residential development

The area of habitat lost through residential development was estimated by multiplying the total area of residential properties implementing the *Gohon no Ki* project by the proportion of each pre-implementation land-use category derived from the sampling (Table 3). Among these habitat types, non-forest habitats other than forest—namely cropland, rice paddies, and farm ponds—cannot, in principle, be compensated by tree planting. Consequently, losses of these habitats represent a net biodiversity loss within the scope of the project.

Table 3 Estimated modified area by the *Gohon no Ki* project by habitat types.

Lost habitat type	Area [ha]
Forest	135.6
Cropland	222.6
Paddy field	55.0
Reservoir	27.7

4.4. <u>An optimization of tree species choices to benefit biodiversity</u>

Up to this point, the restoration effects of native-tree-species-oriented planting design were quantified based on beneficiary bird and butterfly species by planted trees. In reverse, informed species selection in terms of number and composition of potentially beneficiary species can enhance per-site contribution to biodiversity.

Building on this idea, Sekisui House has developed a decision-support tool, the ***Gohon no Ki Compass****,* which integrates a food resource database for birds and butterflies with spatial distribution maps of tree, bird, and butterfly species. The tool proposes tree species combinations that maximize the number of beneficiary species within a given site under a specified number of trees to be planted. In addition, the tool incorporates a scoring algorithm that evaluates the extent to which a given planting design achieves the maximum number of beneficiary species that could be realized at a site under the specified number of planted trees.

Using this algorithm, it was found that typical green spaces in Japan achieve 22 (out of 100) points and recent plantings by Sekisui House on average achieve 34 points. These results suggest that substantial room for improvement remains in enhancing the contribution of urban plantings through optimized combinations of native tree species. Under a simulated scenario in which all sites achieve a score exceeding 50 points, the average number of planted tree species per residence increases from 2.5 to 4.1 (a 1.6-fold increase), while the number of bird and butterfly species benefiting from the plantings increases from 24.5 to 29.8 (approximately 1.2-fold). Furthermore, the resulting *AOH* is estimated to increase 1.7-fold.

Toward 2030, Sekisui House uses a *Gohon no Ki* Compass score of 50 points or higher as a benchmark for delivered properties, thereby promoting residential planting designs that further contribute to the restoration of local ecosystems.

Box 5 Analyses of biodiversity trends across urban areas

This section presents an approach for evaluating the effects of residential planting using long-term trends in urban green cover. In Japan, time-series land-cover data are available, allowing historical changes in green space to be quantified. Focusing on the three major metropolitan regions (the Kanto, Chukyo, and Kansai metropolitan areas), the contribution of the *Gohon no Ki* project was quantified relative to trends inferred from changes in green-space area over time (Figure 18). The assessment was conducted at a 1-km grid resolution and included the number of locally native tree species, as well as species richness, abundance, and Shannon diversity for both birds and butterflies. The methodology for estimating species abundance is based on a description in Fukaya et al. (2020). Changes in these biodiversity indicators attributable to the *Gohon no Ki* project were estimated using models that link biodiversity outcomes to the resources provided by planting, including increases in the number of species gaining access to newly available resources and increases in population size resulting from greater resource availability.

It should be noted that the integrated biodiversity indicators presented here are not directly comparable to the AOH values reported in the main text. All indicators are expressed as relative changes, with conditions in 1977 standardized to a value of 100 and then averaged.

The analysis revealed a long-term decline in green space across the target metropolitan regions since 1977, accompanied by an estimated reduction of up to approximately 10% in biodiversity indicators (Figure 18). Although signs of recovery emerged during the late 2010s, this trend subsequently reversed, with biodiversity declining once again. Values shown beyond 2025 are model projections, indicated by dashed lines, and assume that the *Gohon no Ki* project continues to be implemented at its current rate. Comparison with the baseline scenario indicates that the biodiversity contribution of the *Gohon no Ki* project has been increasing over time (Figure 19).

