Dissecting the Japanese hotspot: refining evaluation of biodiversity in forests at different scales in the Japanese landscape



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Abstract

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Japan is one of the world's 34 biodiversity hotspots, according to Conservation International (CI). The methods used by various organisations to define priorities differ, however, and all have weaknesses when trying to identify hotspots at finer resolutions. The goal of this thesis is to investigate how biodiversity hotspots in Japan could be revealed and mapped in order to encapsulate conservation elements of biodiversity in practical ways and at various scales.

Bioquality is a term that emphasises the concentration within a community of elements of biodiversity with high conservation value. It evaluates the global rarity and taxonomic distinctiveness of plant species or infra-specific taxa using four Star categories. At a plant community level, the Genetic Heat Index (GHI), which is a standardised global range size rarity score, is calculated using weighted Star statuses of species in the community. Bioquality hotspots are assessed here for the first time for the flora and vegetation in Japan – and for temperate Asia – by categorising the Japanese flora into Stars and by applying GHI to survey data and literature-based sources.

Keys to Stars are developed for the Japanese flora, with adjustments for variability in species geographic range size information and for taxonomic relatedness. A Flora of Japan (FOJ) database was compiled as a BRAHMS database, containing 8,262 accepted names (30,656 taxon names in total, including synonyms) in 258 families – the first full database of Japanese vascular plants. A total of 7,145 taxa are assigned Stars; from the rarest to the widespread class, there are 884 Black, 756 Gold, 833 Blue, and 4,672 Green Star taxa, confirming that Japan as a whole contains a high proportion of globally rare taxa (23% taxa in Black or Gold). A protocol for calibrating the weight of Stars based on species geographic range is developed based on fine-resolution distribution maps within Japan and coarse–resolution Taxonomic Database Working Group (TDWG) code information. The protocol optimises calculation for temperate regions.

The first ever bioquality hotspot maps of Japan are produced using two independent data sources on species distribution at national level: 1) 50 botanical prefectures using 4,830 species from the FOJ database; 2) 1,418 Horikawa 'geoquadrats' (0.1° latitude by 0.15° longitude grid) maps covering 829 species. The Ryukyu Islands and Ogasawara Islands are identified as bioquality hotspots, and high mountain ranges in mainland Japan are predicted to contain areas potentially high in GHI; the spatial patterns of GHI are generally concordant between maps of different resolutions. These findings highlight that bioquality assessment can be applied meaningfully at various spatial resolutions.

Using field sampling data and existing literature, three study sites are further investigated on a local level: 1) the *satochi-satoyama* landscape, the current national priority area for biodiversity conservation; 2) various vegetation types of Okinawa-jima Island, the Ryukyu Islands; and 3) the *Utaki* sacred groves within the predicted hotspot of the Ryukyu Islands. The Ryukyu Islands are confirmed to contain bioquality hotspots within many individual sites, while there was generally low GHI across the *satochi-satoyama* landscape.

The field study outcomes, together with a gap analysis of the existing coverage of protected areas, highlight three important points that are directly relevant to national biodiversity conservation planning: 1) the Ryukyu Islands urgently need newly designated protected areas; 2) the *satochi-satoyama* landscape conservation should redirect its focus on cultural benefits to the public; 3) the existing protected areas, particularly on mountain areas, need re-evaluation in terms of upgrading their status in light of the bioquality assessment.

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Cover photo: landscape view of northern mountains of Okinawa-jima Island, the Ryukyu Islands (left); and of typical *satochi-satoyama* in Ibaraki.

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1. Introduction

1.1 Agenda in Biodiversity Conservation

1.1.1 How it started

Japan is one of the world's 34 biodiversity hotspots (Conservation International, 2009a). An estimated 1,950 species out of about 5,600 vascular plant species (34.8%) are believed to be endemic to Japan. Among the vertebrates, 48.9% (46 species) of mammals, 42.4% (28 species) of reptiles and 88% (44 species) of amphibians are thought to be endemic (Conservation International, 2009b). Currently, 14.3% of land area in Japan is under legal protection as National Parks, Quasi-National Parks, and Prefectural Natural Parks (Ministry of the Environment of Japan, 2010b). Selection criteria for these conservation areas are rather crude. Designation is based on the definition that 'an area constitutes a prominent major natural landscape that is representative of the region at global, national and prefectural level' for National, Quasi-National and Prefectural Parks respectively (Ministry of the Environment of Japan, 2012b). There is no government conservation policy specifically aimed at managing its hotspot responsibilities and little research is being conducted to prioritise and manage areas within hotspots. Furthermore, there is very limited information available on the global importance of Japanese biodiversity relative to other areas of the same size (Higuchi and Primack, 2009).

The obvious questions here are: What are the problems with the existing conservation framework? What can be improved to enhance the effectiveness of conservation planning? And what can be learned from the Japanese case? In this introductory chapter, I outline the concept of biodiversity as a conservation target, and describe what has been achieved at international level. Secondly, I examine the issues surrounding selected major global conservation approaches that have been in place for the last few decades. Thirdly, I illustrate the bioquality approach – a methodology developed to assess global rarity of plant species and communities quantitatively and scientifically. Overall, I attempt to explain why Japan is an interesting area to study, and what the important scientific challenges are in adopting a bioquality approach.

1.1.2 Setting biodiversity conservation targets

The term 'biodiversity' has become the overarching key word linking many aspects of nature conservation since it was adopted internationally in 1992. The definition of biodiversity that I follow in this thesis is '*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*' (Secretariat of the Convention of Biological Diversity, 1992).

In this study, I specifically focus on plant conservation and on terrestrial ecosystems in Japan. The debate around biodiversity conservation is increasingly combined with interrelated issues such as sustainable development, ecosystem services and climate change (Balmford *et al.*, 2002, Dobson, 2005, Mace *et al.*, 2010). These aspects of biodiversity are outside the scope of this study although this is not meant to downplay their significance. This study highlights a particular aspect of biodiversity conservation – namely global rarity and taxonomic distinctiveness of species and species assemblages in a given area. This focal theme within biodiversity is termed 'bioquality' (Hawthorne and Abu-Juam, 1995) and is extensively explored throughout the thesis (see section 1.3 for introduction of the concept).

This thesis relates to a very large question regarding conservation science and policy making: How is biodiversity conservation assessed, planned and implemented? Conservation practice ranges from the informal – where actions on the ground may be initiated by passionate individuals or groups with shared interests in some aspect of conservation – to the more formal where conservation processes tend to follow a similar sequence: 1) Identification of conservation targets; 2) Evaluation of priorities; 3) Development of action plans on designated targets; 4) Implementation of conservation activities; 5) Monitoring progress; 6) Assessment of effectiveness of the action (Margules *et al.*, 2002, Margules and Pressey, 2000). In the latter case, large organisations such as Conservation International (**CI**), the World Wildlife Fund (**WWF**), or the International Union for Conservation of Nature (**IUCN**) often take the lead in promoting conservation actions.

One fundamental activity for conservation scientists and policy makers is to set priorities in biodiversity conservation. How we measure and assess priorities can critically affect the efficiency of any conservation activities that are subsequently planned and implemented (Margules *et al.*, 2002). The international targets have been set, reviewed and reformed by the Convention on Biological Diversity (**CBD**) involving 193 countries. Targets for 2020 – the Aichi biodiversity targets – were adopted in 2010. The vision of the 2020 target is that '*by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people*' (Secretariat of the Convention on Biological Diversity, 2010). Individual nations have set their own targets in response to the Convention. Examples include U.K. Biodiversity Action Plans or the National Biodiversity Strategy of Japan (Chandra and Idrisova, 2011). Progress at the national level is then reported to the CBD. Ideally, land management plans on the ground are closely linked to priorities set at higher, national and international levels. However, the CBD's 2020 targets are filled with ambitious goals; they seek substantial improvements and advances in many perspectives to halt the loss of biodiversity at global level (Normile, 2010). For the achievement of broader conservation targets, it is vital that priorities are transferable from higher administrative levels to local management scales.

The key leading global conservation organisations have proposed a range of conservation approaches over the last few decades in response to, and perhaps helping drive, an increasing international movement towards biodiversity conservation (Brooks *et al.*, 2006, Gordon *et al.*, 2005). Examples of the most influential organisations and their conservation approaches that are particularly relevant to this study are CI's '**biodiversity hotspots**', WWF's '**ecoregions**' and IUCN's 'Red List of Threatened Species' (**the IUCN Red list**). These organisations have striven for scientifically robust and comprehensive methodologies as a basis for conservation action, and hence to help each party of the CBD achieve its mission (Gordon *et al.*, 2005).

There has been criticism of the weak link between global priorities and local agendas, leading to inefficient implementation on the ground: e.g. see Rodríguez *et al.* (2007) and Dinerstein *et al.* (2007).

Conservation approaches which set global priorities need to be well defined in order to feed into decision-making and action by national governments and local management areas (Mace *et al.*, 2010). International conservation organisations who promote their conservation approaches and priorities should critically assess how to allocate their funds to projects that match both global and local targets (Rodríguez *et al.*, 2007). There is therefore a need for an assessment tool that strengthens the link between global and local priorities. In the following section, I analyse the scientific effectiveness of some existing conservation approaches led by global organisations (see Box 1.1 for a glossary of phrases used in this thesis).

Box 1.1 Terminology used in this thesis

- An ***approach*** refers to a system which has been developed by various organisations and scientists for identifying key issues in biodiversity conservation and including tools to implement or promote conservation actions.
- A ***conservation organisation*** is as an institution which operates with a shared vision of conservation interests and goals. Many are non-governmental bodies and differ in size ranging from a small community-based volunteer group to an international group whose activity may be run in multiple locations around the world. State authorities such as national parks authorities or the Ministry of the Environment also work in conjunction with these organisations.
- Priority setting and conservation actions take place at various ***administrative levels*** which represent the geographic extent of an area of interest. This level could be:
  - ***Global*** –across the world, or at least in several regions and continents;
  - ***Regional*** – representing a relatively large geographic area formed by more than one country, e.g. Europe, Asia or West Africa;
  - ***National –***individual countries distinguished by political boundaries, e.g. Japan;
  - ***Local*** –sub-national levels that may cover a single management unit like a forest or nature reserve, or several such areas managed by authorities or districts of a country.

1.2 Key organisations and their approaches

1.2.1 Overview of existing approaches

A major interest of this study is the effective use and transfer of scientific evidence and information to management practices, including setting and monitoring priorities at various scales (Brooks *et al.*, 2006, Gordon *et al.*, 2005, U.N.E.P.-W.C.M.C., 2011). Here, three themes will be summarised and reviewed: conservation targets, priority-setting and assessment methods (Table 1.1). Selected global-level conservation approaches are summarised in Table 1.2, with particular emphasis on these three themes. Three major approaches – the IUCN Red list, WWF's ecoregions, and CI's biodiversity hotspots – have been selected for detailed examination. Prior to evaluation of these three approaches, I discuss below why other approaches and regional ones are less relevant to this study.

As this study focuses on plants in terrestrial ecosystems, taxon-specific approaches are not covered here (colour coded in green in Table 1.2) – such as BirdLife International's Endemic Birds Area (BirdLife International, 2010, Stattersfield *et al.*, 1998), the Living Planet Index of WWF, a measure of temporal changes in vertebrate populations since 1970 (Butchart *et al.*, 2010, Loh *et al.*, 2005), and marine and freshwater conservation approaches. Considerations taken for mobile vertebrates and aquatic ecosystems are very different from those for plants.

Two plant-based approaches – Centres for Plant Diversity (W.W.F. and I.U.C.N., 1994-97) and Frontier Forests (Bryant *et al.*, 1997b) – are omitted from detailed examination due to severe limitations in their methodologies. The "Centres for Plant Diversity" list identified 234 sites rich in plant species number and endemism. There has been virtually no update or work specific to this project since the publication of final results in 1997 from either of supporting organisations; IUCN and WWF. The main problem in adopting the Centres of Plant Diversity is that initial assessment of species richness and endemism is done on country basis. Priority sites vary considerably in size, from the Savage Islands in the Atlantic Ocean with land area of 3 km^2 to the Altai–Sayan in Russia and Kazakhstan covering 1,100,000 km^2 (W.W.F. and I.U.C.N., 1994-97). This means that the definition of 'high' richness of endemism is flawed in that it is not standardised by unit area. Two sites identified as

Japanese centres for plant diversity are Mt. Hakusan and Yakushima Island. The former was noted as having no species endemic to the mountain range though many were endemic to Japan; it therefore fails to meet the criteria to be listed as a centre of plant diversity. It is therefore doubtful whether the site selection methodology was standardised among the 400 individual contributors.

"Frontier Forests" list countries with large changes in forest cover from 8,000 years ago to the present and , with a summary of current threats and were produced as results of analysis conducted by World Resources Institute in collaboration with World Conservation Monitoring Centre (WCMC) and WWF. The seven criteria for frontier forests are hard or imprecise to evaluate scientifically e.g. 'be of sufficient size to support ecologically viable populations of the largest carnivores and herbivores associated with that particular forest ecosystem (criterion 1), and to support these species in the face of a major natural disturbance events (criterion 2); 'be home to most of the species and be dominated by indigenous tree species associated with that ecosystem type (criteria 6 and 7) (Bryant *et al.*, 1997a)'. Threats are defined by 'areas where on-going or planned human activities will likely result in the eventual violation of one of the seven frontier forest criteria (Bryant *et al.*, 1997a)'. There are no quantitative threshold to the criteria; and no description of how contributing experts followed assessment protocol if any. As with the Centres for Plant Diversity approach, evaluation was on a national basis with no standardisation of area or environmental variables. Choice of 8,000 years ago as a reference point at which forest cover is assumed to be 'original' is also ambiguous and may be misleading (Willis and Whittaker, 2002). Critically, the resulting list of the top ten countries with the largest area of frontier forest and with the highest plant diversity in terms of estimated species richness present very different pictures. Russia and Canada are ranked first and second with respect to the percentage of the world's total remaining frontier forests while neither is particularly rich in species richness *per se*. Brazil, Venezuela, and Columbia are ranked high in both lists. These countries are listed as having 'great opportunity' for maintaining the original frontier forest and hence, seem to be treated equally despite the apparent difference in biological significance of the countries. It is hard to apply such a confusing ranking system in conservation planning, let alone to translate it into local management action.

There are some additional approaches derived from the main three reviewed here. These are summarised briefly in Table 1.2 but not discussed in detail, because most of the arguments made in relation to criticisms about the main approaches also cover criticisms of the derived approaches. These derived approaches are: High Biodiversity Wilderness Area, Mega Diverse Countries, Key Biodiversity Areas, and Alliance for Zero Extinction (colour coded in blue in Table 1.2).

At a regional level, various methodologies that focus on endemism have been developed. These are termed 'range size rarity' (Knapp, 2002, Williams *et al.*, 1996) or 'weighted endemism' (Crisp *et al.*, 2001, Linder, 2001) approaches. Species' relative endemism within the study area is measured by taking the inverse proportion of the area occupied (Crisp *et al.*, 2001, Williams *et al.*, 1996). A community rarity score within the study area is then calculated by summing the relative endemicity of component species in the area. The main problem with this methodology is that the results depend on the extent of the study area and the resolution at which endemism is measured. If a calculation of endemism is applied only to the U.K. for instance, the rarity score is only applicable within the U.K. and is not comparable with those derived from other areas. The species' weights depend on how many total cells are counted in the geographic extent of the study area. Calculation using one-degree grids would lead to a higher estimate of species weight than estimates based on finer grids, i.e. species rarity is highly valued at coarser resolutions (Réjou-Méchain *et al.*, 2011). However, such regional methods do have considerable merit when one wishes to look at patterns within a study area such as a single country (Williams *et al.*, 1996).

Table 1.1 Three problems addressed in the evaluation of the approaches

Focal points and questions for review on the approaches
Targets (component of biodiversity):
▪ Which component of biodiversity is the approach aimed at? Does the approach cover genes, species and ecosystems? Does it aim to cover all taxonomic groups? At what administrative levels it is aimed and applied? ▪ If only some components and taxa are included, do the selected components appropriately reflect the overarching goal of biodiversity conservation?
Criteria for priority setting
▪ Do the criteria truly reflect supposed targets? ▪ Are the criteria to set priorities based on rigorous and unbiased scientific knowledge? ▪ Are priorities decided by objective and quantitative evaluation of scientific data?
Methods for assessment and monitoring
▪ Are the methods appropriate for the stated criteria? Are they at an appropriate spatial and temporal scale? ▪ Are the assessment methodologies standardised, repeatable and practical? ▪ Have the methods been designed for monitoring as well as priority setting?

Table 1.2 Summary of selected global approaches reviewed.

*Target in biodiversity is divided into genetic (Gene), species (Sp.) and ecosystem (Eco.) components of biodiversity. **Scale refers to geographic extent of approaches; local, regional and global. †; Relevance to this study as a conservation priority setting tool: High (H), Medium (M), Low (L). Symbols indicate; ✓= sufficiently met; △= partially met; ✗ not met with respect to evaluation criteria. Key references are numbered and listed at the bottom of the table. Three approaches reviewed and examined in the thesis are in red, derived approaches are in blue and taxon specific approaches are in green.

Approach, Supporting organisations	Target*		i) Representative taxa? ii) Plants assessed?	Criteria for priority setting	Scale**		Monitoring over time	†
Red List of Threatened Species, IUCN[1]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✗	i) Mainly vertebrates. ii) Limited to approx. 12,000 taxa, mainly trees and cycads	8 level conservation status assigned based on: A) Population decline B) Geographic range size C) Small population size D) Very small population or very restricted distribution E) Quantitative extinction risk analysis	*Global:* *Region:* *Local:*	✓ △ ✗	△ Red List Index	H
Ecoregions, WWF[2]	*Gene:* *Sp.:* *Eco.:*	✗ △ ✓	i) Vegetation ii) Primarily plants, total number of assessed taxa unknown.	Adopt regional or national vegetation classification systems. Climatic variation, fire disturbance, and large vertebrate migration also considered for largely homogeneous habitats. Biological distinctiveness considered for Global 200: species richness, endemism, rarity of higher taxa, unusual ecological or evolutionary phenomena, and global rarity of habitat types.	*Global:* *Region:* *Local:*	✓ ✓ ✗	✗	H
Biodiversity hotspots, CI[3]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✓	i) Plant species only, vertebrates 'considered' ii) Plant species assessed accounts for 50% of world endemic species	Areas with 1) ≥ 1,500 species (0.5% of global) endemic to the area 2) ≥ 70% of its original habitat lost	*Global:* *Region:* *Local:*	✓ ✗ ✗	✗	H

Table 1.2 continued.

Bioquality and Genetic Heat Index (GHI), Hawthorne,[4]	*Gene:* *Sp.:* *Eco.:*	△ ✓ ✓	i) Plant species only, taxonomy and communities incorporated. ii) > 10,000 species assessed so far, additional 10,000 in progress	Species assessed for 4-level rarity rank (Stars) on: 1) Global distribution 2) Taxonomic distinctiveness Sum of weighted rarity of component species standardised for the number of species, giving a community score (GHI)	*Global:* *Region:* *Local:*	✓ ✓ ✓	✓ Changes in GHI scores	-
Endemic Birds Area, Bird Life International[5]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✗	i) Bird ii) Not considered	Areas which encompass the overlapping and complete breeding range of two or more restricted-range bird species. Range defined for land birds as an estimated extent of occurrence of < 50,000 km^2.	*Global:* *Region:* *Local:*	✓ ✓ ✗	✗	L
Living Planet Index, WWF[6]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✗	i) Vertebrates ii) Not assessed	Population trend since 1970 for records that: 1) are available at least for two years from 1970 2) provide estimates of population size 3) survey methods and area covered comparable throughout the survey period	*Global:* *Region:* *Local:*	✓ ✗ ✗	✓	L
High biodiversity wilderness area, CI[7]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✓	i) Plant species ii) Assessed species include 17% of total vascular plants	Area ≥ 10,000 km^2 with human population density ≤ 5 people/km^2 1) ≥ 1,500 species (0.5% of the global) endemic to the area 2) ≥ 70% of its original (500 years ago) habitat remaining	*Global:* *Region:* *Local:*	✓ ✗ ✗	✗	M
Mega diverse counties, CI[8]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✓	i) Plant endemism ii) Assessed per country	A country has at least 5,000 of the world's plant species as endemics.	*Global:* *Region:* *Local:*	✓ ✗ ✗	✗	L

Table 1.2 continued.

Alliance for Zero Extinction, 68 organisations[9]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ ✗	i) Vertebrates ii) Not assessed	Site contains: 1) ≥ 1 endangered or critically endangered species in IUCN Red list present 2) the sole area or significant population of target species 3) definable boundary of habitats and conservation unit	*Global:* *Region:* *Local:*	✓ ✓ △	✗	L
Key Biodiversity Area, IUCN[10]	*Gene:* *Sp.:* *Eco.:*	✗ ✓ △	i) Birds, mammals, amphibians ii) Not assessed	IUCN Red list for species assessment + area with: Vulnerability (1 critically endangered or endangered species or 30 vulnerable species) & irreplaceability (restricted range species, site contains > 1% global population of target species.)	*Global:* *Region:* *Local:*	✓ ✓ △	✗	L
Frontier Forests, WRI[11]	*Gene:* *Sp.:* *Eco.:*	✗ △ ✓	i) Plant species richness, large carnivores and herbivores but focus on forest cover ii) Estimated by country, e.g. > 36,000 species for Brazil	Forests that: are large enough to support the largest carnivores and herbivores (1, 2); remain relatively unmanaged by humans (3,4); have a heterogeneous age structure of trees (5); are home to indigenous species of the ecosystem type (6, 7)	*Global:* *Region:* *Local:*	✓ △ ✗	✗	M
Centre of plant diversity, WWF & IUCN[12]	*Gene:* *Sp.:* *Eco.:*	△ ✓ △	i) Plant taxa assessed ii) Estimate of 380,000–399,000 taxa given, with no detail information on assessment protocol	Area is: 1) evidently species-rich, even though the number of species present may not be accurately known; 2) known to contain a large number of endemic species. Gene pool valuable for human, diverse habitat types, threats to habitat devastation also considered in the selection process	*Global:* *Region:* *Local:*	✓ ✓ △	✗	M

Key references: **1**. IUCN (2009, 2010a); **2**. Olson and Dinerstein (1998), World Wildlife Fund (2010); **3**. Myers (1988), Myers *et al.* (2000); **4**. Hawthorne and Abu-Juam (1995); **5**. BirdLife International (2010); **6**. Butchart *et al.* (2010), Loh *et al.* (2005); **7**. Mittermeier *et al.* (1998); **8**. Mittermeier *et al.* (1998); **9**. Gordon *et al.* (2005); **10**. Eken *et al.* (2009); **11**. Bryant *et al.* (1997b); **12**. W.W.F. and I.U.C.N. (1994-97)

1.2.2 Problems with existing global conservation approaches

The three fundamental issues in implementing conservation action using existing global approaches are: 1) defining targets and formulating criteria; 2) adjusting the spatial scale of goals; and 3) standardising assessment methods. All three major conservation approaches reviewed here have different overriding goals (Figure 1.1; Table 1.2). The IUCN Red List focuses on the assessment of extinction risk of species (IUCN, 2009); WWF ecoregions are aimed at listing representative types of vegetation and landscapes around the world (Olson *et al.*, 2001). Hotspots in general represent areas with exceptionally high concentrations of important elements of biodiversity such as global rarity, the total number of species, or the number of threatened species (Reid, 1998). Biodiversity hotspots by CI combine two targets for assessing areas of land: a high proportion of endemism and the rapid rate of habitat loss (Mittermeier *et al.*, 2005, Myers *et al.*, 2000). These two CI hotspot parameters could serve distinct and complementary roles if they were implemented effectively, yet the criteria for priority-setting by these and similar approaches are often confusing and the procedure for assessment is not necessarily practicable or standardised (Brooks *et al.*, 2006, Jepson and Whittaker, 2002, Mace *et al.*, 2008). It is often the case that criteria are linked with other problems that are difficult to measure, or that the available data are limited or patchy (Cooper and du Plessis, 1998, Newton and Oldfield, 2008, Walpole *et al.*, 2009). All these issues consequently affect the implementation and monitoring of actions in the field. The problems identified here are summarised in turn for the three conservation approaches.