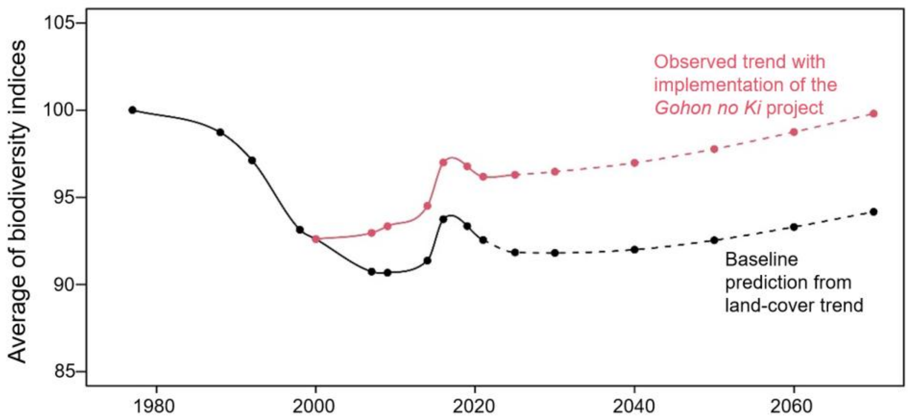

Figure 18 Temporal trends in average biodiversity indices. An observed trend with implementation of the *Gohon no Ki* project is presented against a baseline prediction based on land cover change.

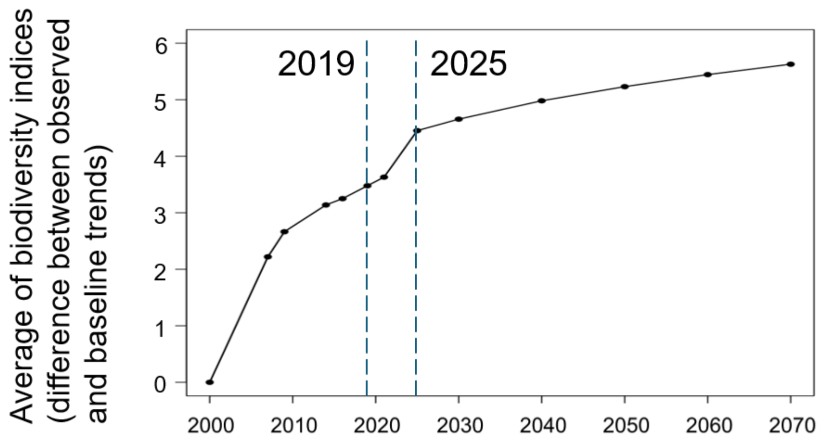

Figure 19 Temporal change in difference in observed and baseline trends.

It is important to recognize that simulation-based evaluations conducted at this macro scale are highly sensitive to the spatial resolution and classification accuracy of the underlying data. Previous studies have shown that different information sources can produce substantially different estimates of land-use patterns and their temporal trends (Radwan et al. 2021). The projections presented here are based on a simple extrapolation of recent trends into the future. Consequently, the estimated magnitude of future effects can vary considerably depending on whether the most recent baseline data indicates a slight increase or a slight decrease in green space. The sensitivity of these projections can be illustrated by comparison with a similar assessment conducted by Sekisui House in 2021. At that time, the most recent land-use map available was from 2014, and urban green cover exhibited a declining trend. Using the latest available data, however, urban green cover shows a slight increase, which in turn alters the projected net contribution attributable to Sekisui House's activities.

Accordingly, the future trajectories presented here should not be interpreted as precise forecasts of future conditions. Rather, they are more appropriately viewed as an indication of the direction in which current corporate activities are likely to influence future outcomes under present assumptions.

5. Business value and future of the *Gohon no Ki* project

5.1. Economic value of urban green spaces

The *Gohon no Ki* project has aimed to restore habitats in urban environments through the planting of native tree species. The results presented in the previous section provide scientific evidence of positive biodiversity outcomes for birds and butterflies by the project. The following sections examine the kinds of social and economic value that such urban greening efforts can generate.