In the IUCN Red List approach, too little standardisation is not so much the problem as too much standardisation across very different organisms. Species with different life spans are measured using the same threshold values (Butchart *et al.*, 2007, Keith *et al.*, 2000, Mace *et al.*, 2008, Newton and Oldfield, 2008, Stork, 2010). The time period for which data are consulted is usually from 1970 to the present, which has been criticised as being too short to assess population trends for at least some groups of organisms (Willis *et al.*, 2007).

The lack of standardised methods for comparing vegetation types in WWF ecoregions also introduces problems. Regional vegetation classification maps were used to delineate ecoregion boundaries (Olson *et al.*, 2001). The assessment of some areas (e.g. boreal and polar regions) also incorporated climatic data to impose divisions of ecoregions containing largely homogeneous vegetation (Olson *et al.*, 2001). This classification was assessed with intensive input from experts (e.g. taxonomists, botanists, biologists and field specialists together with the IUCN Species Survival Commission (IUCN, 2012)) but with no quantifiable criteria (Schmidt, 1996). There are, however, no standardised thresholds or reference conditions to determine where to split or merge classifications. Some priority areas – the 'Global 200' – have been proposed by comparing the biological distinctiveness of each areas (Olson and Dinerstein, 1998, Olson and Dinerstein, 2002), but each ecoregion is different in size and these areas cannot be compared quantitatively (Figure 1.1).

Even where approaches do include quantitative thresholds, there can be imprecision. Thresholds of the two quantitative criteria used for defining CI hotspots have been criticised for their ambiguity (Mace *et al.*, 2000, Ovadia, 2003). CI's hotspots are defined by high plant species endemism (i.e. species which are only found in the area specified) combined with a high rate of habitat loss (Mittermeier *et al.*, 2005) (Figure 1.1). The hotspots are variable in size, and thus the assessment of endemism is imprecise because the larger the area, the greater the number of endemic species it is likely to contain (Brooks *et al.*, 2002). The evaluation of threat levels is also difficult because of the combined effect of complex factors affecting habitats (Brooks *et al.*, 2002). The method relies partly on an assessment of the original extent of vegetation. However this 'original extent' is unclear without extensive knowledge of historical changes in vegetation patterns (Willis *et al.*, 2007); even then, any vegetation cover will change throughout history due to climatic changes.

The second type of problem is that it is difficult to link components of biodiversity selected as priorities in existing conservation approaches, whether genes, species or ecosystems, with the overarching goal of biodiversity, which is to maximise conservation of all the components.

For the species-based IUCN Red List, there is no obvious quantitative basis for aggregating species statuses into scores or assessments for communities or other sets of species – apart from listing absolute numbers of species in each threat category – although attempts have been made: e.g. Key Biodiversity Areas (Eken *et al.*, 2009). In order to be identified as key biodiversity conservation areas, a site must contain one Critically Endangered (CR) or Endangered (EN) species, or 30 Vulnerable (VU) species. The site also has to hold a significant proportion of the species' global population (Eken *et al.*, 2009). Decision on such a quantitative distinction between conservation status in the Red List and the biological significance of the size of the area is rather arbitrary. It is not clear on what basis 30 Vulnerable species equates to 1 Endangered, or why Critically Endangered is treated as the same as Endangered. The population measurement is ambiguous because the larger area would lead to the greater chance of the area being important. By contrast, the Red List Index – a measure of temporal changes in overall extinction risk of a taxonomic group since 1970 – treats threat status such that the categories Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Near Threatened (NT) are given weights of 4, 3, 2, and 1 respectively. Extinct (EX) and Extinct in the Wild (EW) are given weights of 5 and Least Concern (LC) is zero-weighted (Butchart *et al.*, 2007, Butchart *et al.*, 2005). Thresholds in criteria distinguishing these categories are, however, not standardised in a quantitative way. For example, criterion B1 states that a taxon with a range smaller than 100 km^2 qualifies for CR (second highest status after Extinct) while VU species may have a range 5,000 km^2 or 20,000 km^2 in terms of the extent of occurrence (Table 1.3). The weight given for CR species (weight 4) by the Red List Index is twice as big as VU (weight 2). However, CR species have four times smaller range size than VU ones, implying that the weight should be four times greater rather than double. The justification for weighting Red List statuses in this way is not explained by the developers.

Site selection in WWF ecoregions is mainly based on vegetation classification, as 'vegetation is an important proxy for both plants and invertebrates, which together constitute the vast majority of species' (Olson and Dinerstein, 1998, Olson and Dinerstein, 2002). Assessment at the species level is mentioned, but details of the protocols or methodologies adopted are not given. Studies such as those by Fa and Funk (2007) and Loh *et al.* (2005) have attempted to incorporate ecoregion classifications

with species analysis and the ranking of conservation needs. Such work has been limited to vertebrates to date and results are often displayed on a global map, which is too coarse to detect fine-level variation on the ground.

The CI hotspot approach attempts to integrate species (number of endemics) and habitats (history of change in terms of area loss) (Table 1.2). This means that areas that are high in endemism and are not yet heavily disturbed can be excluded as conservation priorities. Although such areas have been highlighted as wilderness areas (Mittermeier *et al.*, 1998), the areas in question are based on political boundaries. Thus, CI's hotspot approach does not provide biologically meaningful outcomes (Brooks *et al.*, 2002).

1.2.3 Thoroughness of assessment and scope for future monitoring

The effectiveness of conservation assessment tools relies greatly on standardisation and the repeatability of evaluation methodologies. This also affects how such tools can be used for monitoring changes over time. The limitations of the examined approaches in this context are evident from what has been achieved so far.

Only 2% of the world's known species have been assessed on the IUCN Red List, which is biased towards birds, mammals, reptiles and amphibians (Vie *et al.*, 2008). For plants, only 12,914 vascular plant species out of 281,052 total species had been assessed by 2010 (IUCN, 2010a). The slow rate of progress despite more than two decades of effort is partially due to 1) the limited state of taxonomic knowledge, and 2) the poor data coverage in some regions such as South and Southeast Asia and South America (Lughadha *et al.*, 2005, Newton and Oldfield, 2008).

This problem of limited knowledge, however, applies equally to any system that relies on species-level assessment. It is clear that a fundamental problem of the IUCN Red List relates more to the complicated evaluation process that requires intensive data input than just to the lack of data. Decisions on conservation status are made by experts (IUCN, 2010a). Guidelines are provided, but are difficult

for non-experts to implement and require extensive data input. Therefore, replication of assessments is not practical or transparent to the end users. The recently developed Red List Index is designed to measure temporal changes of extinction risk for taxonomic groups since 1970 (Butchart *et al.*, 2007, Butchart *et al.*, 2005), but this index has only been assessed for 6% of known vertebrate species, demonstrating the practical difficulty of carrying out such time-series-based assessments (Baillie *et al.*, 2008, Butchart *et al.*, 2007, Butchart *et al.*, 2005). The definitions used in the Red List have been modified over time, meaning that it is almost impossible to make any rigorous comparison of status change (Lughadha *et al.*, 2005).

WWF ecoregions do cover vegetation across the world, but the basis for on-going monitoring of changing conditions in ecoregions was not fully discussed by the developers (Olson *et al.*, 2001). Various attempts to identify at-risk ecoregions have been made: for instance, by overlaying land cover data sets, and measuring the rate of habitat conversion for each ecoregion (Hoekstra *et al.*, 2005); or by incorporating human population density measures (Sanderson *et al.*, 2002). Such work is again data-intensive and not repeatable, suffering from a lack of any agreed standard method. Though these assessments can be used as a background for national strategies and priorities, it is often unclear how the choice of such large and varied priority regions should feed into priority areas at the local management level.

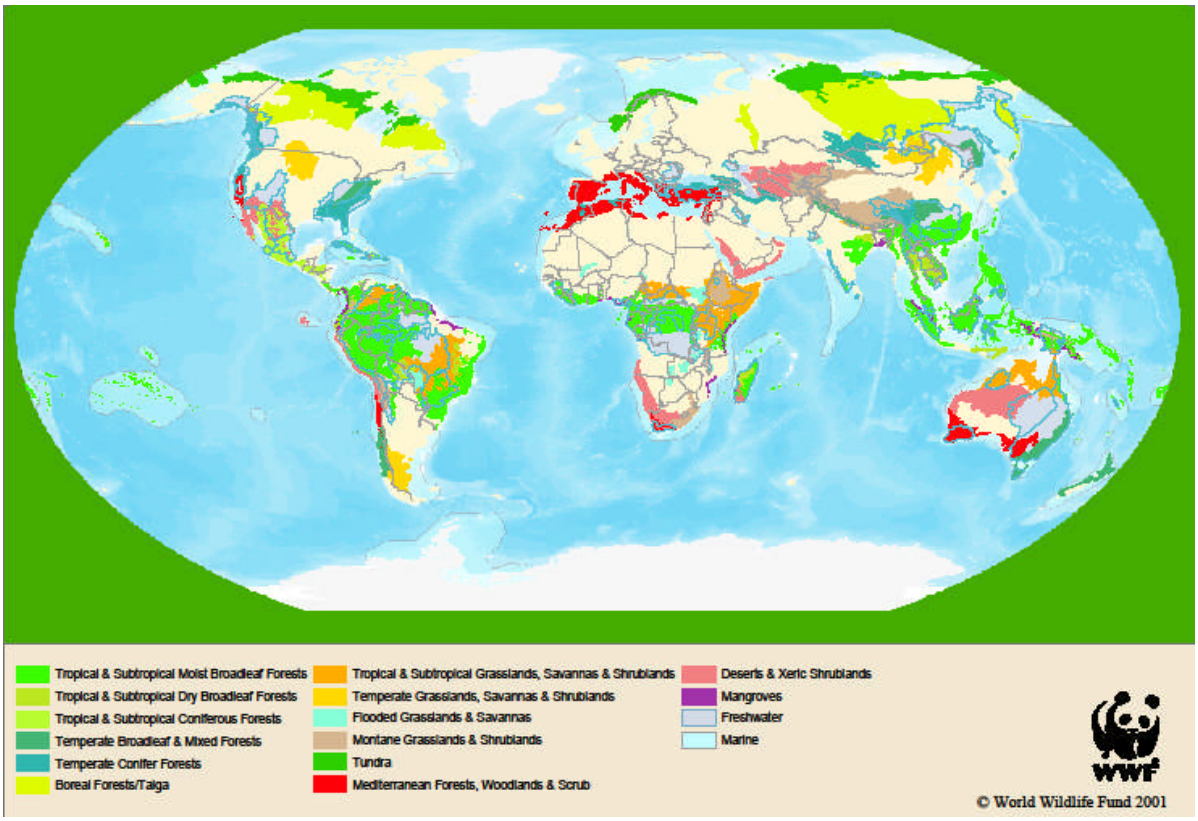
CI's hotspots were developed not to monitor temporal changes but to indicate where immediate action is needed (Mace *et al.*, 2000). There are critical limitations on standardising the assessments, as described above. The lack of reference conditions for the 'original' vegetation in their definition means that it is extremely difficult to monitor changes in the 'heat' of such a hotspot. Threat assessments are complicated by the range of threats to be considered, e.g. development pressure, human migration and climate fluctuations. Even if one could adequately standardise the definitions of original vegetation and threat, combining these two quantities – which operate on different dimensions – into one clear score poses an additional challenge (Mace *et al.*, 2000).

Table 1.3 Simplified overview of thresholds for the IUCN Red List of Threatened Species criteria. Adapted from Butchart *et al.* (2005) with modifications (IUCN, 2009).

Criterion	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Qualifiers and notes
A1: reduction in population size	≥ 90 %	≥ 70 %	≥ 50 %	over 10 years/3 generations in the past, where causes are reversible, understood and have ceased
A2–4: reduction in population size	≥ 80 %	≥ 50 %	≥ 30 %	over 10 years/3 generations in past, future or combination
B1: small range (extent of occurrence)	< 100 km^2	< 5,000 km^2	< 20, 000 km^2	plus two of (a) severe fragmentation/few localities (1, ≤5, ≤10), (b) continuing decline, (c) extreme fluctuation
B2: small range (area of occupancy)	< 10 km^2	< 500 km^2	< 2,000 km^2	plus two of (a) severe fragmentation/few localities (1, ≤5, ≤10), (b) continuing decline, (c) extreme fluctuation
C: small and declining population	< 250	< 2,500	< 10,000	mature individuals. Continuing decline either (1) over specified rates and time periods or (2) with (a) specified population structure or (b) extreme fluctuation
D1: very small population	< 50	< 250	< 1,000	mature individuals
D2: very small range	N/A	N/A	< 20 km^{22} or ≤ 5 locations	capable of becoming critically endangered or extinct within a very short time
E: quantitative analysis	≥ 50 % in 10 years/ 3 generations	≥ 20 % in 20 years/ 5 generations	≥ 10 % in 100 years	estimated extinction risk using quantitative models, e.g. population viability analyses

Near threatened (NT): a taxon does not qualify for any of the three threatened statuses now, but is close to quantify for, or is likely to quantify for, a threatened category in the near future.

Least Concern (LC): a taxon does not qualify for CR, EN, VU, or NT. Widespread and abundant taxa are included in this category.



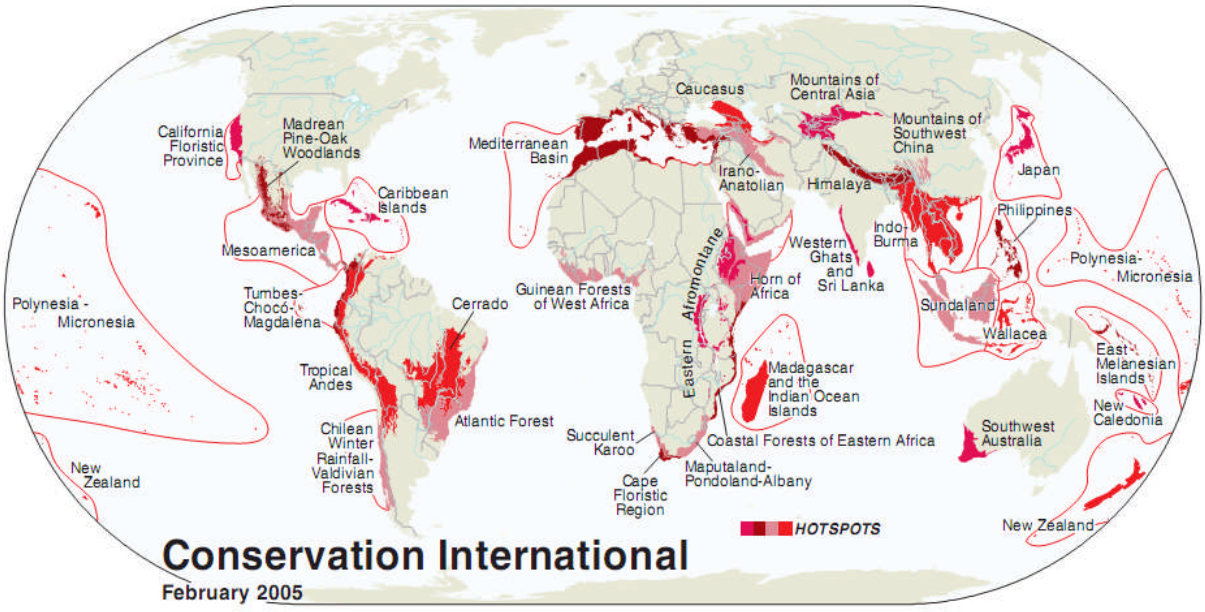


Figure 1.1 Map of Global 200 (top) priority ecoregions produced by WWF (World Wildlife Fund, 2010), and 34 biodiversity hotspots (bottom) selected by CI (Conservation International, 2009a)

1.2.4 Effectiveness of existing approaches

No single approach appears to be robust in terms of providing justification for standardised representation of biodiversity components at multiple levels, for underpinning objective and standardised sets of criteria, or being efficient as a basis for developing monitoring schemes. Existing approaches have their own targets and set of priorities within the theme of biodiversity conservation (Table 1.2). There is limited potential for examining other properties within their framework, which may lead to a biased evaluation of selected properties with respect to conservation values. Their assessment criteria are often difficult to interpret by non-experts. Their methods are often not repeatable due to the restrictive data requirements and the lack of standardised protocols in most approaches (Brooks *et al.*, 2006). These approaches fail in many ways to facilitate monitoring over time. In the case of the IUCN Red List, where the assessment of temporal change has been attempted, only a fraction of species have actually been evaluated and the results lack meaningful messages that are directly applied to decision-making on management practice (Lughadha *et al.*, 2005).

One of the most significant constraints in adopting any of the reviewed approaches is that the maps or lists of global priorities are not easily translated into actions at local management levels (Dinerstein *et al.*, 2007, Rodrigues, 2007). Most of the priority areas identified are too coarse to interpret management needs at specific sites in which policy-makers and practitioners are interested (Dinerstein and Wikramanayake, 1993). As Schmidt (1996) argued, '[c]onservation value is not the only thing that determines which sites actually get protected, whether planners use the ecosystem or hotspot approaches […] When it comes down to selecting actual sites, the biggest problems are the practicalities – availability of lands, money and capturing the attention of decision makers'. Approaches developed for setting priorities need to show their worth as transparent and comprehensive tools to guide conservation, rather than to make the decision-making process confused and biased.

1.3 Bioquality and the Genetic Heat Index: the approach adopted in this study

1.3.1 Concept of bioquality

The word 'bioquality' was introduced by Hawthorne and Abu-Juam (1995) and is defined as '*[a] term emphasising the relative concentration of various types of species in a community, in contrast to "biological diversity" which emphasises numbers of species. A community here refers to plant species assemblage in a given area, which may be a sample plot or particular vegetation surveyed. Bioquality by default stresses the concentration of "high conservation value" elements of biodiversity in a community, in respect of their global rarity and distinctiveness*' (Hawthorne and Abu-Juam, 1995). This value is indicated by four categories for species, called Stars, which are used to calculate community score. As such, bioquality expresses a quality related to different levels of biodiversity that many conservationists acknowledge, albeit often implicitly, in their concepts of conservation priority.

With bioquality, the measurement of biodiversity-related conservation value has been isolated from the separate issue of predicted threats to the habitat or the species. Threat and rarity value are confounded in both the IUCN and the CI approaches. A focus on the biological properties of global rarity and taxonomic distinctiveness, attributes which are closely interlinked, makes assessment using the bioquality approach directly measurable in a formalised and empirical way.

Box 1.2 The Star system and Genetic Heat Index (GHI)

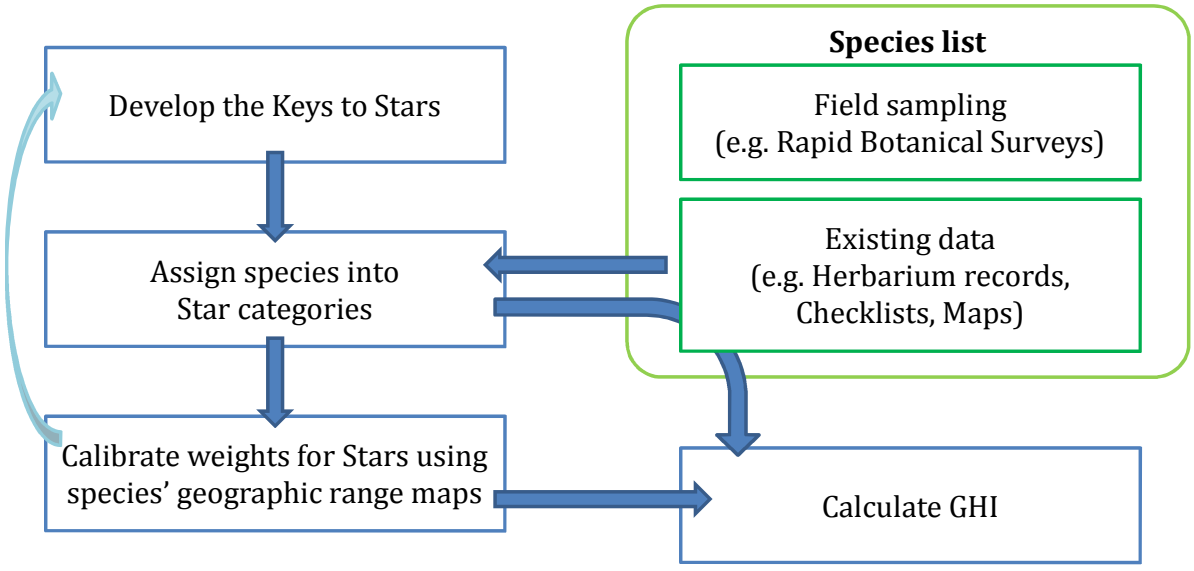
Species are ranked according to the Star rating system based on global rarity, with secondary consideration of abundance within their range, and of ecological and taxonomic attributes. Coloured Black, Gold, Blue and Green Stars (in order of decreasing conservation importance or wider geographic range size) are given to each species. In the original formulation (for Ghana), the weights of each Star category are in inverse proportion to the mean number of degree squares occupied by the component species for each Star, relative to a notional range for Green Star species rounded down to 72 (Hawthorne, 2012, Hawthorne and Abu-Juam, 1995). Green Stars are then allocated a weight of zero. GHI is calculated by totalling the scores for all qualifying species, dividing by the sum of the number of species with Stars, and multiplying by 100.

Star	Black	Gold	Blue	Green
Weight (w)	$\frac{aGN}{aBK}$	$\frac{aGN}{aGD}$	$\frac{aGN}{aBU}$	$\frac{aGN}{aGN} - 1$

$$\textbf{GHI} = \frac{((\boldsymbol{wBK}\times\boldsymbol{nBK})+(\boldsymbol{wGD}\times\boldsymbol{nGD})+(\boldsymbol{wBU}\times\boldsymbol{nBU})+(\boldsymbol{wGN}\times\boldsymbol{nGN}))}{(\boldsymbol{nBK}+\boldsymbol{nGD}+\boldsymbol{nBU}+\boldsymbol{nGN})} \times \mathbf{100}$$

where a is the average number of degree squares (i.e. area) occupied by the component species of a Star, w is a weight given for a Star category and n is the number of species for each Star category in a study area. Stars are abbreviated as BK = Black; GD = Gold; BU = Blue; GN = Green.

Route to bioquality assessment using the Star and Genetic heat Index (GHI)



The diagram above illustrates the flow of bioquality assessment. The Star system is first established and taxa are assigned Stars. Secondly, the weights of Stars are estimated and adjustments to the keys to Stars are made if necessary. These initial parts are dealt in Chapter 2. Then, species lists, such as survey data, checklists, or maps, are used to calculate the GHI scores. This is investigated in Chapters 3 and 4.

The Star system and Genetic Heat Index (Box 1.2) is a standardised species- and community-level scoring system developed to assess bioquality. GHI is related to a range size rarity index (Harcourt *et al.*, 2002, Hawthorne and Abu-Juam, 1995, Kessler, 2002), but with rarity scores expressed as a proportion of the total species count, and with 'rarity' weights standardised by reference to global one-degree ranges (for tropical and subtropical species).

Criteria for assigning Stars to species are primarily the plant species' geographic range size, and to a limited extent, its ecology and taxonomy. Although the system is based on Stars assigned to each species, and the Stars are based largely on global rarity, other factors are used to adjust the Stars slightly for particular species, so that infra-specific taxa can also be included and assigned Stars separately if necessary. Similarly, the varied opinions of taxonomists who might take a broader or narrower concept of a species can be accommodated.

This fine-tuning option can be exemplified with two types of species. Species A is a species in a monospecific family which is very distinct from any extant relatives. Species B is similar in global rarity to species A, but has very closely related, wide-ranging species. Species B and some close relatives might perhaps in the future all be sunk taxonomically, extending the new species' range significantly. In the philosophy of the Star system, species A can be allocated to a higher Star category than species B, because species B's genes are likely to be more widespread than those of species A. This approach gives us a theoretical basis for allocating Stars to infraspecific variants, even though at the moment, pending DNA sequencing for many more species, the scope for such subtlety is limited. Such changes in taxonomic status or difference in treatment by different taxonomists is not an unusual problem (Isaac *et al.*, 2004). This adjustment option also has the advantage of making the GHI more stable in the face of future taxonomic revisions.

1.3.2 Effectiveness of the bioquality approach examined

The bioquality approach has several advantages that differentiate it from other existing global approaches. The Star system defines a species-level rating which is directly mapped to the GHI as a community-level score. Equivalent GHIs can be calculated for plant communities at larger scales, e.g. for whole forests and strategic planning, or to make use of herbarium databases when finer-scale data are not available. Such multi-level, quantitative integration of components of biodiversity (i.e. species and communities in one measure) is seldom attempted in other approaches. Where it has been attempted outside of a bioquality approach, – such as range size rarity (Williams *et al.*, 1996) or weighted endemism (Linder, 2001) – the result is not globally standardised or not even calculable for all spatial scales. A GHI of 300 observed in a forest in Japan theoretically has a similar conservation importance with respect to global rarity of plant communities as the same score calculated in a similar-sized forest in other parts of the world. Similarly, a Black Star species in tropical Africa has quantitatively equivalent value to a Black Star species in Japan. Therefore, comparative analysis of rarity value can be readily performed on both species and communities around the world by the bioquality approach, although such examination is beyond the scope of this thesis.

Simple categorisation of global rarity into four ranks is another advantage in the bioquality approach, which was explicitly developed to allow most use to be made from any available data, as rapidly as possible. Classifying into four ranks is simple, enabling the rapid assessment of many taxa. A total of over 13,000 taxa have been assessed (3,000 taxa in the U.K. (Hawthorne, W.D. & Harris, S.A., personal communication), 3,000 in Trinidad (Baksh‐Comeau *et al.*, in press.), 1,000 in Chile (Hawthorne, W.D., personal communication), 1,000 in Mexico (Gordon *et al.*, 2004, Hawthorne and Hughes, 1997), 3,500 in Upper Guinea (Ghana (Hawthorne, 1996), Liberia (ArcelorMittal Liberia Limited, 2010)), 1,000 in Lower Guinea (Cameroon (Tchouto, 2004)), 500 in Gabon (Walters *et al.*, 2012) and 700 in Malaysia (Lee *et al.*, 1996)) with a further 5,500 in Japan (this thesis), 5,000 in Brunei, and 12,000 for the cerrado in Brazil to be added soon (Hawthorne, W.D., personal communication) (Figure 1.2). This sum will soon bring the total to almost 30,000 plant taxa, i.e. 10%

of the earth's vascular flora (Mora *et al.*, 2011), achieved by a handful of individual taxonomists and botanists.

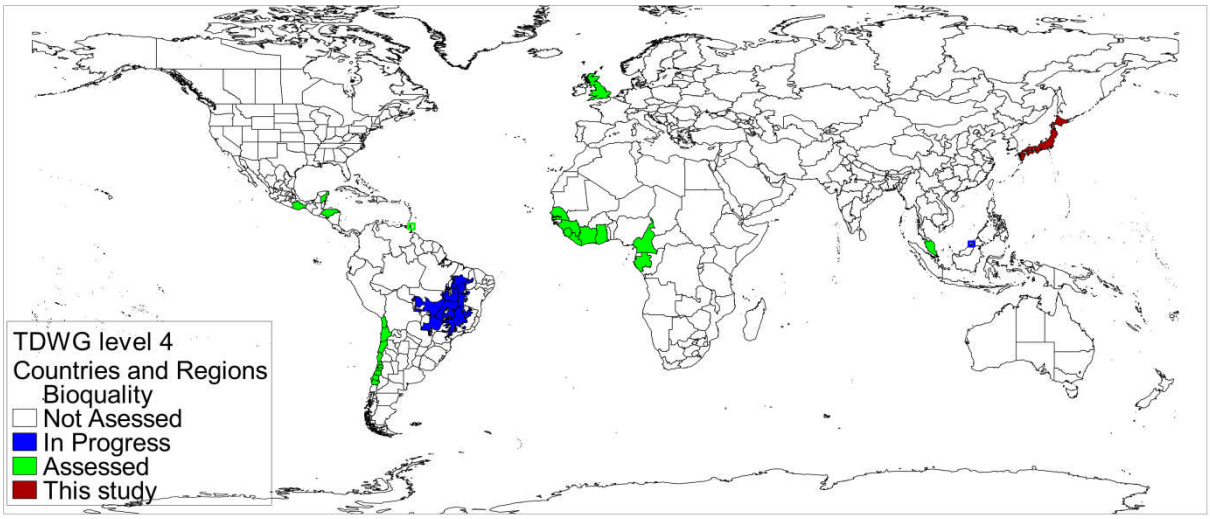


Figure 1.2 Map of areas evaluated or proposed for bioquality assessment. Japan, this case study area is highlighted in red. Trinidad and Tobago and Brunei, which are too small to be seen on the map, are highlighted by rectangles.

The bioquality approach was initially applied at the local management level, while keeping its assessment focus on global rarity (Hawthorne and Abu-Juam, 1995). This is fundamentally different from other approaches where priority assessment is aimed at the global level. The monitoring procedure using GHI at a local scale (RBS, see Chapter 4) is practical. Analysis of GHI scores using repeated botanical survey data in a study site or network of sites enables the measurement of temporal changes in community composition, and its conservation value, at a very local scale. Outcomes are easy to interpret even by non-scientists such as policy-makers and those engaged in land management on the ground.

1.3.3 Why I decided to evaluate bioquality approach for my study

The Star system and GHI satisfy many important requirements of a tool for setting conservation priorities in a standardised and practical way (Table 1.2). The area assessed by the bioquality approach has expanded since its initial development, although the total area evaluated is still relatively limited

compared to other existing approaches. By its very 'bottom-up' nature, it started locally and is expanding gradually (Figure 1.2). Nevertheless, where applied, this system has been shown to fulfil most of the key issues addressed above and is increasingly being adopted for site-level conservation work (Gordon *et al.*, 2004, Tchouto *et al.*, 2006). In comparison to the IUCN Red List, which required hundreds of field experts to assess 12,000 plant taxa, the Star status has already been evaluated on the equivalent number of plant taxa by a handful of taxonomists and ecologists for the examined areas, indicating that the potential for a larger number of taxa to be assessed using the bioquality approach is very high.

The Star system and GHI contribute to a proactive approach for prioritising the conservation of rare species and communities with high irreplaceability. CI's hotspots, by contrast, combine threats as a measure of vulnerability and so can be regarded as reactive approach (Brooks *et al.*, 2006). The challenge facing the bioquality approach is mostly related to advertising the system, given that other approaches have gained currency. There is little research to date, and none in Asia except for eastern Malaysia, which explicitly compares bioquality with other approaches (Hawthorne, W. D., personal communication). The accumulation of worked examples will be important in establishing its function in practical biodiversity conservation science; this thesis is one such example.

A key goal of this study is to develop the Star system and GHI for Japan (Chapters 2 and 3), and thereafter to see how the scientific backbone of the bioquality approach can be improved. In Chapter 5, I investigate how the results from bioquality analysis relate to other selected measures of biodiversity. Given that existing studies are mostly located in tropical regions, I examine the applicability of bioquality assessment in a temperate region, where latitude–longitude grid cells are not standard in area, and develop the rules for assessing Star weights. Star weights are calibrated based on species geographic range size. Initially in tropical Africa, range size was calculated as the number of latitude - longitude grid cell occupied. This becomes a problem when the same measurement is adopted in temperate region like Japan where the actual area of the latitude – longitude grid cell decreases at higher latitude. The effect of using different grid size is examined in Chapter 2. Investigation of the

behaviour of GHI scores at varying, nested levels of spatial resolution from global through national to local, would add evidence on how much a bioquality approach can reflect the fine-detail anatomy of the area of interest at different geographic extents. This scalability of the bioquality approach is examined in Chapters 3 and 4. The 'dissection' of a country hotspot down to individual site levels and observation on spatial patterns of global rarity is the core theme of this study.

1.4 Japan as a hotspot: introduction to the study area

1.4.1 Why is Japan interesting to study?

At the national level, Japan faces a range of challenges to fulfil its international responsibility as well as local agendas relating to biodiversity conservation. National-level analysis of priorities is critical in relation to implementation of conservation action, because key decisions about the national environmental policy exert a strong influence on local land management. Yet, the Japanese conservation framework barely overlaps with global priorities. Japan as a whole is a CI hotspot so in a sense any conservation effort addresses this. Nine terrestrial ecoregions (excluding Kamchatka–Kurile meadow and sparse forests and South Sakhalin–Kurile mixed forests on the Russian border) are identified for Japan by WWF's ecoregion approach and the Nansei-shoto archipelago forests are identified as one of Global 200 priority sites. However, there is no standardised method to zoom into the selected priority ecoregion or to evaluate its conservation importance relative to others.

It is evident in Japan that there is little coherence between the priority-setting approaches of global organisations. There are only 176 vascular plant species listed on the global IUCN Red Data list for Japan (IUCN, 2010a). Japan's nine WWF ecoregions are reiterations of Miyawaki's vegetation types (Appendix A), with no detailed information on which vegetation types merit conservation attention (Nakanishi *et al.*, 1993, Olson *et al.*, 2001).

Japan's National Biodiversity Strategy (Ministry of the Environment of Japan, 2007) is a core government policy statement for biodiversity conservation. It identified three key themes of particular

concern: 1) species loss and habitat degradation due to development pressure; 2) neglect of management in traditional rural landscape called *satochi-satoyama* (see Chapter 4); and 3) the spread of invasive species (Ministry of the Environment of Japan, 2007). The scientific justification for prioritisation of this *satochi-satoyama* landscape is weak. Its status as a conservation priority predominantly resulted from its national socio-economic interest. Thus, this landscape requires re-evaluation particularly in relation to its global importance. These three priority themes and the existing network of protected areas have little relation the targets set in the CBD's 2020 target (Kamei and Nakagoshi, 2006).

Severely limited data accessibility by non-Japanese-speaking scientists has been a major issue in working on this country (Kier *et al.*, 2005, Yesson *et al.*, 2007). For instance, there are no up-to-date English-language field guides to plant species. However, there is a substantial amount of accumulated data on the taxonomy and distribution of many organisms including plants. Therefore, there is great potential for studying the Japanese flora with respect to the evaluation of the bioquality approach.

1.4.2 The scope for bioquality analysis in Japan

Before the current work, there has been little systematic and detailed assessment of global importance of plant diversity in Japan despite extensive taxonomic knowledge and botanical collection established within the country. Limited data accessibility outside of the nation has subsequently restricted perspectives on conservation policy planning, which tend to be shared only within Japanese communities. Japan provides an interesting case for investigating issues with taxonomic knowledge and geographic range size estimates in evaluating global rarity. It is one of the better known floras in the world with respect to taxonomic description, with over 5,500 plant species. The geographic distributions of many taxa are also well documented, at least regarding the portion of the range that lies within Japan.

In order to separate out the biodiversity hotspots within Japan, an investigation of the patterns of spatial distribution of rare species and high GHI-scoring communities is performed using a variety of data sources, including field surveys and literature-based records. Analysis of the effect of sample size and methods to detect the 'genetic heat' of communities are examined to demonstrate the significance of the bioquality approach. Broad-scale patterns are explored in Chapter 3, and data from new fieldwork in two areas will be analysed in Chapter 4, to see how the Japanese hotspot looks at finer resolutions.

1.5 Summary of Chapter one

Global priorities with respect to the 2020 biodiversity targets are not directly linked to site-specific conservation, and the scientific grounding for identifying key areas is often weak. Any new approach should:

a) be globally standardised and can be applied for global priority-setting and local management,

b) integrate species assessment with community assessment,

c) express biological patterns alone (threats can be estimated separately), and

d) be practical and comprehensive to a wide variety of users.

It should also be transparent, objective and easily updated as new data come in or when taxonomic opinion changes.

The bioquality approach overall performs better than others in meeting most of the evaluation criteria addressed in this review (Table 1.1). The task now is to critically evaluate and consequently enhance scientific support for this approach as a conservation priority setting tool.

The main focus of this study is to test critically the robustness of the bioquality approach and to reveal limitations and sensitive nature of existing methods in the practical application of community-level priority assessment. I consider Japan as a case study area for using the bioquality approach, in effect to

dissect this hotspot – to investigate the patterns of bioquality at various scales, producing the first ever map of the Japanese hotspot, and to refine evaluation of biodiversity in the country.

1.6 Research aims and the content of this thesis

1.6.1 Overall aim of the study

How can biodiversity hotspots in Japan be discovered and mapped to encapsulate the concept of biodiversity in practical ways at various scales?

Two key objectives to achieve this study goal are:

- To develop and verify the Genetic Heat Index for plant species and communities in Japan using the Star system proposed for bioquality analysis;
- To investigate the patterns of spatial distribution of hotspots at different scales using various data sources.

1.6.2 Specific research objectives and outline of following chapters

I approach these questions from the perspectives of individual species (Chapter 2), national scale mapping (Chapter 3) and plant communities at local sites (Chapter 4). The results are discussed by comparison with other selected measures of biodiversity (Chapter 5).

Chapter 2: the Star system is applied and examined for the Flora of Japan.

The main output of this chapter is a Star rating of all the species in the Japanese vascular flora.

Key issues in developing criteria for Stars in temperate regions are investigated, specifically highlighting the following themes;

1) How much variation in the proportion of Stars results from incorporating consideration of a) uncertainty in geographic ranges, and b) taxonomic relatedness in the criteria?

2) Is there disparity in the Star representation when one compares results based on two data sources: the Flora of Japan and Kew's World's Checklist of Selected Plant Families?

3) What considerations are required for calculating the weights of Stars in the Japanese case?

Chapter 3: the Japanese hotspot redefined.

The main output of this chapter is the first ever detailed biodiversity hotspot map for Japan, based on vascular plant bioquality, and compiled from two main data sources: botanical prefecture data from the Flora of Japan database and Horikawa geoquadrat dot maps. Bioquality analysis is set at a national level and patterns of hotness (Genetic Heat Index, or GHI) in Japan are examined using different data sources. The agglomeration technique that was developed to compare two different maps at varying spatial resolution is also analysed.

1) Where are plant bioquality hotspots in Japan?

2) Are spatial patterns of bioquality hotspots congruent between maps created by different data sets?

3) How can data at different spatial resolutions be combined to make a master map of Japan's bioquality hotspot(s)?

4) How much variation in calculated GHI is observed using different techniques of agglomeration?

Chapter 4: Case studies in the field: GHI assessment on selected landscapes.

In this chapter, the significance of national hotspots is investigated at a local level using Rapid Botanic Survey (RBS) and existing literature to sample bioquality at the local scale directly and rapidly in the

field. The Japanese hotspot is thus further dissected using GHI scores calculated from locally collected field data in two main test regions; the *satochi-satoyama* landscape in Kanto region, and the Ryukyu Islands.

1) What are the bioquality scores of the selected case-study sites? How do local patterns relate to the national patterns of which they are part?

2) What are the likely causes of the local variation in bioquality? What are the implications of the observed ecological and GHI patterns with respect to conservation management on a site basis?

Chapter 5: Bioquality as a conservation assessment tool in comparison to other measures

Effectiveness of bioquality approach at community level is analysed against selected measures of biodiversity at national context.

1) To what extent are spatial patterns of bioquality hotspots, using Horikawa maps, congruent with other existing measures of biodiversity, notably species richness, endemism and range size rarity?

2) Is the current coverage of protected areas in Japan likely to be adequate for conserving bioquality hotspots?

3) Where are the priority areas that could be added to the existing protected area network to achieve the 17% target of the CBD at a national level and to improve Japanese contribution in response to global priorities?

Chapter 6: Future biodiversity assessment in Japan.

Finally, scientific contribution of findings in this study and implications to future biodiversity assessment in Japan and policy decision making will be discussed.

2 The Star system applied and examined for the flora of Japan

2.1 INTRODUCTION

Three problems must be examined when developing a rarity-based conservation assessment approach: the interpretation of species as an assessment object; definitions of rarity; and treatment of poor quality or biased data. Species level is one of three fundamental levels of definition of biodiversity (Secretariat of the Convention of Biological Diversity, 1992). It is an obvious primary level for working on conservation and gaining public attention for conservation targets. In the case of the Star system (examined in detail in this chapter), the proportion of rare taxa in the flora, weighted by the degree of this rarity, indicates the level of global rarity in – and hence the bioquality of – the study area. It is therefore important to consider how we measure and rank species' global rarity, and to develop an objective and standardised protocol for this assessment.

Under the bioquality approach, species and infraspecific taxa are categorised into four levels of global rarity called Stars (Box 2.1). Stars are units of global rarity, useful at the species level for highlighting the globally rarest species. They are also the basis of the community assessment addressed in Chapters 3 and 4. Global rarity in the Star system is primarily evaluated by species' geographic range sizes. Stars for a few species may be adjusted subsequently due to considerations of: 1) taxonomic relatedness to other such taxa with a different range; and 2) other factors of the ecology or relating to uncertainty in the data. For instance, species that are very sparsely distributed within their range may be upgraded – effectively designating them as rarer – and species for which the key data (i.e. taxonomic position such as synonymy, or range) are uncertain may be downgraded to become effectively commoner and therefore ultimately given less weight in the calculation of bioquality scores for communities.

It should be noted that introduced taxa are by default not given a Star status because they are not of primary concern for conservation with respect to global rarity. However, given that invasive species can be of significant threat to conservation (Bhagwat *et al.*, 2012, Bradshaw *et al.*, 2008), a separate measurement on the negative impact of such taxa may be considered. This is beyond the scope of this study; hence the development of invasive species index is not explicitly explored here.

Box 2.1 Summary of the Star system and the Genetic Heat Index (GHI)

A taxon's global rarity is classified into one of four ranked groups called Stars. The community score: Genetic Heat Index (GHI) is calculated using the following equations. A weight is calculated for Stars in the first line of equations; then the weights are used to calculate the GHI below.

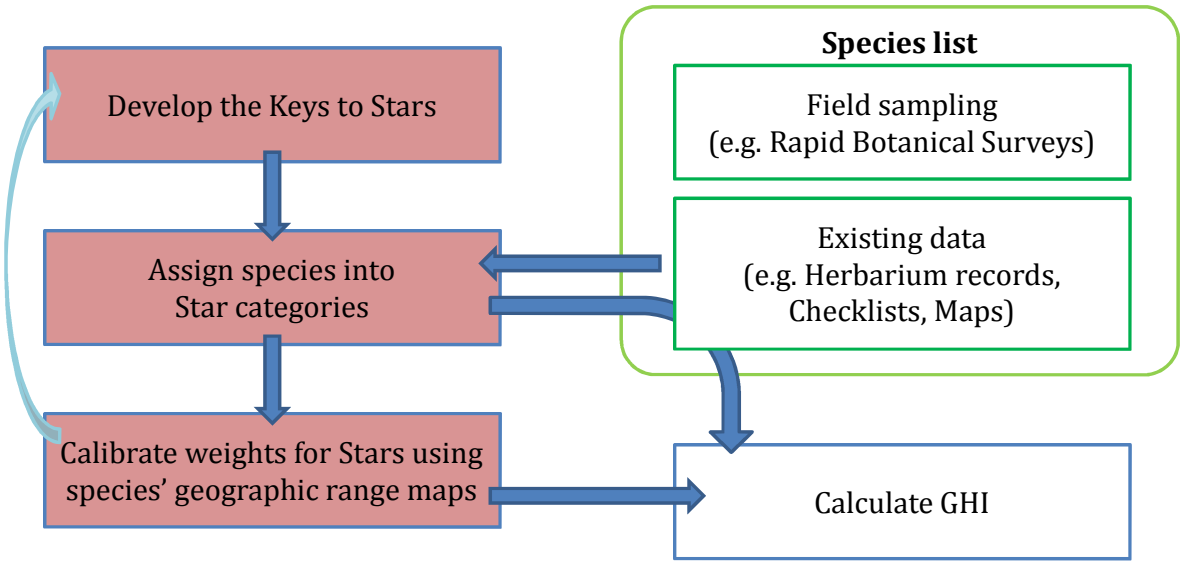
$$\mathbf{GHI} = \frac{((\boldsymbol{wBK}\times\boldsymbol{nBK})+(\boldsymbol{wGD}\times\boldsymbol{nGD})+(\boldsymbol{wBU}\times\boldsymbol{nBU})+(\boldsymbol{wGN}\times\boldsymbol{nGN}))}{(\boldsymbol{nBK}+\boldsymbol{nGD}+\boldsymbol{nBU}+\boldsymbol{nGN})} \times \mathbf{100}$$

Star	Black	Gold	Blue	Green
Weight (w)	$\frac{aGN}{aBK}$	$\frac{aGN}{aGD}$	$\frac{aGN}{aBU}$	$\frac{aGN}{aGN} - 1$

Where a is the average number of degree squares (i.e. area) occupied by the component species of a Star, w is a weight given for a Star category and n is the number of species for each Star category in a study area. Stars are abbreviated as BK = Black; GD = Gold; BU = Blue; GN = Green.