Urban green spaces and plantings have increasingly been recognized not merely as landscape elements, but as forms of *green infrastructure*. *Green infrastructure* refers to a system of utilizing ecosystem functions to address a range of urban challenges. It has been conceptualized as providing multiple functions, including mitigation of urban heat, stormwater runoff control, air purification, enhancement of psychological well-being, and biodiversity conservation (Gill et al. 2007; Tzoulas et al. 2007). Under ongoing climate change, the role of urban vegetation in regulating thermal environments has attracted growing attention. Urban trees reduce temperature increases through shading and evapotranspiration, thereby mitigating the urban heat island effect. More recently, these effects have been shown to extend beyond improvements in comfort, reaching levels that directly affect human mortality. For example, a study of 93 European cities estimated that increasing tree cover to 30 percent could potentially prevent approximately one-third of heat-related deaths (Iungman et al. 2023). This suggests that urban planting can function as a form of public health infrastructure.

This perspective suggests that the value of urban planting should be understood in terms of their multifunctionality, including the extent to which it reduces health risks for urban residents and, more broadly, how it contributes to the resilience of urban economic activity. Reductions in heat stress contribute not only to lower mortality but also to sustained labor productivity, reduced healthcare costs, and improved urban livability. In this sense, the restoration of urban green spaces that produce positive biodiversity outcomes can be understood not only as a conservation activity, but also as an infrastructure investment that underpins urban sustainability and economic value.

5.2. One Health approach to the multidimensional evaluation of urban planting

Recent research has shown that the restoration of urban biodiversity contributes not only to improvements in the physical environment but also to human psychological well-being. Studies have begun to demonstrate that the effects of urban nature on well-being depend not merely on the presence of green space itself, but also on the richness of species it supports.

Among them, kinds of species that are familiar to people and commonly encountered in everyday environments, such as birds and butterflies, are thought to play a particularly important role. Studies of urban residents have reported that seeing birds or hearing birdsong is associated with immediate increases in positive emotions and reductions in anxiety and stress (Dallimer et al. 2012; Hammoud et al. 2022; Hammoud et al. 2024). Biodiversity may therefore enhance human well-being through direct and immediate experiences in everyday life. More recently, evidence has begun to suggest that the accumulation of such momentary psychological benefits may contribute to longer-term mental health outcomes. For example, a study conducted by Sekisui House and the University of Tokyo found that residents of gardens planted primarily with native tree species encountered birds and butterflies more frequently, and that these encounters were associated with lower levels of depressive symptoms (Soga et al. 2025). These findings suggest that biodiversity not only influences mood and emotions in the short term but may also contribute to the maintenance of long-term mental health through interactions with nature. The maintenance of healthy urban ecosystems through residential planting therefore illustrates a core principle of the One Health perspective: that the health of people is closely linked to the health of the ecosystems in which they live.

5.3. Moving further with science

Urban green space restoration that enhances biodiversity contributes to the long-term resilience of cities by improving physical environment, reducing health risks, and strengthening the foundations of urban economic activity. Yet these benefits have remained underrecognized within conventional models of urban development and economic activity. One reason is that a comprehensive framework for understanding and quantifying the value of urban nature restoration through their multiple functions has not been widely adopted. As a result, the contribution of biodiversity-rich urban environments to societal well-being has often been overlooked or undervalued.

By quantifying the outcomes of urban habitat restoration through scientific approaches, these diverse forms of value can be translated into information that is understandable and actionable for a wide range of stakeholders, including investors. Such evidence opens new business and investment opportunities associated with Nature-based solutions. As an active business operator in nature-friendly urban development, Sekisui House remains committed to a science-based approach and seeks to continue demonstrating how biodiversity restoration can be embedded within economically viable urban development.