The mean number of degree squares occupied by Green Stars is standardised to be rounded down to 72 (Hawthorne, 2012). The calculated weights of Star categories shuold be as close to Black 27, Gold 9, Blue 3 in order to make them compatible with the weights originally implemented for African studies.

Route to bioquality assessment using the Star and Genetic heat Index (GHI)



Box 2.2 Examples of definitions of Star categories developed for Ghana and Liberia, and Keys to Stars introduced for Trinidad and Tobago.

1) Definition of Star categories used in Ghana and the number of species assigned each Star with their mean number of degree grid squares (1° latitude by 1° longitude grid) occupied. W = Weights of Stars, calculated from the formula (Box 2.1). Adopted from Hawthorne and Abu-Juam (1995).

Star	No. of species	No. d. s. in Africa	W	Conservation significance
Black	52	1.6±0.5	27	Urgent attention to conservation of population needed. Rare internationally, and at least uncommon in Ghana. Ghana must take particular care of these species.
Gold	208	7.8±3.8	9	Fairly rare internationally and/or locally. Ghana has some inescapable responsibility for maintaining these species.
Blue	414	24.5±12.6	3	Widespread internationally but rare in Ghana, or *vice versa*. It may be in Ghana's interest to pay attention to protecting some of these species.
Green	1044	69.2±49.8	0	No particular conservation concern.

2) Definition of Star categories adopted for Liberia with the number of taxa assigned for each Star category as the result of 42 Rapid Botanical Surveys (RBS) in the study area (Hawthorne, W. D., personal communication).

Star	No. of taxa	Conservation significance
Black	35	Endemic to a limited part of Upper Guinea, typically totalling 1–2 1-degree squares (120 x 120 km^2)
Gold	80	Of some conservation concern, in 2–5 1-degree squares and very common within this range (typically occupying < 9 1-degree squares).
Blue	173	Some slight conservation interest, but widespread, e.g. with scattered distributions across tropical Africa.
Green	642	Of no immediate global conservation concern. Widespread, at least common across Upper and Lower Guinea; often widespread in tropical Africa.

3) Regional framework developed for Trinidad and Tobago (T&T). Global range categories were defined for the T&T flora (left columns). These were translated to Stars in the right hand column as shown unless overruled by secondary adjustment. Adopted and modified from Hawthorne (2012).

	Global range categories and meanings	Sub-conditions, if any, to qualify for Star	Star
1	Endemic or near endemic to T&T. Near endemics are, for example, on Venezuela's Patos island, Paria Peninsula, in the Dutch Antilles or Grenada, not more widespread in S. America or Lesser Antilles.		**Black**
2	EITHER found more widely in, for example, Venezuela or Guyana, and southern Lesser Antilles; not just a small extension beyond T&T OR apparent T&T endemics but with very plausible records or (including likely synonymy) from well outside T&T.		**Gold**
3	EITHER fairly widespread across Venezuela, the Guianas, southern Caribbean	but sparsely distributed, for example, scattered on a few higher Caribbean mountain tops	**Gold**
	OR widespread in Caribbean (to Greater Antilles) and also in northern S. America.	in most or all countries in range with several distant localities, or known to be very abundant in part of range	**Blue**
4	As 3, but extending, for example, to Brazil, Bolivia, Peru	If only known in a distinct patch of; e.g. northern Brazil, S. Guyana; or very scattered throughout	**Blue**
	OR to Mexico and N. America (if both, go 5)	As far as known, found regularly throughout most of the area at least on a 1 degree resolution.	**Green**
5	Widespread in the Americas, but either not generally in the Caribbean, or scattered throughout range	Normally distributed in range, e.g., in most 1-degree squares throughout forest or savannah belts	**Green**
		Unusually scattered or sparse, even allowing for restriction to forest, savannah or similar formations, e.g. montane endemics on scattered peaks.	**Blue**
6	Widespread neotropical as 5 but more densely distributed plus Caribbean		**Green**
7–9	Globalised floristic elements	Widespread in Americas (probable origin) but also known today in the Old World; weeds; crops etc.	**Green**

2.1.1 Testing the Star system on the flora of Japan

In this chapter, a step-by-step guide for conservation practitioners to assign Stars to species, 'Keys to Stars' (see examples from previous studies in Box 2.2), was developed and examined. Taxa compiled in the Flora of Japan database were then assigned their respective Star ratings. The weights of Stars were estimated using selected distribution maps. Modifications to the Keys were made during the process of establishing the Star system for the Japanese flora. There are three key challenges in developing the Star system for Japan: 1) completeness and availability of the taxonomic knowledge base; 2) the treatment of taxonomic relatedness in categorising species' rarity; and 3) the calibration of Star weights from species' geographic range sizes in the high latitudinal region in order to be comparable with the standards developed nearer the equator.

2.1.1.1 Transferring available taxonomic knowledge to the Star system

The Star system strives to make the most of commonly available data for the majority of species. Additional protocols may then be developed for dealing with lesser-known species in a way which does not give them too much weight in case of future taxonomic or geographic change. Japan is relatively well studied taxonomically, and an updated Flora of Japan is available, but this flora has yet to be completed for monocots. The first complete English Flora of Japan published in 1965 (Ohwi *et al.*, 1965) has been in review and six out of eight volumes have been published by 2012 (Iwatsuki *et al.*, 1999, 2001, 2005, in preperation-a, b, Iwatsuki *et al.*, 1993, Iwatsuki *et al.*, 1995a, Iwatsuki *et al.*, 1995b). Kew's World Checklist of Selected Plant Families is a good additional data source. However, such global-level references do not always give adequately detailed information on, for instance, fine-resolution geographic range of species. Controlling for potential bias in the Star representation by integrating two different data sources was one of the first challenges examined.

2.1.1.2 Incorporating taxonomic relatedness in species assessment

Assessment of what makes species important from a conservation viewpoint ideally needs to incorporate taxonomic distinctiveness in the evaluation. In principle, phylogeny can contribute to differentiate taxonomic distinctiveness (e.g. Isaac *et al.* (2007) or Sechrest *et al.* (2002)). Integrating phylogenetic studies into the Star system is beyond the scope of this study. Current standards for incorporating taxonomic distinctiveness in the Star system are, however, described and examined in this study.

The Star system attempts to integrate taxonomic distinctiveness at various taxonomic levels into the ranking. The relatedness of species or infraspecific taxa is to be considered in Star rating once an initial Star rating is completed at the species level, potentially by providing additional protocols. Multi-step protocols to assign Stars allow for species to be upgraded if detailed information is available that reveals, for example, their distinctness from other species or their unusually sparse distribution within the global range. Conversely, rare infraspecific taxa may be considered for downgrading if the species as a whole is widespread (Hawthorne, 2012). The interpretation of infraspecific variation differs considerably between taxonomists; thus, another purpose of additional protocols is to give flexibility and standardisation in decision-making regarding taxonomic conflicts. During the process of compiling the Flora of Japan database, it became apparent that there were a considerable number of infraspecific taxa named in Japan. Therefore, the effect of different protocols for adjusting taxonomic relatedness will be extensively investigated in the search of a simple and practical solution to integrate taxonomic distinctiveness in the Star system.

2.1.1.3 Defining rarity measures at various spatial resolutions

The resolution at which species' range sizes are measured needs careful consideration when evaluating species rarity using geographic range. Resolution refers to the size of polygons or grid cells for which presence or absence of species is recorded. Two types of measure for geographic range size are: Area of Occupancy (AOO) which sums up the area (or the number times size of gridded cells) in which

species' presence are noted; and Extent of Occurrence (EOO) which measures the area that lies within the outermost perimeter of all present cells (Gaston and Fuller, 2009). The coarser the resolution of gridded maps, the larger the AOO range size estimate becomes, a statistical inevitability termed the 'scale–area' relationship (Hartley and Kunin, 2003, Kunin, 1998). The problem in overestimating range size at coarser resolution is that measurement is based on the assumption that species occur throughout the area within the gridded cell, which is seldom true in the real world. However, finer-resolution grids may imply equally wrongly that species are absent from small cells from which records are absent. Therefore, the resolution used to depict biological patterns of spatial spread of study taxa is an important consideration (Gaston and Fuller, 2009), for which the assessment of data availability across all taxa under consideration is crucial.

The mean count of grid cells occupied by a sample of species in each Star is used to calculate the weights for Stars, and this same weight is applied to each member of the Star. Species' geographic range sizes in the Star system were estimated at a resolution of one degree latitude by one degree longitude when the Star system was first formulated by Hawthorne and Abu-Juam (1995) for Ghanaian species. This is often the only available resolution of published maps for some regions or plant taxa, especially for tropical groups. The disadvantage of using a one-degree grid system, especially regions further from the equator, is that it is not an equal-area resolution. Degree squares cover less area at higher latitudes.

For the Horikawa dot map data used in this study, (see Methods below) species presence is recorded in 10′ latitude by 15′ longitude grid cells called 'geoquadrats'. The difference in area of the largest and smallest degree grid cell is 29.8%. The maximum geoquadrat area is 469.18 km^2 with central point 24.42° N 123.13° E: the minimum area is 361.33 km^2 at 45.58° N 141.86° E. Given such change in area for Japan, which extends from 22° N to 45° N, a resolution other than a 1-degree grid should be considered for calibrating weights for Stars in this study. The protocol refined by Hawthorne (2012) suggests that the criteria for Stars in other regions should aim for the same weights as those calculated in Africa, i.e. 27:9:3:1 ratios for Black:Gold:Blue:Green Star species using the 1-degree grid. An

alternative 100 km by 100 km grid cell size is considered in order to examine the effect of grid size on weight calculation for the Japanese flora.

The main aims of this chapter are to develop the Star system for the flora of Japan and critically examine potential sources of bias and sampling error along the way. The key question in this chapter is: how can existing data be used to establish the Star system, for the flora of Japan, to make the results compatible with those developed elsewhere? Two common issues in conservation assessment are addressed: interpretation and use of taxonomic knowledge and calibration of species' range size estimates by making use of available data.

2.2 RESEARCH QUESTIONS

Three objectives and specific research questions addressed in this chapter are:

1) To develop the criteria and database for the Star system for the flora of Japan;

2) To test for the stability of its classification criteria with respect to geographic, taxonomic and data-source considerations.

   - How much variation in the proportion of Stars results from incorporating consideration of a) uncertainty in geographic ranges, and b) taxonomic relatedness in the criteria?

   - Is there disparity in the Star representation when one compares results based on two data sources: the Flora of Japan and Kew's World's Checklist of Selected Plant Families?

3) To investigate how species' geographic range sizes estimated at various resolutions and different extents affect calibration of rarity scores in the Star system for Japan

   - What considerations are required for calculating weights of Stars in the Japanese case?

This chapter is structured as follows: First, data sets used for compiling the Flora of Japan database and for calibrating weights of Stars are outlined. Secondly in Methods section, how various data sets were treated in developing the Keys for Stars are described, which will be examined for sensitivity test as outlined. Using Horikawa dot maps and Taxonomic Database Working Group (TDWG) code information, techniques to estimate geographic range sizes in order to calibrate weights for Stars at two resolutions (1-degree grid and 100-km grid) and at two spatial extents – within Japan and global – are outlined. The results are divided into three parts: 1) description of the Keys to Stars for the Japanese flora (section 2.6); 2) a summary of the Flora of Japan database compiled and assigned for Stars (section 2.7); 3) the calculation of weights for Stars (section 2.8). The scientific importance of the Flora of Japan database and the Star system in advancing conservation assessment of the Japanese flora will then be discussed.

2.3 DATA SOURCES

The Flora of Japan database for this study was compiled in BRAHMS software (version 7) from two main data sources:

- Flora of Japan (hereafter **FOJ**) volumes 1, 2a, 2b, 2c, 3a and 3b (Iwatsuki *et al.*, 1999, 2001, 2005, Iwatsuki *et al.*, 1993, Iwatsuki *et al.*, 1995a, Iwatsuki *et al.*, 1995b);

- Kew's World Checklist of Selected Plant Families and Kew's list for the Gramineae (hereafter **Kew WCSP**) (W.C.S.P., 2012).

Additional data sources consulted are: Missouri Botanic Garden's Tropicos (hereafter **MO Tropicos**) available at http://www.tropicos.org, Global Compositae Checklist (hereafter **TICA**) available at http://compositae.landcareresearch.co.nz/Default.aspx, the International Legume Database & Information Service (hereafter **ILDIS**) available at http://www.ildis.org/, and the Old Flora of Japan (hereafter **old FOJ**) (Ohwi *et al.*, 1965) .

For calculation of weights for Stars, the following data sets were assembled:

- Horikawa geoquadrat maps (here after **Horikawa dot maps**): Within-Japan distribution maps for 862 taxa on a 10′ latitude by 15′ longitude grid, with the individual cells as the basic sample unit here, and called 'geoquadrats' produced by Horikawa (1972, 1976).

- TDWG occurrence data from Kew WCSP: 1,657 species (out of 2,444 taxa, excluding 174 taxa without Star status; 519 infraspecific taxa; and 94 Gramineae species which are under revision in the Kew database) with a full list of Taxonomic Database Working Group's geographic region codes (**TDWG**) occurrences at level 3 (Biodiversity Information Standards TDWG, 2011, Kew GIS unit, 2011).

- **The Farjon conifer database**: Global database for 615 conifer species covering over 29,000 specimen collected across the world and fully reviewed taxonomic description was compiled and made available online in BRAHMS format by Farjon (2010).

It was suspected that the Horikawa dot map series is biased towards narrow-ranged species; it is known that it only represents the Japanese part of the range for non-endemic species. The species' global geographic range in the Flora of Japan database is available only as TDWG level 3 codes, or as full-text descriptions.

The conifer database was used to investigate the relationship between the 1-degree grids or 100-km grid and TDWG level 3 codes. It was expected that if there was a robust relationship between grid count and TDWG L3 counts, it could be used to estimate the mean range of Green Star species in term of grid cells occupied based on TDWG level 3 codes.

2.3.1 Flora of Japan (FOJ)

FOJ volumes 1, 2c and 3a were obtained in the form of tabulated text files from one of my collaborators, Motomi Ito's group at the University of Tokyo, Japan. The online database is also

available for these volumes at http://foj.c.u-tokyo.ac.jp/gbif/. Volumes 2a and 2b are currently only available as hard copy, hence 807 text files of scanned individual pages of the two volumes were provided with permission by Ito. Data in plain text were flagged with identifiers of field names used in the database such as citation, distribution and so on. Errors in text recognition were also corrected manually. The cleaned text file with flagged identifiers of field names was then transformed to a table format by a parsing script programmed by my colleague Chris Dixon and imported into BRAHMS.

2.3.2 Kew's world checklist of selected plant families (Kew WCSP)

Kew WCSP was used to cover monocot families which are not yet published in the revised Flora of Japan series. Monocot data were obtained from Kew's online database at http://apps.kew.org/wcsp/home.do; and from Kew's Grasses list at http://www.kew.org/data/grasses-syn/ for Gramineae (last accessed on 5 March 2012). 'Botanical countries' are defined by the TDWG level 3 codes and used as search criteria to build a checklist of monocots in Japan using Kew's data.

TDWG codes are four-level globally standardised codes for taxa's geographic distribution. From the largest area geographic units are delineated as continent (level 1), regions (level 3), botanical countries (level 3), and basic recording units (level 4) (Biodiversity Information Standards TDWG, 2011). Regions are commonly recognised natural areas (e.g. Arabian Peninsula, Indian Subcontinent) or those circumscribed for this purpose (e.g. Malesia, East Africa) (Brummitt, 2001). Levels 1 and 2 combined generate the numerical codes; e.g. African continent is 2, and the regions of Africa are numbered 20-29. Japan is 38 (at level 1, 3 and 4 are assigned for temperate and tropical Asia respectively) (Brummitt, 2001). Botanical countries at level 3 are sometimes equivalent to political countries, but larger countries are often broken up into smaller botanical country units. Each level 3 botanical country is named by a unique 3-letter code (Bradshaw *et al.*, 2008). The four botanical countries with their TDWG codes (Figure 2.1), extracted for Japan were: JAP for mainland Japan, OGA for Ogasawara Islands, NNS for Ryukyu Islands (Nansei-Shoto), and KZN for Kazan Islands (Biodiversity Information Standards TDWG, 2011). Intersection of the Level 3 units with political (ISO) units is

used for level 4. In many cases, this is identical to level 3. In the case of Japan, mainland Japan is further divided into Hokkaido (JAP-HK), Honshu (JAP-HN), Kyushu (JAP-KY) and Shikoku (JAP-SH), while small islands groups are NNS-OO for Ryukyu Islands, KZN-OO for Kazan Islands, and OGA-OO for Ogasawara Islands, with OO indicating the definition is equivalent to that of level 3.

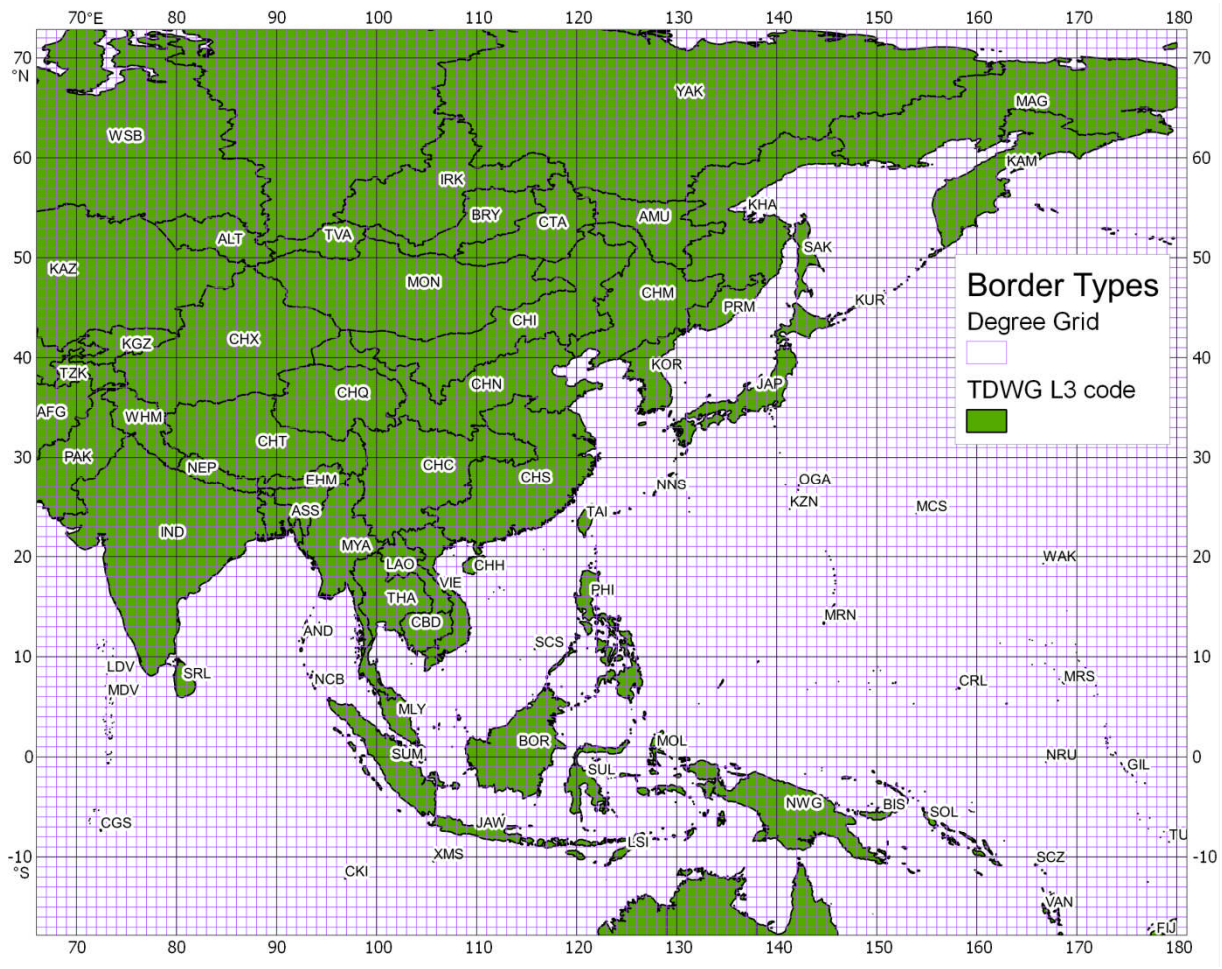


Figure 2.1 Taxonomic Database Working Group's geographic region (TDWG) Level 3 codes (green) overlain by 1-degree grid (purple), enlarged for part of Asia and neighbouring areas.

2.3.3 Compiling the database of the Flora of Japan

The final Flora of Japan database holds 30,656 names including taxa added from survey data and other sources such as checklists. It comprises 8,262 accepted names, 40 unresolved taxa and 22,156 synonyms. Accepted names include 1,788 infraspecific taxa (1,399 varieties and 389 subspecies), 375 hybrids, 28 cultivars, and 192 formae.

With respect to data sources, 9,566 taxonomic names were transferred from Ito's FOJ volumes 1, 2c and 3a, and I added an additional 8,947 taxonomic names from FOJ volumes 2a and 2b to the database. 11,242 and 426 names were further added from Kew WCSP and Grass list respectively. FOJ covers the majority (71.1%, 5,875 names) of the 8,262 accepted names in the database. Kew WCSP provides 2,261 accepted names (27.4% of the total accepted in the database). The remaining 1.5% relates to species recorded in survey data, checklists and maps with names that are not mentioned in either source but may only be in IPNI, and were hence treated as unresolved. Taxonomic information was assembled from various data sources for these additional taxa. As Kew's checklist is being revised for Gramineae, 427 accepted names of the family Gramineae were incorporated into the database but their synonyms or distribution information were not included (W.C.S.P., 2012). Gramineae was omitted from analyses unless Stars were assigned using other existing data sources. Grass species identified in Rapid Botanical Survey plots (Chapter 4) have been checked individually for synonymy and distribution.

For cases where there are conflicts in taxonomic status or opinion between FOJ and Kew WCSP, (e.g. FOJ treating a name as accepted while Kew WCSP treating the same name as a synonym or *vice versa*), a standard protocol was developed:

1. FOJ is the first source for taxonomic and ecological information. If FOJ is not available, Kew WCSP is used as the secondary source.