6. References

Beninde, J., Veith, M., & Hochkirch, A. (2015). Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation. Ecology Letters, 18(6), 581–592. https://doi.org/10.1111/ele.12427

Blair, R. B. (1999). Birds and butterflies along an urban gradient: Surrogate taxa for assessing biodiversity? Ecological Applications, 9(1), 164–170. https://doi.org/10.1890/1051-0761(1999)009[0164:BABAAU]2.0.CO;2

Caro, T. M., & O'Doherty, G. (1999). On the use of surrogate species in conservation biology. Conservation Biology, 13(4), 805–814. https://doi.org/10.1046/j.1523-1739.1999.98338.x

Cooper, J. E., Plummer, K. E., Middlebrook, I., & Siriwardena, G. M. (2024). Using butterfly survey data to model habitat associations in urban developments. Journal of Applied Ecology, 61(4), 773–783. https://doi.org/10.1111/1365-2664.14583

Cornell, H. V., & Harrison, S. P. (2014). What are species pools and when are they important?. Annual Review of Ecology, Evolution, and Systematics, 45(1), 45-67. https://doi.org/10.1146/annurev-ecolsys-120213-091759

Crawford, C. L., Wiebe, R. A., Yin, H., Radeloff, V. C., & Wilcove, D. S. (2024). Biodiversity consequences of cropland abandonment. Nature Sustainability, 7(12), 1596-1607. https://doi.org/10.1038/s41893-024-01452-1

Dallimer, M., Irvine, K. N., Skinner, A. M. J., Davies, Z. G., Rouquette, J. R., Maltby, L. L., Warren, P. H., Armsworth, P. R., & Gaston, K. J. (2012). Biodiversity and the feel-good factor: Understanding associations between self-reported human well-being and species richness. BioScience, 62(1), 47–55. https://doi.org/10.1525/bio.2012.62.1.9

Dempsey, N., & Nam, J. (2024). Urban parks in crisis...again? A historical examination of the political, economic, and social context of UK parks. Landscape and Ecological Engineering, 20(3), 311–322. https://doi.org/10.1007/s11355-024-00597-7

Derdouri, A., Murayama, Y., Morimoto, T., Wang, R., & Aghasi, N. H. M. (2025). Urban green space in transition: A cross-continental perspective from eight Global North and South cities. Landscape and Urban Planning, 253, 105220. https://doi.org/10.1016/j.landurbplan.2024.105220

Elith, J., & Leathwick, J. R. (2009). Species distribution models: ecological explanation and prediction across space and time. Annual Review of Ecology, Evolution, and Systematics, 40(1), 677–697. https://doi.org/10.1146/annurev.ecolsys.110308.120159

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., Helkowski, J. H., Holloway, T., Howard, E. A., Kucharik, C. J., Monfreda, C., Patz, J. A., Prentice, I. C., Ramankutty, N., & Snyder, P. K. (2005). Global consequences of land use. Science, 309(5734), 570–574. https://doi.org/10.1126/science.1111772

Fukaya, K., Kusumoto, B., Shiono, T., Fujinuma, J., & Kubota, Y. (2020). Integrating multiple sources of ecological data to unveil macroscale species abundance. Nature Communications, 11(1), 1695. https://doi.org/10.1038/s41467-020-15407-5

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: The role of green infrastructure. Built Environment, 33(1), 115–133. https://doi.org/10.2148/benv.33.1.115

Graham, L. J., Haines-Young, R. H., & Field, R. (2017). Metapopulation modeling of long-term urban habitat-loss scenarios. Landscape Ecology, 32(5), 989–1003. https://doi.org/10.1007/s10980-017-0504-0

Hammoud, R., Tognin, S., Burgess, L., Bergou, N., Smythe, M., Gibbons, J., Davidson, N., Afifi, A., Bakolis, I., & Mechelli, A. (2022). Smartphone-based ecological momentary assessment reveals mental health benefits of birdlife. Scientific Reports, 12(1), 17589. https://doi.org/10.1038/s41598-022-20207-6