2. Where taxonomic information or global distribution data are incomplete for both FOJ and Kew WCSP, other references were searched such as MO Tropicos, TICA and old FOJ.

An IUCN list for plant taxa in Japan was created using their online database by filtering for taxonomy: vascular plants (Tracheophyta) and location: Japan (IUCN, 2010a). The Japanese Red List of Threatened Species compiled up to 2007 (Japan Integrated Biodiversity Information System, 2010) was also separately entered into the BRAHMS database. The former list is global, thus refers to **the IUCN Red List** in this study. The latter is a regional one, which adopts separate assessment protocols

for regional assessments (IUCN, 2003). This one is distinguished from the global list, and called **the Japanese Red List** in this study.

2.3.4 Horikawa geoquadrat dot maps

Horikawa and his colleagues compiled distribution maps for 862 taxa (hereafter **Horikawa dot maps**) across 1,418 grid cells of 10′ latitude by 15′ longitude, called 'geoquadrats' (roughly at 20 × 20 km resolution; 1/24 degree^2) across Japan (Horikawa, 1972, 1976). Taxon distribution was based largely on their own collections and field observations with a few supplemented by data from herbaria, monographs and established local floras. The maps were digitised, geo-referenced and re-sampled using GIS software (ArcGIS version 9.1 (2011) and QuantumGIS version 1.7.4 (2012)). This was done initially using a custom programme created and operated by one of my collaborators Tomoki Higa and his colleagues at Forestry, Forest Products Research Institute, Japan. I have checked every map and manually corrected errors; largely misrecognition of data points due to the poor colour quality on original hard copies during this digitising process or due to inaccurate allocation of geoquadrats on small islands (Figure 2.2). Geoquadrats that fell over small islands occasionally split the land into more than one square which led to data points located mostly in the ocean on the resulting maps. In these cases, data points were merged by Horikawa, usually to one, and moved to completely enclose the island (Horikawa, 1972). In this study, these islands were effectively re-split by the digitisation process, i.e. multiple grid cells were recreated and presence records were fitted on these grids.

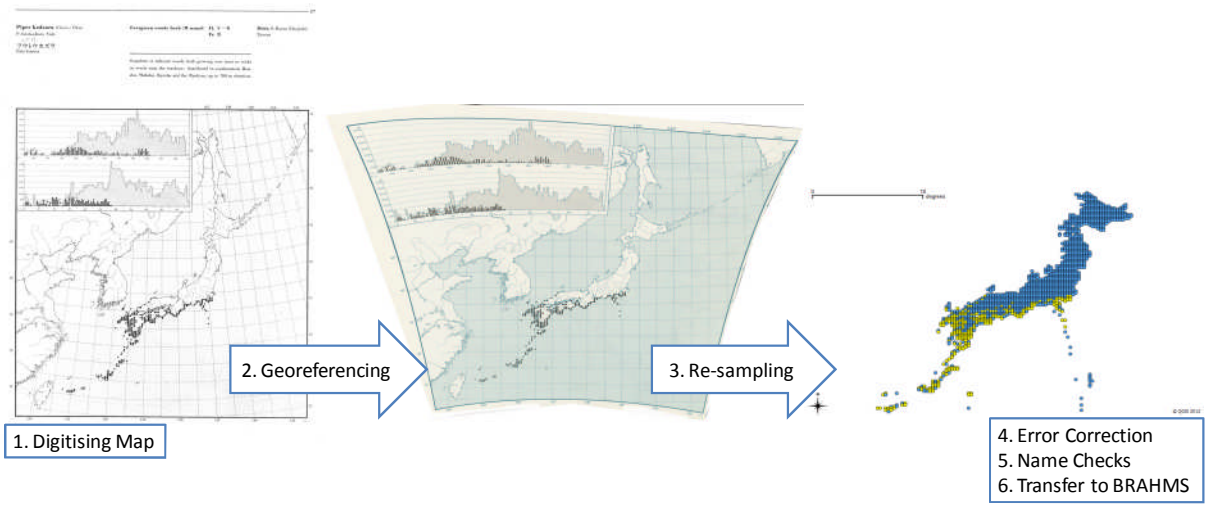


Figure 2.2 Flow diagram showing GIS processing done for compiling 862 Horikawa maps.

All taxonomic names in Horikawa dot maps were checked against FOJ and other sources and updated to the accepted names where necessary. Three taxa now treated as synonyms of others in the Horikawa dot maps were merged to their accepted names in the database. This was done by examining Japanese names used in Horikawa dot maps. Japanese names are often more reliable than Latin names in the sense that all field guides and most Japanese taxonomic references use Japanese names. Scientific names often seem to be taken from old references or the source may be unclear, causing some taxonomic uncertainty. 30 moss species were amongst the 862 maps, but are excluded from further analysis. 97 infraspecific taxa were excluded from range size calculations, because their full species range was not mapped there. All 167,562 cleaned Horikawa cell presence records with corrected taxonomic names were then transferred to BRAHMS with corresponding location details (latitude, longitude).

2.4 METHODS

2.4.1 Developing the Keys to Stars

The assembled Flora of Japan database contains descriptive information on global and within-Japan species distribution. *Prefecture* and *districts* were selected as geographic units in the Keys (see section 2.6.6) because these were the frequently-used geographic expressions for species distribution. In

existing studies, country (e.g. Ghana, Trinidad and Tobago) or regions (Guinea, Caribbean) have been used as such geographic units (Box 2.2). The exact area covered by these different geographic expressions is variable, yet it should be reminded that the Keys are designed so that the area occupied by species in individual Star categories is comparable between regions. It is also practical to use geographic units that are based on frequently used local description of species distribution to make the Keys comprehensive to conservation practitioners on the ground. Criteria were developed for these units by examining their areas and geographic features so that mean species' geographic range size of Stars would be area equivalent to, in terms of ratios for the number of 1° latitude by 1° longitude grid squares occupied, approximately Black 1, Gold 3, Blue 9, and Green 27. This makes the Star categories comparable to the proposed standard (Hawthorne, 2012). Keys were developed to be conservative in the face of ignorance and to assume a maximum extent (i.e. less global rarity) from coarse-resolution data. Stars were assigned to taxa using FOJ as the primary source of data; then consulting the Kew WCSP as the secondary source, and others such as MO Tropicos, TICA and old FOJ where necessary.

When using Kew WCSP data, species distribution information was often only available at coarse resolution, such as for main island groups of Japan, instead of more specific localities. Additional criteria to assign Stars conservatively using such data were also developed (page 55).

Once default or first-approximation Stars have been assigned using the Keys to Stars, inter- and intra-specific variation, i.e. taxonomic relatedness was examined based on descriptions in the literature. Guidelines for taxonomic adjustment were developed to reallocate Stars if appropriate. This is particularly important in this study because of the large number of infraspecific taxa described in the Flora of Japan database. (21.6% of accepted names in the database are subspecies or varieties).

2.4.2 Testing sensitivity of Criteria for assigning Stars

The following six methods (Box 2.3) were tested for the sensitivity of using various protocols for assigning Stars to taxa.

Box 2.3 Six methods examined for sensitivity analysis of Star criteria

0. **Default**: Stars are assigned following the Keys to Stars and by upgrading taxa with no close relatives even at higher taxonomic levels. No Star status was given in the case of uncertain distributions.

1. **Geo**: an additional Key (Page 55) to assign Stars for taxa with distribution only known at TDWG level 3 is applied. Taxa with distribution only known within Japan were assigned Stars using the initial Keys for endemic taxa.

2. **Geo up**: Taxa with distribution only known at TDWG level 3 or within Japan are upgraded by one category from the Star assigned by Geo method. Taxa with unknown distribution are given the highest rarity rank of Black.

3. **Geo down**: Taxa with distribution only known at TDWG level 3 or only within Japan are downgraded by one category from the Star assigned by the Geo method. Taxa with unknown distribution are given the lowest rarity rank of Green.

For examining taxonomic relatedness, Stars were first assigned using the initial keys (page 52) and additional guidelines for taxa with coarse-resolution geographic information (page 55), then adjustments were made by the following methods:

4. **Infra auto**: Infraspecific taxa are automatically downgraded by one Star category compared to the default rating assigned to the taxon.

5. **Infra selective**: Infraspecific taxa have their Star categories selectively modified following the additional guideline proposed (Table 2.1).

Methods 2 and 4 would not be a normal or even reasonable approach for Star assignment. However, these are included merely to test the impact of extremes in the protocol in the face of missing data.

In addition to a comparison of the proportional representation of four Star categories, the effect of different Star classification methods on GHI was investigated. The purpose of this analysis is to examine fluctuations in GHI that would be caused by different Star classification methods, i.e. to test the sensitivity of the final GHI to the various methods. This sensitivity analysis informs a decision on how much attention to detail is appropriate. Using prefecture species lists parsed from the Flora of Japan database – the full description of data preparation is described in Chapter 3 – five Star classification methods were compared against the default method for prefecture level GHI. Analysis on GHI as a community score is explored fully in Chapters 3 and 4. The R script developed for this analysis is listed in Appendix B.

2.4.3 Estimating species' geographic range sizes and calibrating weights for Stars

The purpose of measuring species' geographic range sizes is to help fine-tune the criteria for Stars, such that the weights for Stars are compatible across projects, or as close as possible to 27:9:3:1 weight ratios for Black: Gold: Blue: Green, calculated for other countries. To test this, after refining the Key for Stars as much as practical, the mean geographic range sizes were calculated for each draft Star classification. The weights of each Star category were calculated by taking inverse mean range size of species in a Star relative to that of Green species, following the standard procedure (Box 2.1) (Hawthorne, 2012). In the case of Japan using Horikawa dot map data, species' geographic ranges were calculated at two resolutions (1-degree grid and 100-km grid) and at two spatial extents (within Japan and global). Conifer data that contained both TDWG and herbarium specimen data were used to investigate the relationship between TDWG counts and grid cell occurrences.

A 1° latitude by 1° longitude grid (hereafter **1-degree grid**), the standard grid size for weighting Stars in the Star system for tropical countries, was superimposed on the geoquadrats (Figure 2.3). The land (as opposed to sea) area of each geoquadrat was measured using a 50 m DEM (Digital Elevation Model) for the four main islands of Hokkaido, Honshu, Shikoku and Kyushu and small island groups to check errors (data courtesy of Motoki Higa at Forestry, Forest Product Research Institute, Japan) (Japan Map Center Foundation, 2011). Geoquadrats were merged to 1-degree grid cells in the statistical package R (Appendix B). The summed number of grid cells occupied by individual taxa was recorded for each species at the two (1/24 and 1-degree) resolutions.

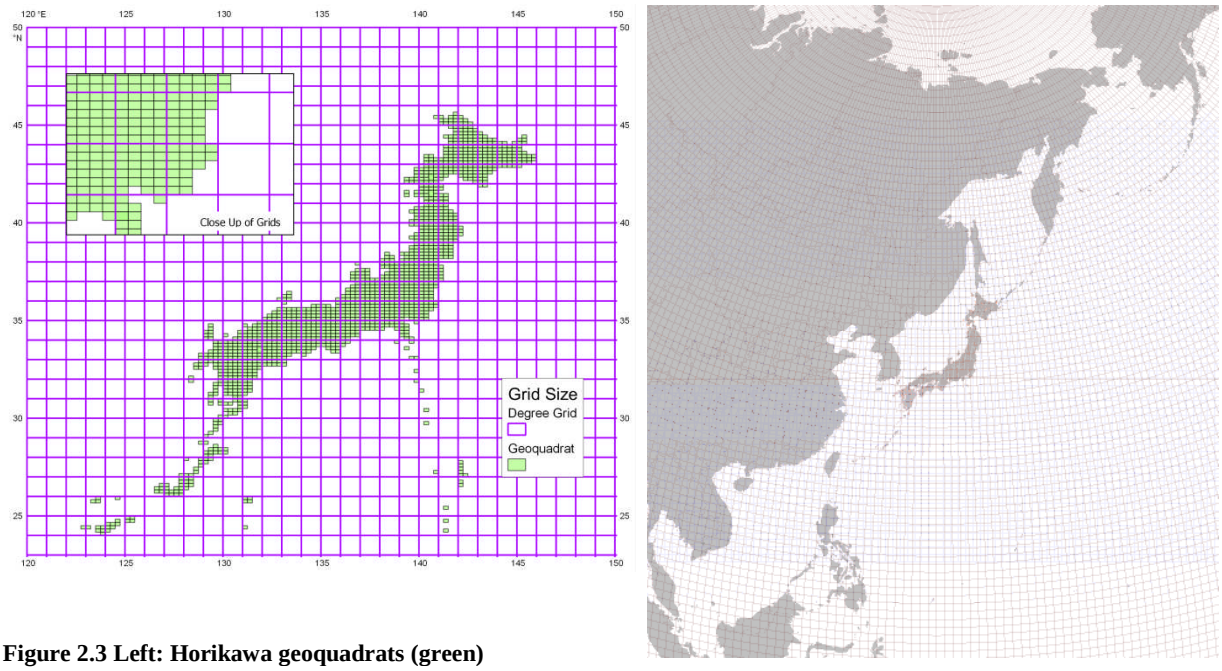


Figure 2.3 Left: Horikawa geoquadrats (green) superimposed by 1-degree grid cell (purple). 4 by 6 geoquadrats are contained in 1-degree grid. Right: Map of Japan and surrounding areas projected by Lambert azimuthal equal-area projection centred at 35° N and 135° E.

In order to compare the effect on Star weights of using an equal-area, rather than a degree-based grid, cell-based range sizes were also estimated based on a projection to an equal-area grid. Latitude and longitude coordinates on central points of each geoquadrat were obtained, and transferred to a kilometre-based coordinate on the map generated by Lambert azimuthal equal-area projection centred at 35° N 135° E on mainland Japan (Figure 2.3). A 100 km by 100 km grid (hereafter **100-km grid**) was then superimposed on the original Horikawa geoquadrat centre points using this projection; and the number of 100-km grid squares occupied by individual species was estimated (see Appendix B for R script). This therefore involves an approximation that species occurred in the 100-km cells in which the centre-point of the geoquadrat was located; whereas some geoquadrats on the borders of the 100-km cells in fact have an unresolvable part of their sample area in the adjacent 100-km cell.

Using Horikawa dot maps, 219 Japanese-endemic species were initially used to calibrate weights for each Star at 1-degree and 100-km grid resolutions, as for these species the Japanese is also the global distribution. Secondly, Horikawa dot maps supplemented with outside-Japan distribution information were used to estimate mean geographic range sizes for an additional 26 near-endemic (6 Black, 10 Gold and 10 Blue Star) species on the 1-degree grid. All of these species' distributions outside Japan are restricted to either Taiwan or parts of Korea, or Sakhalin to the Kuriles. The geographic range size

of these species outside Japan was calculated in terms of 1-degree grid occurrence using either TDWG level 3 codes or interpreting descriptive global distribution information from FOJ, Kew WCSP or other available data sources. The total number of 1-degree grid cells occupied was calculated by referencing locations of 1-degree grid cells on the regional map (Figure 2.1). One-degree grids with less than 1% land cover were excluded from counting. These counts were then added to the total number of species' present 1-degree grids in Japan, derived from Horikawa dot maps. This methodology was developed to give a maximum possible degree-square count given the available information. How calibration of weights are affected by different data measured at varying resolutions was investigated subsequently (page 76).

In the conifer database, global point localities for herbarium specimens of each species and TDWG level 3 occurrences were examined. 947 taxa have either a TDWG level-3 (or 4) distribution or specimen records or both. Of these, 314 infraspecific taxa and 168 non-accepted names were excluded from the weight calculations. Many species lack TDWG level-4 data while some have, hence all TDWG distribution information was summarised to level 3 (**TDWG L3 count**). Latitude–longitude coordinates of 28,625 specimen location records containing 776 unique taxa were converted to presence–absence records on a global **100-km grid** and on a **1-degree grid**. For the 100-km grid cell count, a map with 28,625 locality records of all specimens in the database was re-projected into the Mollweide equal-area projection with 35° N 135° E, (the Meridian for Japanese Standard Time). The number of occupied 100-km grid cells; and of occupied 1-degree grid cells were obtained for 495 accepted species, using mapped specimen locations. Species' geographic range sizes in terms of these three counts were then compared in R (script in Appendix B). The predicted relationship using conifer data to extrapolate grid occurrences from TDWG data was tested for selected species with TDWG level-3 code information compiled in the Flora of Japan database.

2.4.4 Analyses

All statistical tests were run in the R package (version 2.14.1) except for G-test using a Excel programme developed by McDonald (2009). A *G*-test of independence was performed for comparing classifications based on FOJ and on Kew WCSP. The *G*-test was chosen for its additivity, i.e. it is possible to partition individual *G*-values run for each Star category to check which of the four Star categories is significantly different in terms of proportion of taxa represented compared to the expected ratio (Sokal and Rohlf, 1995). To test the sensitivity of Star classification protocols, prefecture-level GHIs calculated by different methods were compared with that by default using Spearman's rank correlation analysis and Wilcoxon's signed rank test (paired). Prefecture GHIs using six Star classification methods showed right-tailed distribution (Shapiro–Wilk normality test all $P < 0.001$ (R package 'Stats' version 2.16.0)), hence these tests were selected. Spearman's rank correlation analysis was performed for comparison of range size estimated from 100 km grid to TDWG level-3 codes and 1-degree grids. This test was selected because species geographic range size estimate were not normally distributed (Shapiro–Wilk normality test all $P < 0.0001$ for 1-degree grid, 100-km grid, TDWG L3 count). Linear regression was additionally performed to predict the relationship between these two measurements.

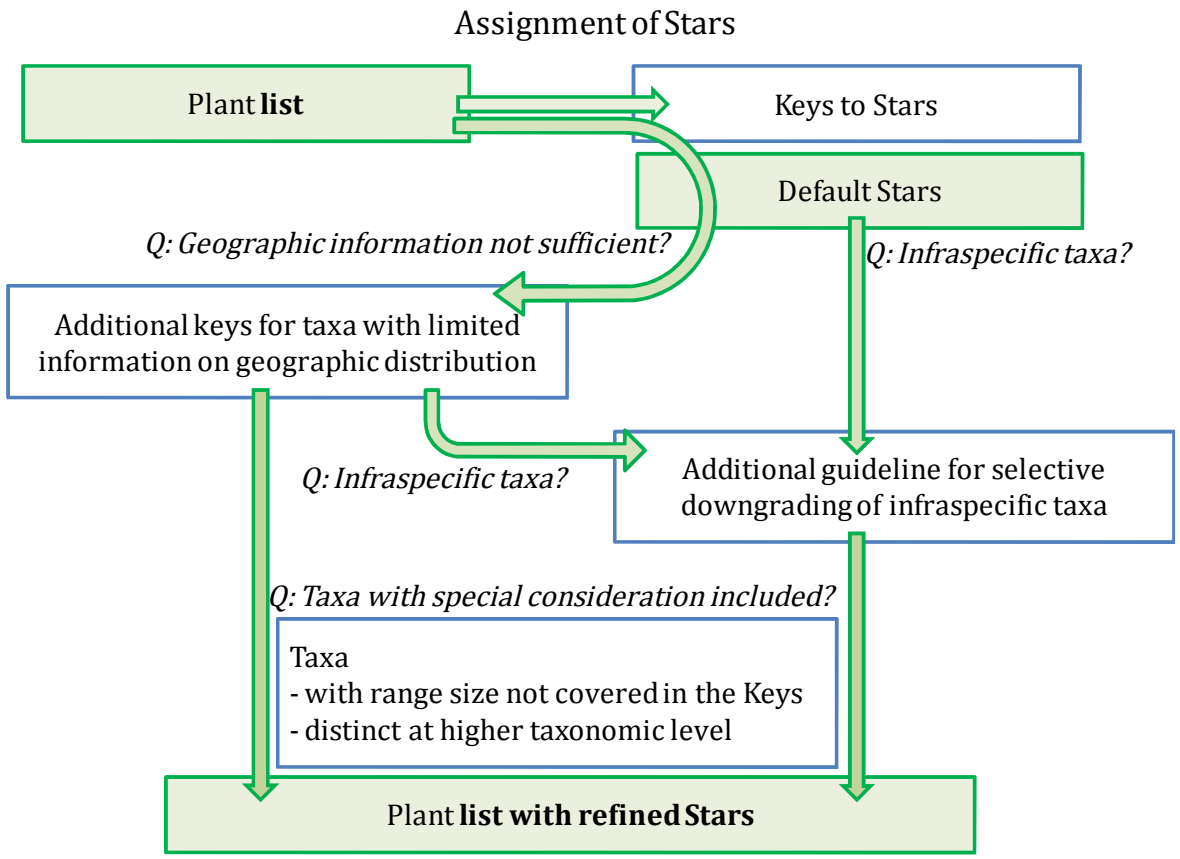
2.5 RESULTS

2.6 Keys to Stars with taxonomic and geographic adjustment

The following criteria are proposed to assign Stars with adjustment for taxonomic relatedness. This incorporates results from examination of different classification methods and data sources (page 46).

Stars are assigned in two major steps: classification of taxa into default Stars, then, possibly, adjustment to a final Star based on taxonomic relatedness or other criteria (Box 2.4). The initial assessment is performed using Keys to Stars for the Japanese flora (section 2.6). When information on the geographic distributions of taxa is scarce, additional keys are used as a supplementary guide to assign Stars to as many taxa as possible (section 2.6.2). This applies for taxa whose geographic distribution is either not available in the Flora of Japan or lacks adequate detail. The latter case often applies to reference such as Kew's World Checklist of Selected Plant Families and Missouri Botanic Garden's Tropicos. General principles on how to make adjustments from default Stars for rare-within-range or infraspecific taxa are illustrated (section 2.6.4). These in effect provide a conservative assessment of Star value in cases of uncertainty. The criteria follow the general principle described in the Keys by default. The geographic boundaries adopted for the Japanese key to default Stars, i.e. *prefectures* and *districts* are described on section 2.6.6.

Box 2.4 Flow of assessment steps to assign Stars for the Japanese flora



2.6.1 **Keys to Stars for the Japanese flora**

1. Endemic to Japan

2. Endemic to any (or all) of the following small island groups

Ryukyu Islands, Ogasawara Islands, Izu Islands = **BLACK**

2a. Not only in the small island groups

3. Not so widespread in Japan (≤ 2 districts AND ≤ 14 prefectures)

Only in ≤ 7 prefectures = **BLACK**

In > 7 prefectures = **GOLD**

3a. Widespread in Japan (> 2 districts OR > 14 prefectures)

4. Occur in ≤ 10 prefectures

In ≤ 5 prefectures and rare (e.g. mountain tops, along the coast line) = **BLACK**

In > 5 prefectures = **GOLD**

4a. Occur in > 10 prefectures

Not in all districts = **BLUE**

In almost all districts = **GREEN**

1a. Not endemic to Japan

2. Apart from Japan, only in one of Taiwan OR Korea OR the Kuriles & Sakhalin, use the table:

Distribution outside Japan		**Distribution within Japan**			
Regions	Distribution in the regions	Islands or ≤ 1 district	≤ 2 districts	≤ 3 districts	> 3 districts
Taiwan	< ½ island	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	≥ ½ island	**GOLD**	**BLUE**	**GREEN**	**GREEN**
Korea	Islands or sparse distribution	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	Not only in islands nor restricted	**GOLD**	**BLUE**	**GREEN**	**GREEN**
Kuriles & Sakhalin	Only in the south Kuriles	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	Not only in the south Kuriles	**GOLD**	**BLUE**	**GREEN**	**GREEN**
China	≤ 2 provinces	**GOLD**	**BLUE**	**GREEN**	**GREEN**
	>2 provinces	**GREEN**	**GREEN**	**GREEN**	**GREEN**

2a. Not only in one of Taiwan OR Korea OR the Kuriles & Sakhalin, and beyond = **GREEN**

2.6.2 Additional keys for taxa with limited information on geographic distribution

The following additional guideline is for taxa whose geographic distribution is either not available or description lacks local specification:

1. Endemic to Japan

2. Endemic to any (or all) of the following small islands groups e.g. NNS, OGA, KZN = **BLACK**

2a. Not only in the small island groups

3. No more than one region of Japan (≤ 2 districts) e.g. N. Japan, C. Honshu = **GOLD**

3a. Over one region of Japan (> 2 districts)

4. Not across all of mainland Japan e.g. C. & S. Japan, Honshu = **BLUE**

4a. Across or only described as Japan = **GREEN**

1a. Not endemic to Japan: follow the Keys (previous page)

2.6.3 Taxa with globally limited distribution whose range is not covered by the Keys

Non-endemic taxa with globally restricted distributions and not covered by the keys may still be assigned a Star higher than Green. Blue Star is allocated to species which meet both of the following conditions (examples identified in the database for this study are listed on page 60):

1) The taxon is found only in islands or one district in Japan;

2) The taxon is distributed outside Japan but is limited to small islands or areas equivalent to one district of Japan.

2.6.4 Taxonomic relatedness: Downgrading Stars for infraspecific taxa

The key allocates a default Star based on distribution, but this can be modified using subsidiary criteria for infraspecific taxa (Table 2.1). The resulting Stars for infraspecific taxa after taxonomic adjustment are shown inside the area shaded in red. Hybrids and cultivars are by default not assigned a Star in this assessment. Formae have the same Star as the taxon to which they belong.

Table 2.1 Additional guideline for selective downgrading of infraspecific taxa in relation to their species.

1. Species-level default Star	**2. Infraspecific taxon before adjustment, i.e. default Star based on range alone**			
	Black	**Gold**	**Blue**	**Green**
Black	Black	—	—	—
Gold	Black*	Gold	—	—
Blue	Gold	Gold*	Blue	—
Green	Blue	Blue	Blue*/Green	Green

1. Work out the default Star for the species in which the infraspecific taxon belongs. Using the same key, calculate that applicable for the range of the infraspecific taxon alone. This default infraspecific Star rank can only be the same or higher than the species level Star because the variety can only be less widespread than the species that contains it.
2. Adjust the Star ranking for infraspecific taxa against corresponding Star for species.

   Cases where the infraspecific taxon has the higher Star status than its species (marked *) can only apply where infraspecific taxa:

   EITHER have extremely localised restricted distribution compared to the species as a whole. In this case Stars are unchanged from its initial status assigned by using the Keys based on range alone.

   OR are particularly morphologically distinct from sister infraspecific taxa, such that different taxonomists might well have considered them separate species.

2.6.5 Taxonomic relatedness: upgrading Stars for rare taxa

Similarly, species which are distinctive at a higher taxonomic level, such as one in a monospecific family, can be upgraded a Star, if it was previously close to the borderline for the higher ranked Star. This has symbolic value more than being particularly important in the bigger bioquality picture, as very few species are known to be so isolated. Given that there are only a handful of such clear-cut cases in the Japanese flora, modification in Star rating was dealt with individually in the later section (page 60). Genera that are believed to be endemic to Japan have been examined for their Star status and results are summarised in later section Table 2.3.

2.6.6 Interpretation of districts and prefectures used in the keys

Users of the Key to Stars are advised to consult the following guidelines.

- The 14 sub-prefectures of Hokkaido are treated as prefectures in the keys.
- Where distribution is only described at the scale of districts with no specification of prefectures, the total number of prefectures within the district should be used as an approximation. This is a conservative choice, potentially making species seem less rare than they are, as is advised in the case of uncertainty (Hawthorne, 2012).

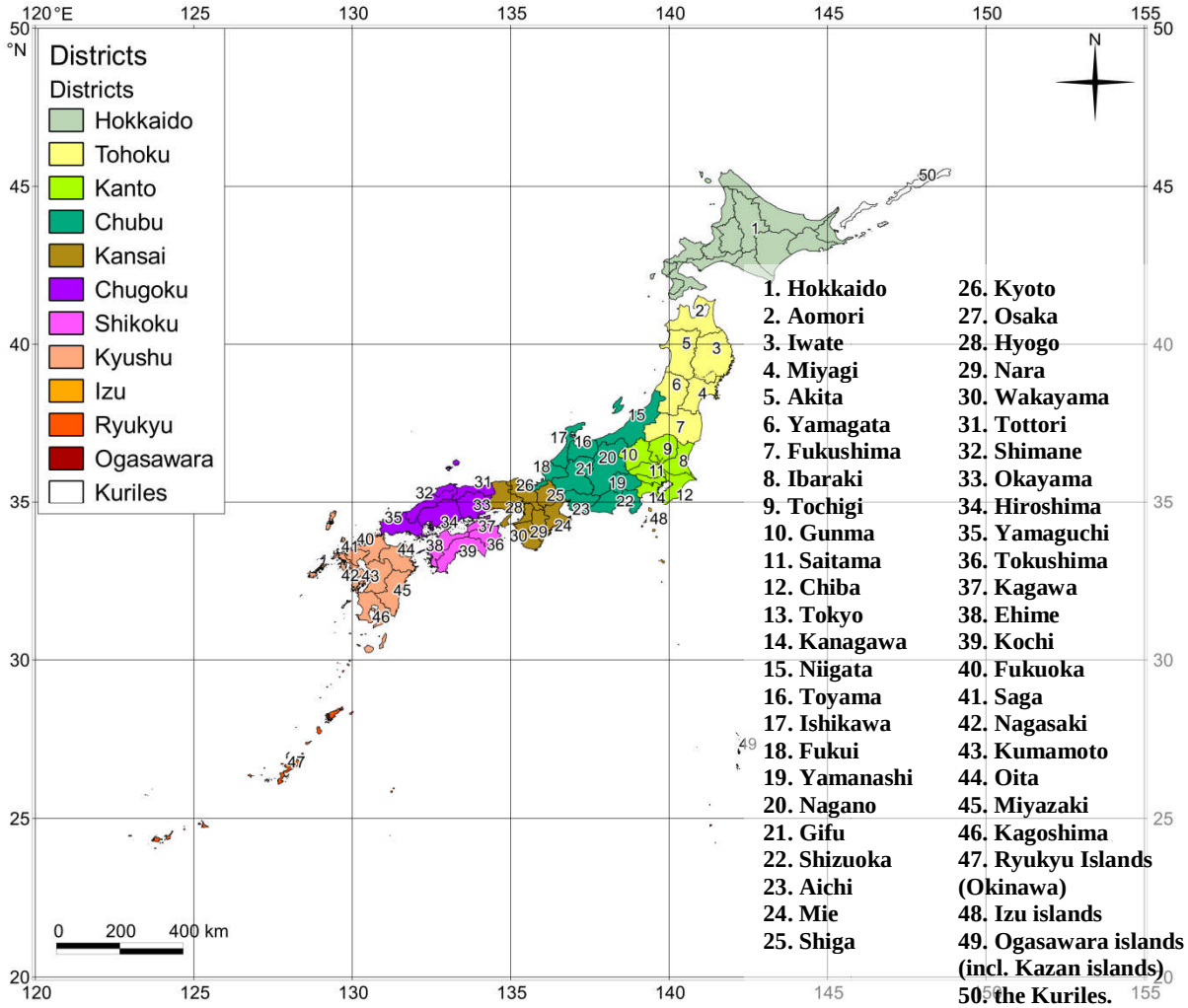


Figure 2.4 Map of Japan showing districts in colours. Botanical prefectures used in this study are numbered.

2.7 Summary of the Flora of Japan database with Stars

In this chapter, taxon refers to species and infraspecific taxa such as varieties and subspecies. Taxon totals are the total number of species and infraspecific taxa in the database. A species-level entry (with no variety specified) and all varieties of that species, whether or not it is the typical variety, are counted as separate taxa. For example, the following list counts as three taxa as *Clinopodium micranthum* that contains the following two varieties:

Clinopodium micranthum (Labiatae)

Clinopodium micranthum var. *micranthum*

Clinopodium micranthum var. *sachalinense*

Any of these entries on its own is listed as separate names in the database although they would count as one species. This count system is adopted in this study because the Flora of Japan often does not specify the typical variety of the species, and in some cases only infraspecific taxa were listed without description of the species that they belong to.

2.7.1 Overview of the database with Stars

A total of 6,506 taxa out of 8,262 accepted names in the database were initially assigned Stars using the default Keys to Stars. There were 375 hybrid, 28 cultivars, and 192 formae as accepted names in the database for which Stars were not assigned on their own. 40 unresolved taxa are also treated as unclassifiable (Star-less) even when these taxa were found in plots or other survey data. 1,688 infraspecific taxa were also given Stars, suitably adjusted (see Page 46). 641 taxa have had Stars refined using the supplementary guideline for taxa with limited geographic information (Page 55). After fine-turning Star statuses, a total of 7,145 taxa (86.5% of all accepted taxa in the database) were assigned a Star status.

2.7.2 Example taxa with special considerations applied to their Star rating

Eleven species and two infraspecific taxa had geographic ranges that are not covered adequately by the keys, due to unusual global distributions. These species are not endemic to Japan, but have globally restricted range size. Such taxa were given higher than Green Star rank using the suggested guideline (page 55). The Star status of non-Japanese endemic restricted-range taxa is listed in Table 2.2. Two infraspecific taxa also fall within this condition in the Flora of Japan database. Taxa were further adjusted for taxonomic relatedness following the guideline (page 56). The Star status of two taxa after applying taxonomic relatedness adjustment is as follows:

- *Carex subumbellata* var. *subumbellata* (Cyperaceae)

  Based on the key alone, this taxon was initially Gold Star but was downgraded to Blue, based on infraspecific adjustment. Species *Carex subumbellata* Meinsh. which occurs in Sakhalin and Japan (Kew WCSP) is assigned Green. Variety *subumbellata* occurs in Sakhalin, and N. Japan (Mt. Yubaridake) (Kew WCSP).

- *Tarenna gracilipes* (Hayata) Ohwi var. *kotoensis* Hayata (Rubiaceae)

  Tarenna gracilipes (Hayata) Ohwi is given Gold Star and is only found in W. and S. Kyushu, Ryukyu and Taiwan (FOJ 3a) or Nansei-shoto and Taiwan (Kew). *Tarenna gracilipes* var. *kotoensis* is also initially allocated Gold Star status. This taxon is found in Ryukyu (Sakishima Islands) and Lanyu Island. (FOJ 3a). Note that this infraspecific taxon is treated as synonym of *Tarenna asiatica* (L.) Kuntze ex K.Schum., which is Green with distribution in India to Japan and Borneo (Kew WCSP). Flora of Japan has been taken as primary data source in this study but is subject to future taxonomic examination, but whatever its taxonomic status this close alliance has signalled the reduction of *T. gracilipes* var. *kotoensis* to Blue Star.

Table 2.2 Taxa with globally limited distribution, whose range do not fall within Keys or additional Keys. Abbreviated Star category is used: BK; Black, GD; Gold, BU; Blue, GN; Green. Data sources are abbreviated as: Kew WCSP; Kew, Flora of China; Fl. China (Zhengyi *et al.*, 2004).

Family	Taxonomic name	Star	Ggeographic distribution
Araceae	*Alocasia atropurpurea* Engl.	BU	Nansei-shoto (Okinawa), Philippines (N. Luzon) (Kew).
Cyperaceae	*Carex brachyanthera* Ohwi	BU	Nansei-shoto to Taiwan, New Guinea (Kew).
	Carex hattoriana Nakai ex Tuyama	BU	Taiwan to Ogasawara-shoto and Caroline Is. (Palau) (Kew).
Labiatae	*Ajuga pygmaea* A. Gray	BU	Japan (S. Kyushu) to Taiwan, SE. China (Jiangsu) (WCSP, Fl. China).
Orchidaceae	*Calanthe nipponica* Makino	BU	SE. Tibet, N. & C. Japan (Kew).
	Odontochilus inabae (Hayata) Hayata ex T.P.Lin	BU	Japan (Yakushima) to Taiwan, N. Vietnam (Kew).
	Cheirostylis liukiuensis Masam.	GD	China (Hong Kong), Nansei-shoto to Taiwan (Kew).
	Cheirostylis takeoi (Hayata) Schltr.	BU	N. Vietnam, Nansei-shoto to Taiwan (Kew).
	Thrixspermum fantasticum L.O.Williams	BU	Nansei-shoto to Philippines (Leyte) (Kew).
Pandanaceae	*Freycinetia formosana* Hemsl.	BU	Nansei-shoto to Philippines (Batan Isl.) (Kew).
Zingiberaceae	*Alpinia flabellata* Ridl.	BU	Nansei-shoto to Philippines (Kew).

Taxa that are rare considering higher taxonomic levels were investigated separately for upgrading of their Star status. Two monospecific families have species that are endemic to Japan and are both upgraded from Blue to Gold Stars – effectively in respect of their assumed globally rare genes:

- Sciadopityaceae: *Sciadopitys verticillata* (Thunb.) Siebold & Zucc. has a global distribution on rocky slopes of mountains at elevation between 700 m and 1200 m in Central to West Honshu, Shikoku and East Kyushu (Iwatsuki *et al.,* 1995a). This species distribution is also agreed by WCSP which is described as SC. & S. Japan.

- Glaucidiaceae: *Glaucidium palmatum* Siebold &Zucc. occurs in summer-green forests, thickets, and in meadows at 200–2300 m in elevation in Hokkaido (Hidaka Mountains and westward) and on the Japan Sea side of Tohoku and Chubu Districts of Honshu (Iwatsuki *et al.*, 2005).

Fifteen genera – *Dendrocacalia*, *Diaspananthus*, *Miricacalia*, *Ranzania*, *Thujopsis*, *Tsusiophyllum*, *Hakonechloa*, *Dactylostalix*, *Eleorchis*, *Pteridophyllum*, *Anemonopsis*, *Pseudopyxis*, *Boninia*, *Peltoboykinia* and *Apodicarpum* – are believed to be endemic to Japan (Kato and Ebihara, 2011). A total of 20 taxa were examined for upgrading Star status (Table 2.3).

Table 2.3 Summary of species in genera endemic to Japan, or non-endemic but with globally restricted geographic range. Due to rarity at genus level, modification of Star status was considered as described. Star category is abbreviated as BK= Black; GD= Gold; BU= Blue; GN= Green. Taxa with modified Stars are highlighted by Star category in bold. Geographic distribution and habitats are described in square brackets. †; the number of taxa in genus. '?' indicates either genera in review or with taxonomic conflict. Data sources are abbreviated as: Flora of Japan, FOJ with volume numbers; Kew WCSP, Kew; MO Tropicos, MO; TICA.

Family and taxonomic name	†	Star status		Notes: taxonomic status in non-FOJ reference, distribution, habitat
		Before	After	
Asteraceae ***Dendrocacalia crepidifolia* (Nakai) Nakai**	2	BK	BK	Accepted, with no information on distribution (TICA) [Ogasawara Islands (Hahajima). Margins of forests (FOJ 3b)] The other name is *Dendrocacalia crepididifolia* Nakai which is not recorded in FOJ
Asteraceae ***Diaspananthus uniflorus* (Sch.-Bip.) Kitam.**	1	GD	**BK**	Accepted, with matching distribution (TICA) [C. Honshu (Pacific side from Kanagawa Pref. to Wakayama Pref.), Shikoku and Kyushu. Rich humus in deciduous forests (FOJ 3b)]
Asteraceae ***Miricacalia makineana* (Yatabe) Kitam.**	1	GD	**BK**	Accepted, with no information on distribution (TICA) [Honshu (Pacific side, westward from Kanto Dist.), Shikoku and Kyushu. Humus rich slopes in deciduous forests on high mountains (FOJ 3b)]
Berberidaceae ***Ranzania japonica* (T.Ito) T.Ito**	1	GD	**BK**	Accepted, with no information on distribution (MO) [C. to N. Honshu, mainly Japan Sea side. Moist places in deciduous forests (FOJ 2a)]
Cupressaceae ***Thujopsis dolabrata* (L. f.) Sieb. & Zucc**	2	BU	**GD**	Accepted, with matching distribution (Kew) [Honshu (southward from Miyagi Pref.), Shikoku (Tokushima Pref.) and Kyushu. In sunny rocky places; 300--1700 m (FOJ 1). SC. & S. Japan (Kew)]
***Thujopsis dolabrata var. hondae* Makino**		BU	**GD**	[Variety: S. Hokkaido and N. Honshu (northward from Gunma Pref.). In rocky places; 100--2000 m (FOJ 1). N. & NC. Japan (Kew)]
Ericaceae ***Tsusiophyllum tanakae* Maxim.**	1?	GD	GD	Unresolved, in review (Kew) [C. Honshu. On rocks on mountain-ridges; 500--2100 m (FOJ 3a)]
Gramineae ***Hakonechloa macra* (Munro) Honda**	1	GN	**GD**	Accepted, with global distribution only as JAP (Kew) Distribution recorded in Honshu (Tokaido Dist. from Sagami to Kii Prov.); rather rare (Ohwi, 1965)
Orchidaceae ***Dactylostalix ringens* Rchb.f.**	1	GN	**BU**	Accepted, only found from Sakhalin to Japan (Kew)
Orchidaceae ***Eleorchis japonica* (A.Gray) Maek.**	1	BU	**GD**	Accepted, only in S. Kuriles to N. and C. Japan (Kew)

Table 2.3 continued.

Papaveraceae ***Pteridophyllum racemosum* Siebold & Zucc.**	2	GD	GD	Unresolved (Kew). [Honshu (central and northern parts). Coniferous woods; rare (FOJ 2a)] The other name *Pteridophyllum decipiens* (Wight & Arn.) Thwaites is recorded as a synonym of *Filicium decipiens* (Wight & Arn.) Thwaites (MO)
Ranunculaceae ***Anemonopsis macrophylla* Siebold & Zucc.**	1	GD	**BK**	Accepted, in review (Kew) [Honshu (from Iwate to Shizuoka Pref. and Kii Mountains, chiefly on Pacific Ocean side) and Shikoku (Ehime Pref.). In margins of deciduous forests; 1000-2000 m (FOJ 2a)]
Rubiaceae ***Pseudopyxis depressa* Miq.***	3	BU	**GD**	1 species endemic to Japan*, 1 endemic to China, 1 Japan and China (Zhejiang)** *[Honshu (southward from Tokyo Pref.), Shikoku and Kyushu. Forests edges; 200--800 m (FOJ 3a) C. & S. Japan (Kew)]
Pseudopyxis heterophylla* (Miq.) Maxim. *		GD	GD	**[Honshu (Pacific Ocean side from western Kanto to Kinki Dist.). In forests, more or less shady places; 500--1200 m (FOJ 3a) China (Zhejiang), SC. Japan (W. Kanto, Kinki) (Kew)] Chinese endemic species is *Pseudopyxis monilirhizoma* Tao Chen, found in Zhejiang (Kew)
Rutaceae ***Boninia glabra* Planch. ***	3?	BK	BK	Unresolved genus, in review (Kew) *[Ogasawara Isls. (Chichijima).In forests (FOJ 2c)]
Boninia grisea* Planch. *		BK	BK	**[Ogasawara Isls. (Chichijima & Hahajima groups; Kita Iwo-jima, Minami Iwo-jima). In forests (FOJ 2c)]
Boninia grisea var. crassifolia* Nakai **		GD	**BK**	***[Ogasawara Isls. (Chichijima and Anijima). On windswept rocky places.(FOJ 2c)]
Saxifragaceae ***Peltoboykinia watanabei* (Yatabe) H.Hara ***	2	GD	GD	1 endemic to Japan* but in review (Kew), 1 Japan and China (Fujian)** (MO) *[Shikoku and Kyushu. Shady places in woods in mountainous areas (FOJ 2b)]
Peltoboykinia tellimoides* (Maxim.) H.Hara *		BU	**GD**	**[N. & C. Honshu.S hady, damp slopes in valleys in mountains. Japan and China (Fujian) (FOJ 2b)]
Umbelliferae ***Apodicarpum ikenoi* Makino**	1	GD	**BK**	Accepted, in review (Kew) [Honshu (Kanto Dist. and Aichi Pref.).Wet muddy places along rivers in lowlands; rare (FOJ 2c)]

2.7.3 The Star representation at family level

The flora of Japan database contains 258 families, 242 of which match with Kew's family list (the Royal Botanic Garden Kew, 1992). There are 1,553 genera in the database. The majority (191) of families have fewer than 20 taxa while the remaining 28% (76) families contain 20 to over 500 taxa. *Carex* (Cyperaceae) with 375 accepted taxa was the most speciose, followed by 99 taxa in *Cirsium* (Asteraceae), 89 taxa in *Rhododendron* (Ericaceae), 78 taxa in *Viola* (Violaceae), 76 taxa in *Salix* (Salicaceae) and 76 taxa in *Dryopteris* (Dryopteridaceae). A full list of families and their Star representation is provided in Appendix C.

The six most speciose families are some of the largest families of flowering plants across the world (Heywood *et al.*, 2007) (Table 2.4). Species in most of these families tend to be widespread, with 67%–89% of taxa classified into Green Star, whereas the overall average for all species is 65%. However, just less than half (45%) of taxa in Asteraceae was assigned Green (with 21% Black and 21% Gold Stars). Leguminosae was divided into three subfamilies in the Flora of Japan database, the vast majority in subfamily Papilionoideae. When three subfamilies of Leguminosae are merged as recommended by the APG III system (The Angiosperm Phylogeny Group, 2009), the total number of taxa increased to 233 (9 Black, 8 Gold, 14 Blue, 202 Green).

Table 2.4 The most speciose families in the Flora of Japan database with the number of genera and taxa in four Star categories. Families in brackets are classification adopted in Angiosperm Phylogeny Group III (APG III) system.