Hammoud, R., Tognin, S., Smythe, M., Gibbons, J., Davidson, N., Bakolis, I., & Mechelli, A. (2024). Smartphone-based ecological momentary assessment reveals an incremental association between natural diversity and mental wellbeing. Scientific Reports, 14(1), 7051. https://doi.org/10.1038/s41598-024-55940-7

Hanski, I., & Ovaskainen, O. (2000). The metapopulation capacity of a fragmented landscape. Nature, 404(6779), 755–758. https://doi.org/10.1038/35008063

Hunter, M., Westgate, M., Barton, P., Calhoun, A., Pierson, J., Tulloch, A., Beger, M., Branquinho, C., Caro, T., Gross, J., Heino, J., Lane, P., Longo, C., Martin, K., McDowell, W. H., Mellin, C., Salo, H., & Lindenmayer, D. (2016). Two roles for ecological surrogacy: Indicator surrogates and management surrogates. Ecological Indicators, 63, 121–125. https://doi.org/10.1016/j.ecolind.2015.11.049

Iungman, T., Cirach, M., Marando, F., Pereira Barboza, E., Khomenko, S., Masselot, P., Quijal-Zamorano, M., Mueller, N., Gasparrini, A., Urquiza, J., Heris, M., Thondoo, M., & Nieuwenhuijsen, M. (2023). Cooling cities through urban green infrastructure: a health impact assessment of European cities. The Lancet, 401(10376), 577–589. https://doi.org/10.1016/S0140-6736(22)02585-5

Japan Landscaping Center (2025). Ryokka Jumoku Kyoukyuu-kanouryou [Available Supply of Trees for Landscaping.] [in Japanese]. https://www.jpgreen.or.jp/kyoukyu_jyouhou/zaiko/index.html

Johnson, M. D. (2007). Measuring habitat quality: a review. The Condor, 109(3), 489–504.

https://doi.org/10.1650/8347.1
Kubota, Y., Kusumoto, B., Fujinuma, J., & Shiono, T. (2017). Systematic conservation planning for biodiversity conservation: Basic concepts and outline of analysis procedure. Ecological Research, 67(3), 267–286. https://doi.org/10.18960/seitai.67.3_267
Lehtomäki, J., Kusumoto, B., Shiono, T., Tanaka, T., Kubota, Y., & Moilanen, A. (2019). Spatial conservation prioritization for the East Asian islands: A balanced representation of multitaxon biogeography in a protected area network. Diversity and Distributions, 25(3), 414–429. https://doi.org/10.1111/ddi.12869
MacArthur, R. H., & Wilson, E. O. (1967). The theory of island biogeography. Princeton University Press.
McDonald, R. I., Mansur, A. V., Ascensão, F., Colbert, M., Crossman, K., Elmqvist, T., Gonzalez, A., Güneralp, B., Haase, D., Hamann, M., Hillel, O., Huang, K., Kahnt, B., Maddox, D., Pacheco, A., Pereira, H. M., Seto, K. C., Simkin, R., Walsh, B., Werner, A. S., & Ziter, C. (2020). Research gaps in knowledge of the impact of urban growth on biodiversity. Nature Sustainability, 3, 16–24. https://doi.org/10.1038/s41893-019-0436-6
Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being: Synthesis. Island Press.
Moilanen, A., & Kotiaho, J. S. (2018). Fifteen operationally important decisions in the planning of biodiversity offsets. Biological Conservation, 227, 112–120. https://doi.org/10.1016/j.biocon.2018.09.002
Murphy, S. J., & Smith, A. B. (2021). What can community ecologists learn from species distribution models?. Ecosphere, 12(12), e03864. https://doi.org/10.1002/ecs2.3864
Ohlmann, M., Munoz, F., Massol, F., & Thuiller, W. (2024). Assessing mutualistic metacommunity capacity by integrating spatial and interaction networks. Theoretical Population Biology, 156, 22–39. https://doi.org/10.1016/j.tpb.2024.01.001
Osaka City. (2008). Koukyouyou Ryokkajumoku no Hinshitsu Sunpou Kikaku Kijun (An) no Kaitei oyobi Un-youtou nitsuite [Revision and Operation of Quality and Dimensional Standards for Public Landscaping Trees (Draft).] [in Japanese]. https://www.city.osaka.lg.jp/kensetsu/cmsfiles/contents/0000363/363666/0402-koukyouryokkahinsitu.pdf
Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. Ecological Modelling, 190(3-4), 231–259. https://doi.org/10.1016/j.ecolmodel.2005.03.026
Radwan, T. M., Blackburn, G. A., Whyatt, J. D., & Atkinson, P. M. (2021). Global land cover trajectories and transitions. Scientific Reports, 11(1), 12814. https://doi.org/10.1038/s41598-021-92256-2