Family	Genera	Black	Gold	Blue	Green
Cyperaceae	27	22	21	80	464
Asteraceae	96	122	120	72	255
Orchidaceae	90	44	4	48	209
Gramineae (Poaceae)	134	11	8	7	204
Rosaceae	41	21	28	24	148
Leguminosae-p.* (Fabaceae)	60	8	8	13	183

*Leguminosae-p.; Papilionoideae

A few families had notably high proportions of rare taxa, i.e. with more than 40% of taxa as Black Star (Table 2.5). Several endemic genera such as *Asarum* (Aristolochiaceae), *Hypericum* (Guttiferae), and *Pittosporum* (Pittosporaceae) contribute to these rare families (see page 79 for examination of rare families). Species in two monospecific families were given Gold Star status by upgrade (page 57).

Table 2.5 The number of taxa in four Star categories per family for 1) families with high proportion of rare taxa, i.e. Black, Gold and Blue, and 2) families with high proportion of Green Star taxa. Families in parentheses are classification under the Angiosperm Phylogeny Group III (APG III) system.

1) Families with high proportion of rare taxa. ** Glaucidiaceae is included in Ranuculaceae in the APG III system, but is treated as an independent monospecific family in the Flora of Japan and in this study.

Family	Genera	Black	Gold	Blue	Green
Aristolochiaceae	2	**39**	16	5	8
Guttiferae (Clusiaceae)	11	**20**	12	5	12
Theaceae	9	**12**	0	3	8
Podostemaceae	2	**7**	0	0	2
Pandanaceae	2	**4**	0	1	2
Melastomataceae	4	**4**	1	0	4
Burmanniaceae	3	**4**	0	0	6
Pittosporaceae	1	0	**5**	0	3
Glaucidiaceae**	1	0	**1**	0	0
Sciadopityaceae	1	0	**1**	0	0

2) Families with high proportion of Green Star taxa. †; fern, ‡ fern allies.

Family	Genera	Black	Gold	Blue	Green
Gramineae (Poaceae)	134	11	8	7	204
Leguminosae-p. (Fabaceae)	96	8	8	13	183
Cruciferae (Brassicaceae)	44	6	1	3	104
Polygonaceae	11	3	1	7	95
Juncaceae	2	0	0	3	48
Polypodiaceae †	12	4	3	1	43
Thelypteridaceae †	2	3	3	0	37
Aspleniaceae †	1	1	3	1	37
Onagraceae	6	0	0	1	41
Hydrocharitaceae	10	1	0	1	33
Hymenophyllaceae †	4	3	0	0	29
Cucurbitaceae	17	4	1	1	25
Moraceae	7	5	0	0	26
Chenopodiaceae (Amaranthaceae)	9	2	0	0	26
Convolvulaceae	11	1	1	1	25
Malvaceae	9	3	0	1	23
Potamogetonaceae	3	1	0	0	26
Commelinaceae	6	0	0	0	26
Lycopodiaceae ‡	1	0	1	2	21
Amaranthaceae	8	0	0	0	23
Typhaceae	2	0	0	0	17
Lythraceae	6	0	0	2	13
Pyrolaceae (Ericaceae)	6	0	0	0	15
Iridaceae	1	0	0	0	13
Menispermaceae	6	0	0	0	12
Ulmaceae	5	0	1	0	11
Droseraceae	2	0	1	0	10

2.7.4 Comparing data quality between FOJ and Kew WCSP

Approximately 71% of accepted taxa with Stars in the database were provided by the Flora of Japan (FOJ), and of the remaining 27% were contributed by the Kew World Checklist of Selected Families and Grass list combined (Kew WCSP), and 1.5% from other sources. In terms of Star rating, 80.9% of accepted names in FOJ and 60.1% of those in Kew WCSP were initially assigned Stars with the original Keys (page 52). Taxa with Stars increased to 86.4% and 87.1% respectively when additional keys (page 55) and adjustment to taxonomic relatedness (page 56) were employed using the 'infra-selective' method described above (page 46).

Proportions of Stars were significantly different between FOJ and Kew WCSP both in default with initial Star assignment (G = 281.365, P < 0.0001, d.f. = 3) and in 'infra-selective' method (G = 182.222, P < 0.0001, d.f. = 3). The difference is apparent in the high proportion of Green Star taxa in Kew WCSP (Figure 2.5). Two points of consideration for the future work are: 1) taxonomic representation by different data sources needs examination in order to detect a potential bias in Star classification; 2) the Star status of taxa from Kew WCSP, particularly of Japanese endemic species with uncertain distribution within the range should be further investigated using fine-resolution data.

There were a total of 175 taxa accepted in FOJ but synonymised in Kew WCSP; and 73 taxa *vice versa*. Of these, the former 175 included 14 Black, 29 Gold, 14 Blue and 98 Green Star taxa and the latter contained 8 Black, 7 Gold, 10 Blue and 40 Green Stars. This proportion is not significantly different (G = 3.996, P = 0.2619, d.f. = 3), suggesting that adoption of either data source for resolving taxonomic conflict would be unlikely to change the overall proportional representation of the four Star categories. Therefore, for simplicity, preference is given to FOJ over Kew WCSP in this study.

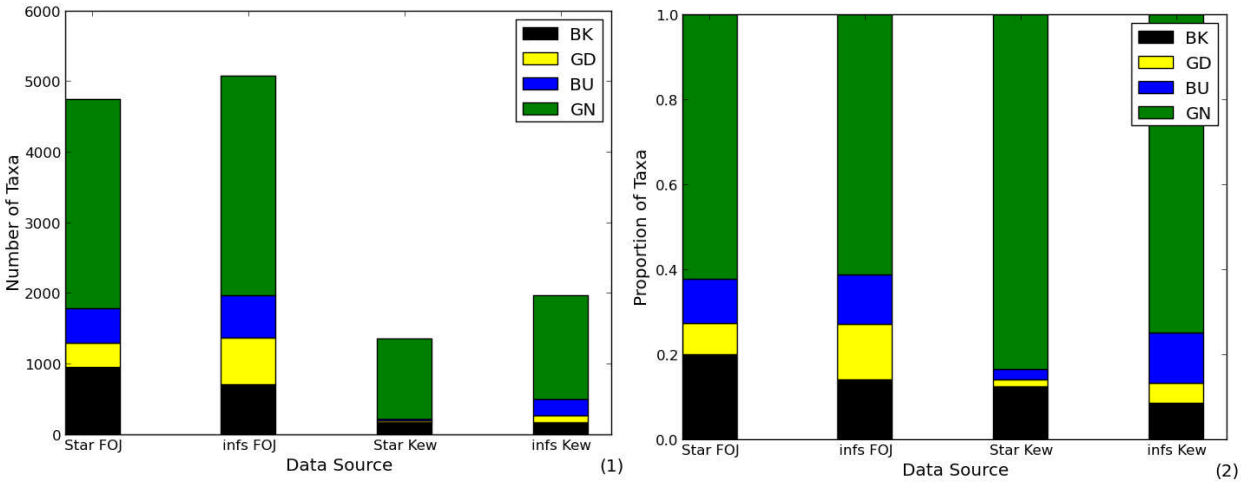
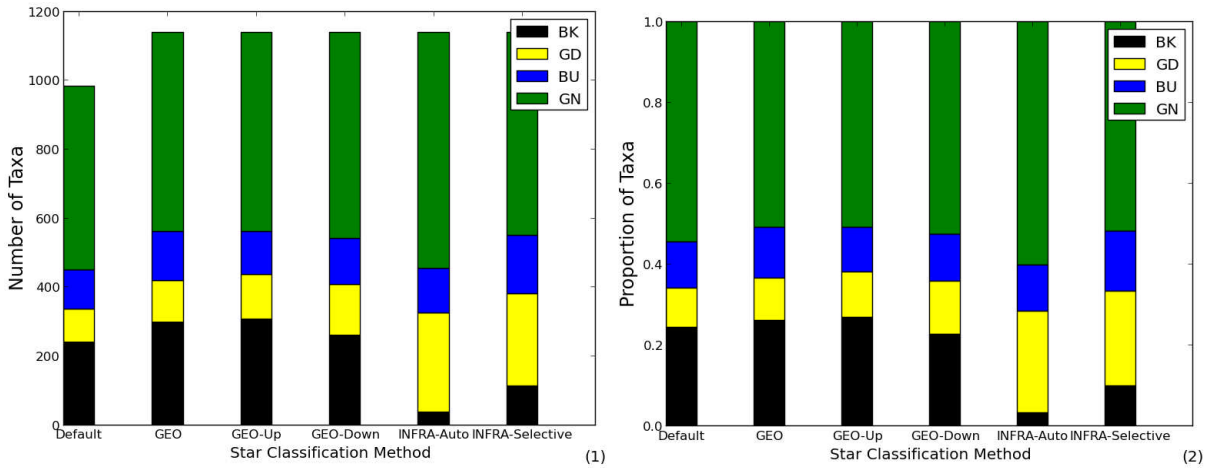


Figure 2.5 Number of taxa assigned to Stars from 2 data sources: 1) total number of taxa including infraspecific taxa and 2) proportions of taxa in each Star. FOJ = Flora of Japan, Kew = Kew's WCSP. Star = Stars assigned using default keys. 'infs' = Stars using Keys plus modifications using the Infra-Selective guideline. Four Star categories are in their corresponding colours of Black, Gold, Blue and Green.

2.7.5 Sensitivity analysis of different protocols for Star classification

Using the six Star classification methods that adopt different protocols for treating geographic uncertainty and infraspecific taxa (see Methods, page 46), the variations in representation of Stars and prefecture level GHI were investigated. First, the proportional representation of Stars was compared to the default Stars without modification in relation to 1) geographic uncertainty and 2) infraspecific taxa (Table 2.6).

In terms of adjustment to enable species with limited geographic information to be given Stars, Blue Stars under the 'Geo' classification method and Gold for both 'Geo-up' and 'Geo-down' methods showed the largest increases in the number of taxa in these Star categories, compared to the default (Figure 2.6). The boost in Blue taxa is mainly brought about by the inclusion of Japanese endemic species that are listed as such in Kew WCSP, but with no detailed information on their Japanese range. This applies especially to the 'Geo-up' protocol, which also caused the biggest increase in the number of Black taxa. The 'Geo-down' method caused the least overall change in Star assignment compared to the default.



Star	Geo	Geo-up	Geo-down	Infra-auto	Infra-selective
Black	+106 (9.0%)	+145 (12.4%)	+36 (3.1%)	−387 (−33.0%)	−290 (−24.7%)
Gold	+61 (16.2%)	+236 (62.6%)	+92 (24.4%)	+406 (107.7%)	+384 (101.9%)
Blue	+235 (43.8%)	+121 (22.6%)	+59 (11.0%)	+146 (27.2%)	+296 (55.2%)
Green	239 (5.4%)	140 (3.2%)	455 (10.3%)	477 (10.8%)	251 (5.7%)

Figure 2.6 Two charts showing the number (left) and proportion (right) of taxa assigned to Stars, using the 6 Star classification methods. The four Stars are in their corresponding colours of Black, Gold, Blue and Green. Star classification methods: 1) Default, 2) Geo, 3) Geo-up, 4) Geo-down, 5) Infra-automatic, 6) Infra-selective. The table shows differences in the number of taxa assigned to the various Stars between default and five classification methods. Abbreviated method names are used. Figures in parentheses are percentage change in the number of taxa from the default.

When 1,688 accepted infraspecific taxa with Stars by default supplemented with 'Geo' method were adjusted for relatedness using 'infra-auto' or 'infra-selective' protocols, over 76% of infraspecific Black Star taxa were down-graded (Table 2.6).

Table 2.6 The number of infraspecific taxa classified into the four Star categories by default, infra-auto, and infra-selective methods.

Star	Default	Infra-auto	Infra-selective
Black	405	0	97
Gold	110	493	471
Blue	145	148	298
Green	745	1047	822

When the effect of changes in Star representation by different protocols on GHI at prefecture levels were examined, all methods are highly correlated with the default (all five methods with r^2 = 0.99, Table 2.7), showing that there is little change of ranking of GHI (Figure 2.7). There were, however,

significant changes in absolute scores compared to those of the default across all methods except 'Geo-down'. The biggest change in GHI for botanical prefectures compared to the default was found in 'Infra-auto' method in which all prefectures had lower scores than the default (Figure 2.8 (1)). 'Geo-down' method caused the least change in GHI compared to the default, with difference in GHI ranging from −11 to +4. The majority of variation in GHI was within ±20 of the default score in all methods except 'Infra-auto'. Both 'Geo' and 'Geo-up' methods tend to increase the scores; this is caused by raised Star rank of some taxa. For these methods, over 400 and 500 taxa respectively were either additionally given Stars or upgraded by one rank compared to the default as a result of applying additional keys to assign Stars for taxa with insufficient details on distribution information.

The 'Infra-auto' and 'Infra-selective' methods lead to prefecture-scale GHIs that are significantly lower than by default (Figure 2.8 (2)). The patterns of such changes in scores were inconsistent among prefectures. The four botanical prefectures with the largest increase in scores by 'Geo' and 'Geo-up' methods were Kazan, Niigata, Fukui and Yamanashi. The five prefectures with the largest decline in scores using the two infraspecific methods were Ogasawara, Hokkaido, Nagano, Shizuoka and Kagoshima. These prefectures probably have high proportions of infraspecific taxa whose Star status were subject to change by adjustment for taxonomic relatedness. Overall, different protocols seemed to have a small effect in the ranking of GHI. As for absolute GHI values, use of coarse resolution geographic information to assign Stars led to a small increase in scores while incorporating taxonomic relatedness resulted in a decrease in GHI. The implications of this analysis are discussed on page 82.

Table 2.7 Differences in GHI at prefecture between the default and five classification methods. s.d. = standard deviation. P-values for Spearman's rho: ******P* **< 0.0001,***P* **< 0.01, ****P* **< 0.05.**

Star classification method	Mean difference ± s.d. in scores compared to the default	Spearman's rank correlation coefficient (*r*)	Wilcoxon's signed-rank test (*P*)
Geo	7.07 ± 6.21	0.9980***	< 0.0001
Geo-up	14.62 ± 6.66	0.9944***	< 0.0001
Geo-down	−0.44 ± 2.46	0.9991***	0.2669
Infra-auto	−40.37 ± 36.03	0.9929***	< 0.0001
Infra-selective	−19.34 ± 28.77	0.9930***	< 0.0001

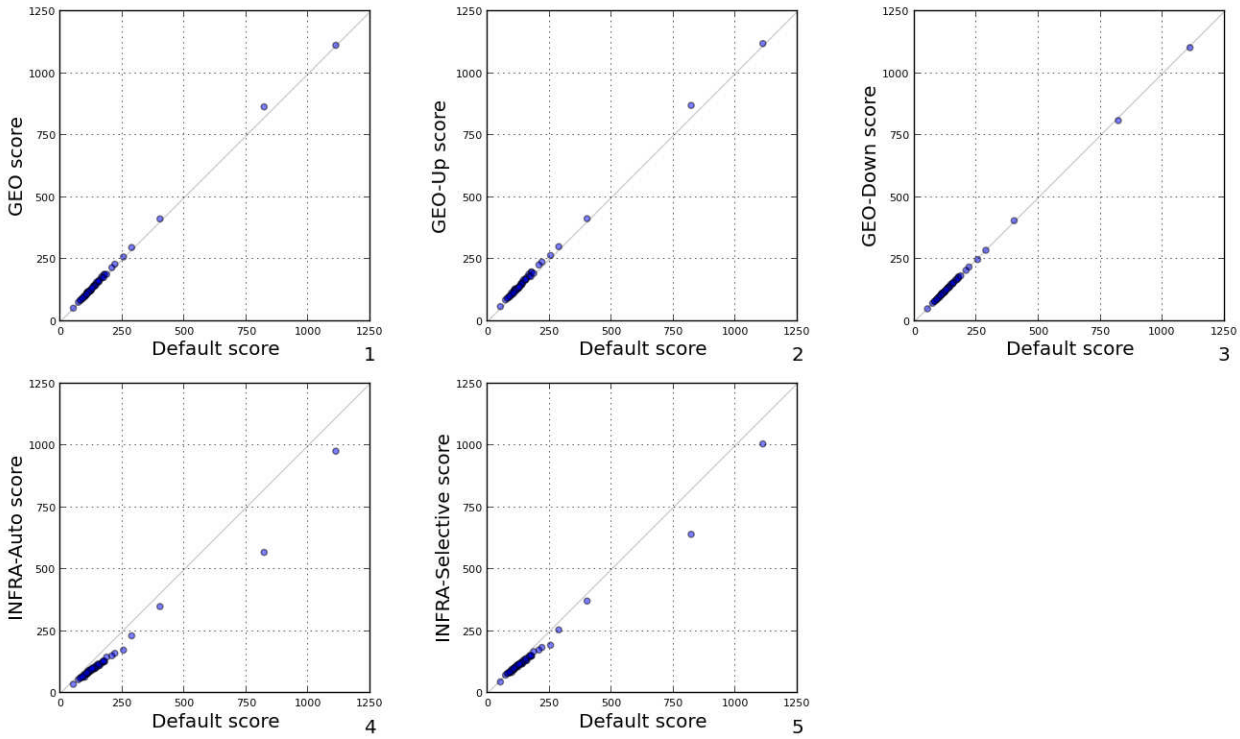


Figure 2.7 Comparison of GHI between default and 5 other classification methods: 1) Geo, 2) Geo-up, 3) Geo-down, 4) Infra-auto, 5) Infra-selective. Each point represents a prefecture. 1:1 ratio line for two score type is drawn for reference.

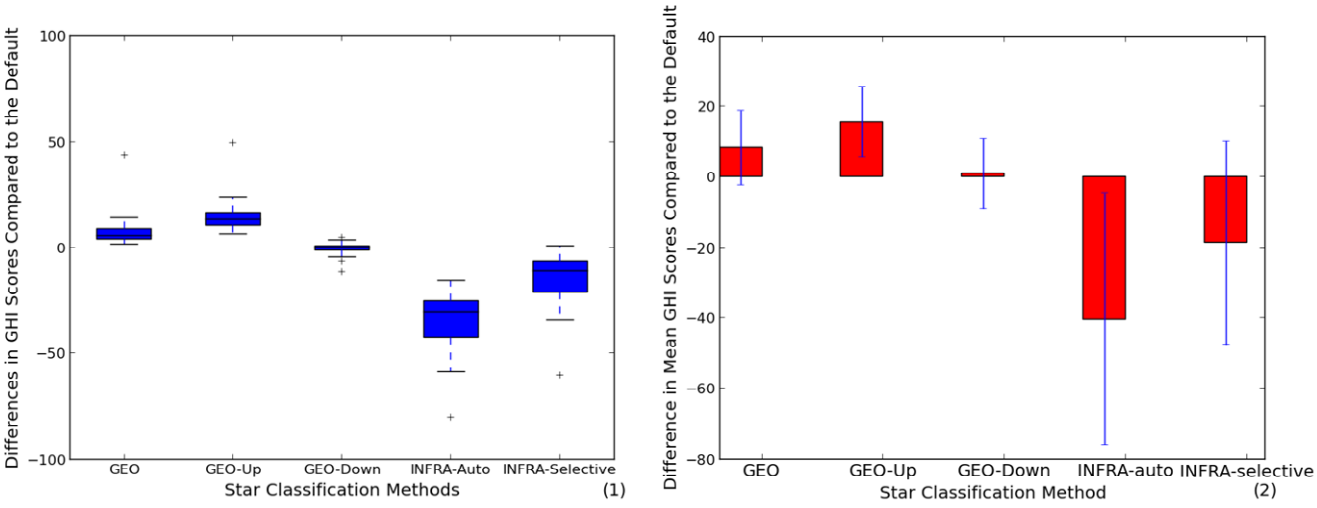


Figure 2.8 Comparison of GHI between default and other classification methods: 1) boxplot of difference in GHI of each classification method from the default scores on prefectures examined, 2) mean difference and standard deviation of GHI at prefecture level comparing to the default scores with each of 5 classification methods. GHI of Ogasawara islands decreased by 134 and 104 in infra-automatic and infra-selective methods respectively, and are omitted from the graph.

2.7.6 Stars and IUCN Red list of threatened species

It is appropriate here to consider the relationship between Stars and IUCN ratings, because they are both taxon-specific scores with some, albeit a different, relationship to the global rarity of the taxon. Only 176 taxa are listed in the IUCN Red List of threatened species for Japan. Given that the list supposedly includes all species that have been assessed, regardless of status, this is very low considering that 8,262 taxa have been completed for assessment in the Star system for this thesis (Table 2.8 (1)). The IUCN list includes 11 non-native species that are identified as threatened in Japan (*Lemna minor* (Araceae), LC; *Lumnitzera littorea* (Combretaceae), LC; *Juniperus communis* (Cupressaceae), LC; *Fimbristylis polytrichoides* (Cyperaceae), LC; *Fimbristylis schoenoides* (Cyperaceae), LC; *Trichophorum subcapitatum* (Cyperaceae), LC; *Phragmites vallatorius* (Gramineae), LC; *Paspalidium punctatum* (Gramineae), LC; *Marsilea minuta* (Marsileaceae), LC; *Malus hupehensis* (Rosaceae), DD; *Typha angustifolia* (Typhaceae), LC). Four synonyms are also used as valid names (*Azolla pinnata*, synonym of *Azolla imbricata* (Azollaceae), LC; *Drosera burmanni*, synonym of *Drosera spathulata* (Droseraceae), LC; *Halophila euphlebia*, synonym of *Halophila major* (Hydrocharitaceae), DD; *Cinnamomum japonicum*, synonym of *Cinnamomum yabunikkei* (Lauraceae), NT) and two species with spelling errors (*Spirodela polyrrhiza* (Araceae), LC; *Clinostigma savoryanum* (Palmae), DD).

As for the Japanese Red List, approximately 80% (1,606 of 2,018 taxa) of listed taxa matched their names with the Flora of Japan database with 1,374 as accepted names (including 2 only found in the old FOJ), 231 synonyms and 1 unresolved. More Black Star species were listed as Threatened compared to the other categories (the proportion of taxa listed from Critically Endangered to Vulnerable relative to the total taxa per category; Black 42%, Gold 11%, Blue 16%, and Green 11%) (Table 2.8 (2)).

The most striking aspect of the IUCN system is the number of taxa which remained unclassified due to no data, compared to what proved possible to classify into Stars. Even at the national level, the majority of taxa (82%) that was assigned Stars seemed yet to be evaluated.

Table 2.8 Comparison of the number of taxa assessed in IUCN Red list of threatened species (1), the Japanese Red list (2), and those assigned Stars.