Reyes-Riveros, R., Altamirano, A., De La Barrera, F., Rozas-Vásquez, D., Vieli, L., & Meli, P. (2021). Linking public urban green spaces and human well-being: A systematic review. Urban Forestry & Urban Greening, 61, 127105. https://doi.org/10.1016/j.ufug.2021.127105

Santos, T., Díaz, J. A., Pérez-Tris, J., Carbonell, R., & Tellería, J. L. (2008). Habitat quality predicts the distribution of a lizard in fragmented woodlands better than habitat fragmentation. Animal Conservation, 11(1), 46-56. https://doi.org/10.1111/j.1469-1795.2007.00146.x

Sato, S., & Sakai, A. (2001). Eaten Process of Rhus sylvestris Fruits by Birds. Applied Forest Research, 10(1), 63-67. https://doi.org/10.20660/applfor.10.1_63

Soga, M., & Koike, S. (2012). Relative importance of quantity, quality, and isolation of patches for butterfly diversity in fragmented urban forests. Ecological Research, 27(2), 265–271. https://doi.org/10.1007/s11284-011-0896-2

Soga, M., Matsumoto, K., & Hisano, M. (2025). Noticing nearby wildlife at home is associated with enhanced mental health and pro-conservation attitudes. Biological Conservation, 311, 111436. https://doi.org/10.1016/j.biocon.2025.111436

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. Landscape and Urban Planning, 81(3), 167–178. https://doi.org/10.1016/j.landurbplan.2007.02.001

United Nations Department of Economic and Social Affairs, Population Division. (2025). World Urbanization Prospects 2025: Summary of Results https://population.un.org/wup/assets/Publications/undesa_pd_2025_wup2025_summary_of_results_final.pdf

Yonekura, K., & Kajita, T. (2003-). BG Plants Japanese-Scientific Name Index (YList). [in Japanese]. http://ylist.info

Zhao, X., Li, F., Yan, Y., & Zhang, Q. (2022). Biodiversity in urban green space: A bibliometric review on the current research field and its prospects. International Journal of Environmental Research and Public Health, 19(19), 12544. https://doi.org/10.3390/ijerph191912544

7. Fact sheets

7.1. Number of planted trees by year

Year	Number of planted trees	Number of planted trees (native to Japan)	Number of planted trees (species native to prefectures)	Number of planted trees (species native to localities)	Species designated as the *Gohon no Ki* species
2001	550,000	305,522	222,818	163,341	230,729
2002	580,000	322,895	235,330	172,375	243,918
2003	600,000	333,531	243,495	178,157	252,498
2004	700,000	390,356	284,818	208,240	294,822
2005	710,000	395,676	288,839	211,226	299,182
2006	750,000	417,594	304,484	222,626	315,929
2007	800,000	389,738	284,072	207,694	294,507
2008	850,000	474,429	346,023	252,850	358,939
2009	710,000	440,452	274,977	208,677	343,058
2010	910,000	535,912	384,499	303,519	414,547
2011	960,000	493,670	356,683	272,192	371,044
2012	1,010,000	576,517	400,804	285,531	434,383
2013	1,063,845	599,067	424,191	296,344	450,564
2014	812,286	474,839	340,538	225,834	360,070
2015	987,174	561,094	417,446	286,534	436,495
2016	1,072,840	626,562	467,478	332,740	489,757
2017	1,031,821	591,461	426,228	299,346	463,139
2018	933,791	645,957	492,010	344,737	489,356
2019	1,091,600	641,671	492,650	339,242	484,579
2020	983,098	563,353	462,586	289,211	369,079
2021	1,010,153	575,065	464,222	306,182	364,677
2022	886,104	511,202	411,130	264,735	329,633
2023	837,449	486,583	369,841	242,454	310,973
2024	851,780	485,892	394,808	253,091	305,238
2025	745,000	481,649	392,665	270,476	311,566
Total	**21,436,941**	**12,320,687**	**9,182,635**	**6,437,354**	**9,018,682**

7.2. Number of implemented cases of the *Gohon no Ki* project

Year	Number of implemented cases in each year	Cumulative number of cases
2001	644	644
2002	917	1,561
2003	1,105	2,666
2004	2,027	4,693
2005	2,119	6,812
2006	2,491	9,302
2007	2,026	11,328
2008	3,411	14,739
2009	2,364	17,103
2010	3,669	20,773
2011	2,596	23,368
2012	4,582	27,951
2013	4,831	32,782
2014	3,929	36,711
2015	3,247	39,958
2016	6,439	46,397
2017	3,533	49,930
2018	4,796	54,726
2019	6,784	61,510
2020	3,073	64,583
2021	3,302	67,885
2022	3,343	71,228
2023	3,160	74,388
2024	3,123	77,511
2025	3,105	80,616
Total	**80,616**	

7.3. Frequently planted trees among species designated as the *Gohon no Ki* species

Year	Item	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5
2015	Species name	*Ilex pedunculosa*	*Quercus myrsinaefolia*	*Cornus kousa*	*Styrax japonicus*	*Acer palmatum*
	N	4,136	2,999	1,808	1,668	1,597
2016	Species name	*Ilex pedunculosa*	*Quercus myrsinaefolia*	*Cornus kousa*	*Acer palmatum*	*Styrax japonicus*
	N	9,840	6,384	5,034	4,513	4,416
2017	Species name	*Aucuba Japonica*	*Ilex pedunculosa*	*Quercus myrsinaefolia*	*Acer palmatum*	*Styrax japonicus*
	N	10,074	6,379	3,677	3,027	2,732
2018	Species name	*Ilex pedunculosa*	*Quercus myrsinaefolia*	*Acer palmatum*	*Cornus kousa*	*Fraxinus lanuginosa*
	N	10,399	4,292	4,064	3,487	3,281
2019	Species name	*Ilex pedunculosa*	*Acer palmatum*	*Quercus myrsinaefolia*	*Fraxinus lanuginosa*	*Cornus kousa*
	N	12,854	6,405	5,848	5,396	5,020
2020	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Quercus myrsinaefolia*	*Styrax japonicus*
	N	7,143	3,855	3,583	3,577	2,655
2021	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Quercus myrsinaefolia*	*Styrax japonicus*
	N	7,500	4,619	4,034	3,522	2,607
2022	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Quercus myrsinaefolia*	*Styrax japonicus*
	N	7,907	5,179	4,312	3,308	2,522
2023	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Styrax japonicus*	*Quercus myrsinaefolia*
	N	8,543	5,964	4,223	3,362	3,142
2024	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Quercus myrsinaefolia*	*Cornus kousa*
	N	8,950	6,437	5,049	3,273	2,655
2025	Species name	*Ilex pedunculosa*	*Fraxinus lanuginosa*	*Acer palmatum*	*Pieris japonica*	*Quercus myrsinaefolia*
	N	8,593	6,817	4,926	3,561	2,806

N denotes number of planted trees. Species names are expressed in binomial form.

8. Glossary

Term	Explanation
Area of habitat	An area of habitat that a given species can occupy. It may be defined context-specifically.
Baseline	In the context of biodiversity assessments, this term refers to conditions of ecosystems or biodiversity without focused intervention.
Carrying capacity	The maximum number of individuals or species that can be maintained in each environment, determined by the number of resources available there (such as food and nesting sites).
Colonization lag	A term refers to delayed (re-)establishment of population after improvements of habitat.
Ecological niche	A general concept refers to species' resource usage, suitable environmental conditions, and dietary habits, which characterize how species interact with surrounding environments for their survival.
Ecosystem services	The diverse benefits that humanity derives from ecosystems.
Extinction debt	A term refers to delayed species extinctions expected as a consequence of habitat loss or degradation. It may take decades to centuries for species to become regionally extinct after substantial reduction of habitat availability.
Extinction threshold	The threshold for resource density or habitat area required for a population to be maintained. It differs from species to species.
Flagship species	A set of species which attract high public attention and serve as symbols for conservation efforts.
Food web	A network of predator-prey relationships among organisms within an ecosystem.
Generalist species	A set of species which utilize wider variety of resources for their survival. They generally have higher adaptivity to environmental changes.
Green infrastructure	A concept of treating natural habitats and artificial green space as infrastructures for living environments.
Greenwashing	A word used to criticize commercial practices of overstating or falsifying the environment-friendly features of products or services while not proving the contribution.

Indicator species	A set of species empirically known to reflect ecosystem conditions.
Indicator surrogate	Surrogates designed to capture changes in ecological conditions.
Kunming–Montreal Global Biodiversity Framework	An international biodiversity framework adopted at COP15 in 2022 that sets global targets through 2030.
Management surrogate	Surrogates used in conservation planning.
Metacommunity	A higher-order species community network in which multiple local communities are interconnected through species migration and dispersal.
Metapopulation theory	A theory that explains dynamics of a group of spatially fragmented populations of a species connected by dispersal of individuals.
Millennium Ecosystem Assessment	A report, led by the United Nations in the mid-2000s, that comprehensively assessed the current state of global ecosystem degradation and its impact on humans.
Mitigation hierarchy	A conceptual framework that formulates a hierarchy of action steps, namely avoidance, minimization, restoration, and offset to reduce negative biodiversity impacts by land developments.
Nature-based solutions	A term refers to utilization of natural or semi-natural ecosystem processes for adaptations to climate change and other societal challenges.
Net positive impact	A state in which an amount of gain achieved by nature-friendly actions is greater than an amount of biodiversity loss.
No net loss	A state in which an amount of biodiversity lost due to development is equal to or smaller than an amount of gain achieved by nature-friendly actions.
One Health approach	An international approach that takes a comprehensive view of the interconnectedness of human health, animal health, and environmental (ecosystem) health, and works toward cross-sectoral solutions.
Spatial heterogeneity of environments	A term refers to an environment with high variety of habitat features such as light and humidity. Relevant spatial scales vary in different contexts.

Specialist species	A set of species which only utilize a specific type of resources for their survival. They are generally vulnerable to environmental changes.
Species distribution models	A statistical method to obtain species distribution ranges by integrating biodiversity observation data with environmental variables such as climate and topography.
Species pool	The totality of species that could potentially occur in a given region.
Stochasticity in population size	A term refers to probabilistic fluctuations in a population size of species, caused by various factors such as annual climate variability.
Surrogate	A set of indicators to represent biodiversity. Surrogate is needed because knowing everything in nature is impossible.
Urban sprawl	A term refers to a situation where absences or inadequacy of urban plannings leads to rapid and unregulated growth of urban settlements into adjacent formerly vegetated areas.

Where Nature Meets Happiness
「5本の樹」計画

ThinkNature

SEKISUI HOUSE

July 14, 2026