(1) The IUCN Red List of threatened species

Star infra-selective	The IUCN Red List of threatened species					
Star category	**Endangered**	**Vulnerable**	**Near Threatened**	**Least Concern**	**Data Deficient**	**No data**
Black	2	2	0	3	3	890
Gold	0	1	1	3	0	765
Blue	0	0	2	8	0	839
Green	1	5	4	118	2	4,691

(2) The Japanese Red List of threatened species

Star infra-selective	The Japanese Red List of threatened species							
Star category	**Extinct**	**Extinct in the Wild**	**Critically Endangered**	**Endangered**	**Vulnerable**	**Near Threatened**	**Data Deficient**	**No data**
Black	2	4	114	127	126	41	2	473
Gold	0	0	22	25	43	18	0	742
Blue	3	0	39	38	49	17	2	620
Green	11	0	142	147	235	113	8	4,157

2.8 Weights of Stars

2.8.1 Data representation of Horikawa dot maps

Horikawa dot maps contained 219 (30% of 725 species examined) species endemic to Japan, and therefore the species' full global range is represented on the maps. There were 6 Black, 10 Gold and 10 Blue non-endemic species but the majority of species in these Star categories were endemic (Table 2.9). All but 15 Green Star species are globally widespread, extending northwards to Siberia, westwards to China, Korea, Taiwan or southwards to Southeast Asia and Australia.

Table 2.9 The number and proportion of taxa assigned Stars for Horikawa dot maps.

Star	All taxa (%)	All species (%)	Endemic species (%)
Black	121 (14.7%)	114 (15.7%)	108 (49.3%)
Gold	57 (6.9%)	40 (5.5%)	29 (13.2%)
Blue	86 (10.6%)	74 (10.3%)	67 (30.6%)
Green	557 (67.7%)	497 (68.4%)	15 (6.9%)

Global range size for Japanese endemic species was measured in terms of the total land area estimated by 50-m DEM for geoquadrats. A histogram for range size in 100 × 100 km classes showed a left-skewed distribution (Figure 2.9). Mean geographic range sizes by this measurement was: Black Star species 1,193 km^2, Gold 13,669 km^2, Blue 58,693 km^2, and Green 152,572 km^2. Some Blue Star species have restricted range sizes as small as those of Black or Gold, because some species actually occur in a much smaller area than expected from their distribution information in the Flora of Japan database. For instance, *Gentiana nipponica* (Gentianaceae) was described to occur in Hokkaido and N. to C. Honshu but only on alpine meadows and moors at 1400–2800 m, hence only recorded in 33 geoquadrats across the region. By contrast, *Cladothamnus bracteatus* (Ericaceae) with similar description on its distribution (Hokkaido, and N. to C. Honshu in subalpine to alpine scrubs of 1200–2700 m) was recorded in 104 geoquadrats. These variations are, however, beyond the level of systematic errors that can be controlled. While detailed inspection of the accuracy of distribution information would be recommended, such intensive review on over 8,000 taxa would be regarded as an interest for future work. 15 endemic Green Star species are very widespread within Japan. Because the

largest total range size possible for Japanese endemics is approximately 380,000 km^2, i.e. the total land area of Japan, there was some overlap in range size between Blue and Green Star species. Nevertheless, Green Star species were mostly more widespread than Blue (Figure 2.9).

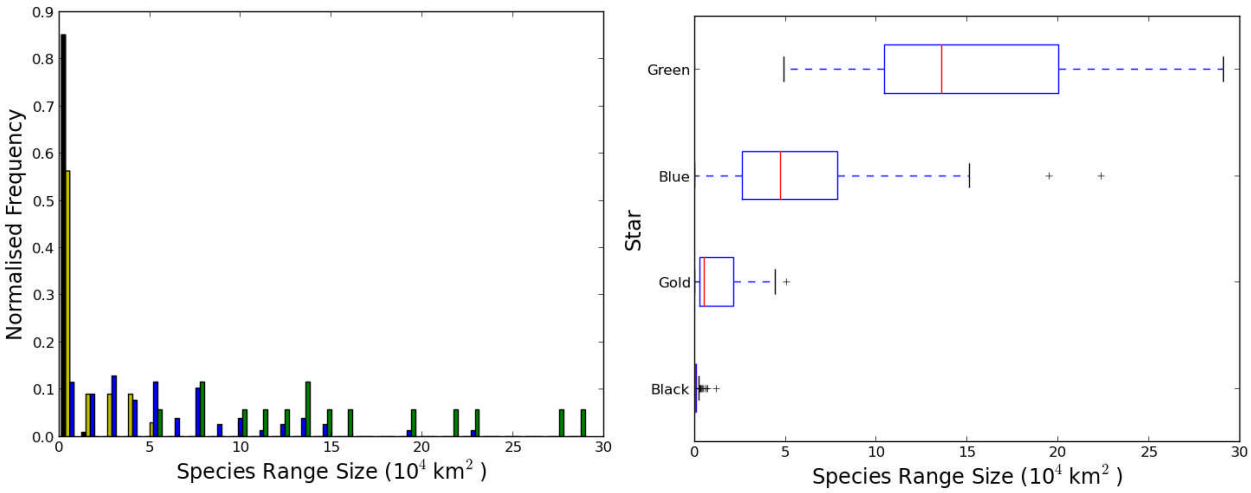


Figure 2.9 Normalised frequency distribution and box plot of within-Japan range size (km^2) for 219 endemic species. Total land area of geoquadrats on which species are recorded to occur was measured using 50-m DEM. Star categories are shown in the corresponding colours of Black, Gold, Blue and Green.

Global range sizes of 26 near endemic species deduced from all available data sources were interpreted in terms of the maximum possible number of 1° latitude by 1° longitude grid cells (see Methods, page 48) occupied. This addition of range size slightly increased the upper limit of geographic range size of species in Black, Gold and Blue categories (species on upper left region in Figure 2.10).

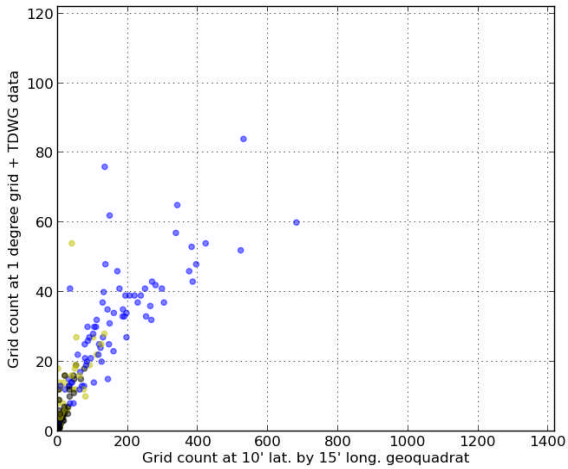


Figure 2.10 The number of 1-degree grid cells occupied plotted against the number of geoquadrats in which species presence records were collated, for 230 Black, Gold and Blue species including 26 non-endemic species. Data are based on Horikawa dot maps supplemented with outside-Japan distribution as (maximum possible) 1° latitude by 1° longitude grid cells for 26 non-endemic species, interpreted from all available information (see Methods, page 48, for details).

2.8.2 Weights of Stars using Horikawa dot maps

When considering endemic species alone, due to the upper limit of geographic range size for endemic Green Star species in Japan, the mean numbers of grid cells for Green was smaller than the standard value adopted for calculating weights (72) irrespective of grid unit (Box 2.1). The weight ratios in reference to Green were, therefore, smaller than proposed 27:9:3:1 ratio when the mean for endemic Green Star species was used in calculation. However, this excludes equivalent-to-Horikawa values for the globally very widespread Green Star species, and it is because of the difficulty of obtaining accurate values for the less interesting, baseline Green Star species that a global standard of 72 as the mean number of 1-degree squares for this Star category has been adopted (Hawthorne, 2012). When weights were calibrated using the suggested standard for mean geographic range size for Green Star species, weight ratios were obtained that approximate to 27:9:3:1 for both the 1-degree grid and the 100-km grid (Table 2.10) – a result indicating successful fine-tuning of the keys to Stars rather than coincidence. There was virtually no difference between the 1-degree grid and the 100-km grid in terms of mean within-Japan range size and therefore weights were almost exactly the same.

Table 2.10 Mean species geographic range size on 1-degree grid or on 100-km grid (A) and weights (B) of Stars calculated by changing species pool. Weights were calculated as the inverse total number of species' occurring grid cells relative to 72; the standardised mean number of grid cell for Green species.

A) Mean number of 1-degree grid (top and bottom rows) or 100-km grid (middle row) occupied by species endemic to Japan or species' global range size including interpreted distribution for additional 21 non-endemic Black. Gold or Blue species.

Species pool	Black	Gold	Blue	Green
219 endemic species on 1-degree grid	2.69	10.48	28.00	53.13
219 endemic species on 100-km grid	2.68	10.48	27.64	52.27
230 species excluding Green (on 1-degree grid)	3.23	12.54	31.21	N/A

B) Weights of Stars = 72 / mean species range size (A)

Species pool	Black	Gold	Blue	Green
219 endemics on 1 degree grid	26.77	6.87	2.57	1.36
219 endemics at 100 km grid	26.87	6.87	2.60	1.38
230 species excluding Green (on 1-degree grid)	22.29	5.07	2.31	N/A

2.8.3 Use of TDWG codes for calibrating Green Star species' geographic range size

The numbers of species in the four Star categories for 1,657 species in the Flora of Japan database with TDWG L3 count were: Black, 205; Gold, 59; Blue, 210; Green, 1183. All Black, Gold and Blue species are restricted to no more than four TDWG level-3 codes. The mean number of TDWG level-3 regions for each Star category was: Black, 1.2; Gold, 1.4; Blue, 1.6; Green, 21.9 (Table 2.11).

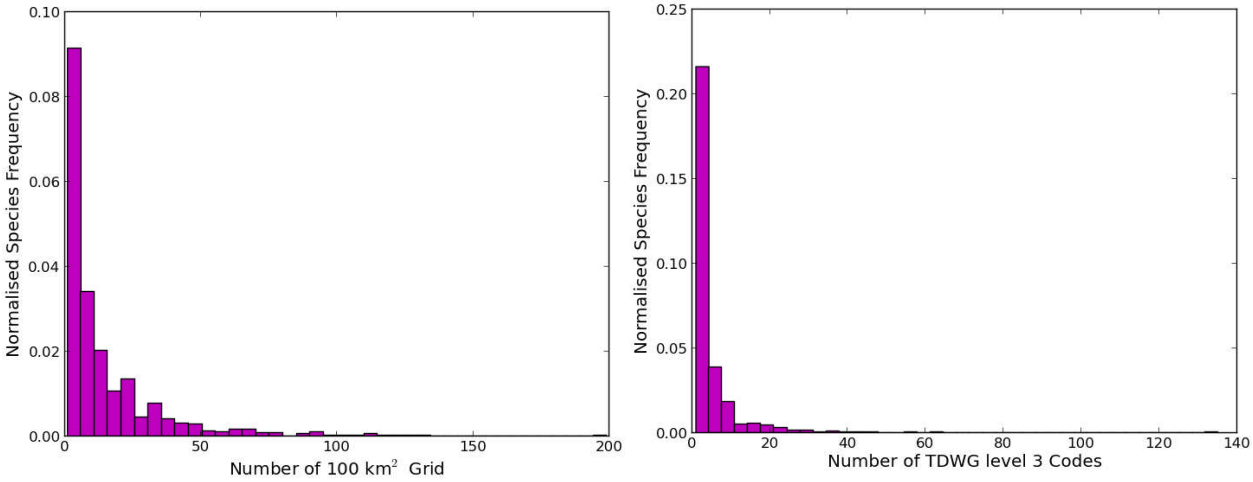


Figure 2.11 Normalised species frequency distributions of the number of occupied 100-km grid (left) and the number of occupied TDWG level-3 codes (right).

For the 495 species examined in the conifer data, the majority (58%) were found in 10 or fewer 100-km grid cells, with a mean of 14 (Figure 2.11). Similarly for TDWG L3 count with mean count of 6.4, the great majority (70%) of species occurs in fewer than 6 and approximately one-third (30%) restricted to one TDWG level-3 region. The land cover of TDWG level-3 codes ranges from 1.75 km^2 to 60,330,000 km^2 with mean area ± standard deviation of 580,400 ± 3,221,796 km^2. This is very variable, suggesting that any extrapolation of species' geographic ranges based on TDWG measurement has to be interpreted cautiously. Nevertheless, given that only a handful of species (38 species, 6%) are globally widespread with over 20 TDWG L3 recorded, the effect of substantial overestimate was expected to be limited in this case. If there was significant correlation between 1-degree grid or 100-km grid occurrences and TDWG L3 count, it is worth examining the potential use of TDWG for a basis for Star weights through extrapolation.

The number of 100-km grid cells occupied globally was correlated both to 1-degree grid and TDWG L3 occupancy values for all species, with Spearman's rank correlation coefficients r = 0.9867; P < 0.001 and r = 0.7594; P < 0.001 respectively (Figure 2.12). When the values were directly compared, the 100-km grid count and 1-degree grid count were significantly different (Wilcoxon's signed rank test (paired) P = 0.00275).

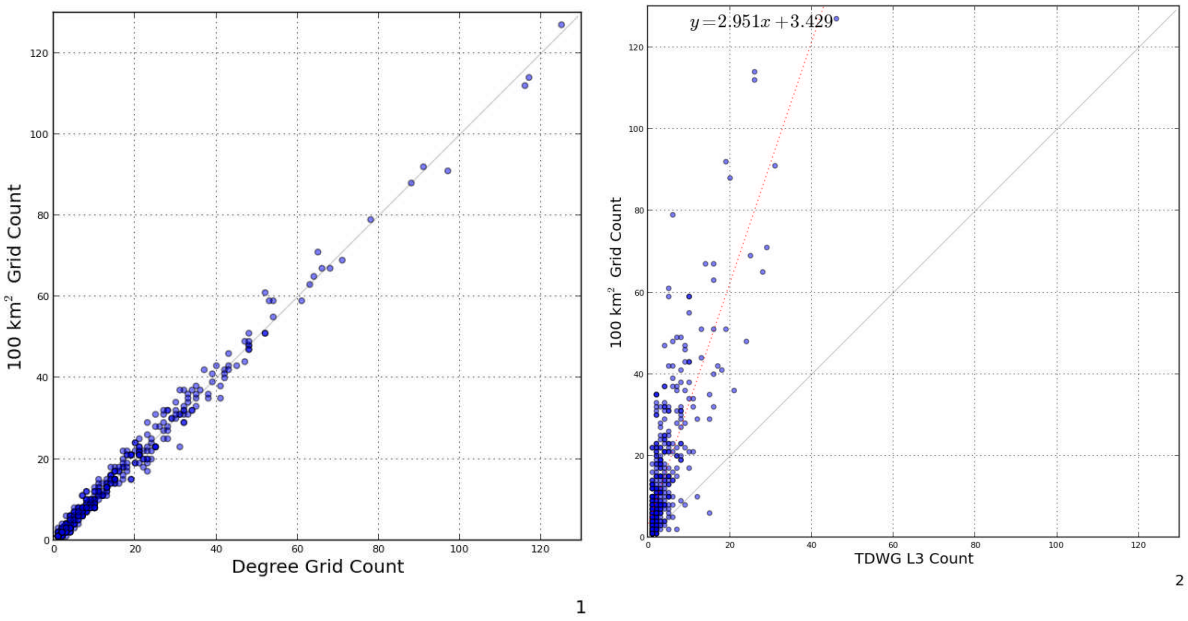


Figure 2.12 The number of occupied 100-km grid cells compared to 1) the number of present 1-degree grid count, and 2) the number of present TDWG level-3 codes for 495 conifer species examined. Linear regression line is drawn for (2).

Table 2.11 Calibration of species' geographic ranges using TDWG level-3 count for the Flora of Japan using the linear regression model examined for the conifer data (Figure 2.12)

Data type	Black	Gold	Blue	Green
Mean TDWG L3 count for 1,657 species in the Flora of Japan database	1.2	1.4	1.6	21.9
The predicted number of present 100-km grid count using the linear regression model	6.97	7.56	8.15	68.06

One TDWG L3 count is equivalent to roughly three 100-km grid cells according to the linear regression model (100-km grid count = TDWG L3 count × 2.951 + 3.429, r^2 = 0.6742, adjusted r^2 = 0.6735, 484 d.f., P < 0.001). Applying this model to 1,657 species with TDWG L3 counts in the Flora of Japan database, the estimated mean geographic range size for Green Star species was 68 (Table

2.11), in the vicinity of the suggested standard of 72. The majority of Black, Gold, and Blue Star species are endemic to Japan so that TDWG L3 count was often only 1 for these species, giving considerably higher number of occupied 100-km grid cells particularly for Black and Gold species.

2.9 DISCUSSION

2.9.1 Significance of the Flora of Japan database

The Flora of Japan database is, to my knowledge, the first complete database of Japanese vascular plants with a few exceptions of taxa in review. 8,262 accepted taxa containing 5,931 species plus 1,688 infraspecific taxa in the database are similar to estimates by the government and in literature (Murata, 2005, Nakanishi *et al.*, 1993). One estimate states that there are 5,565 species '種 (*shu*)' in Japanese, 124 subspecies '亜種 (*a-shu*)', 1,612 varieties '変種 (*hen-shu*)', 815 formae '品種 (*hin-shu*)' and 2 sub-formae '亜品種 (*ahin-shu*)', totalling 8,118 vascular plant taxa including Pteridophyta in Japan (Japan Integrated Biodiversity Information System (J-IBIS), 2011). 34.6% of taxa are grouped into non-Green Stars using infra-selective method in which infraspecific taxa were selectively downgraded using the protocol developed (page 57). 30%–40% of vascular plant taxa are said to be endemic to the country (Biodiversity Centre of Japan, 2009, Murata, 2005). This is, broadly speaking, in agreement with the Flora of Japan database with estimated 31% endemicity (This figure increased to 34% when taxa in review or with conflicting opinions by non-FOJ data source were included).

A notable pattern in the Star representation in Japan is the high proportion of the flora that is classified with Black Stars. Existing studies in continents using the Star system showed a gradual increase in numbers of taxa in Black, Gold, Blue and Green Stars respectively (Hawthorne, 1996, Tchouto *et al.*, 2006). Compared to continental areas, islands often contain higher proportions of species in many taxonomic groups that are endemic to the area (Kier *et al.*, 2009). Geographic separation of the Japanese archipelago from the Asian continent is one of the key factors resulting in localised speciation and diversification of many rare taxa in Japan (Murata, 1977). The Quaternary glaciations are also suggested to be a crucial factor in the development of the Japanese flora (Yahara, 1989). It is suggested

that species (e.g. *Hypericum pseudopetiolatum* (Guttiferae)) that were adapted to cooler climate have become restricted to high mountains since the last glaciations (Murata, 1977). Investigation of such geological and evolutionary factors is beyond the scope of this study, but is an interesting question for future work.

The six families (including legume sub-families) with more than 200 taxa were: Cyperaceae (587 taxa), Asteraceae (569 taxa), Orchidaceae (305 taxa), Gramineae (230 taxa), Rosaceae (221 taxa), and Leguminosae-Papilionoideae (212 taxa) (Table 2.4). These families are globally species-rich and the species are often widespread. Taxa in these families are also very abundant in the Flora of Japan database.

Families with a high proportion of rare taxa, on the other hand, tend to be relatively small families with some genera endemic to Japan (Table 2.5). For instance, *Asarum* (Aristolochiaceae) is one of the genera with the highest number of endemic species in Japan from Tohoku district in the north to the Ryukyu Islands in the south (Kato and Ebihara, 2011). Species or infraspecific taxa in this genus tend to be localised. *Hypericum* (Guttiferae) is another such example, with species limited to mountains in mainland Japan or to small island groups. 9–10 genera are recognised in Pittosporaceae, and all but one are endemic to Australasia (Heywood *et al.*, 2007). One genus, *Pittosporum* within Japan is diversified and only found in Ogasawara Islands (Kato and Ebihara, 2011).

Some families have particularly high concentrations of rare taxa wherever they occur. Theaceae mainly occur in tropical and subtropical regions of America and Asia. Rare Theaceae taxa occur in the Ryukyu Islands, Ogasawara Islands (e.g. *Adinandra, Pyrenaria* and *Schima* species) or have long and narrow distributions in the Pacific (e.g. *Camellina* and *Stewartia* species). Podostemaceae, seasonal aquatic plants, are often endemic to one river system with its genera restricted to one continent (Heywood *et al.*, 2007). For this family, all four species of genus *Hydrobryum* in Japan are extremely localised in Miyazaki or Kagoshima prefectures of Kyushu district, while species of genus *Cladopus* may be more widespread with some species also reported to occur in Fujian, China (Kato and Ebihara, 2011). The genus is under revision (W.C.S.P., 2012), but the Black Star status of extremely restricted species

remains for now. The families Pandanaceae and Melastomataceae are predominantly found in tropical regions, and many are often limited to the Ogasawara Islands or Ryukyu Islands in Japan, some being endemic to these islands (Heywood *et al.*, 2007, Kato and Ebihara, 2011). Examples of narrow endemics in the Pandanaceae include *Freycinetia tawadana*, which only occurs in Iriomote-jima island of the Ryukyus, and *Platanthera boninensis* in the Ogasawara Islands. *Melastoma pentapetalum* and *Melastoma tetramerum* are restricted to the Ogasawara Islands, and *Bredia okinawensis* and *Bredia yaeyamensis* to the Ryukyu Islands (all species in Melastomataceae). Similarly, Burmanniaceae is a tropical plant family but four Japanese endemic species are restricted either to Shikoku (*Oxygyne hyodoi* in Ehime prefecture, *Thismia abei* in Awa province) or the Ryukyu Islands (*Oxygyne shinzatoi*) and *Oxygyne yamashitae* in Yakushima (W.C.S.P., 2012).

2.9.2 Choice of data source

Differences in Star rating using two data sources (Figure 2.5), Flora of Japan (FOJ) and Kew's world Checklist of Selected Plant Families (KEW WCSP), are likely to partly reflect real distributional differences between families, and partly biased by the resolution of the data presented. Taxa endemic to Japan may be recorded as 'JAP' in Kew WCP but are not necessarily given specific locations within Japan. Because of this limited geographic resolution, many of the rarer taxa whose distribution is only known from this source cannot be granted the Black or Gold Star they strictly deserve – in the face of ignorance the Star system is conservative. Monocots, for which the data have been extracted from Kew WCSP, do tend to be globally widespread. Grasses and orchids have a relatively low family-level GHI in other continents, e.g. Trinidad and Tobago (Baksh‐Comeau *et al.*, in press.) and West Africa (Hawthorne, 1996). The relatively low proportion of Gold and Blue taxa in Kew WCSP is probably partially due to lack of fine-level information of species distributions for these monocot families, given the conservative approach adopted for bioquality assessment (and implicit in Geo-down method used here).

FOJ has been adopted as the first source for data in the database. This is particularly useful in Japan where the use of local names, which are only available in FOJ, is predominant and is often the only reference used in conservation practice. Insignificant differences in Star representation for taxa with taxonomic conflict suggests that changes in taxonomic status and associated Stars would not affect overall Star ratings.

2.9.3 Star classification methods

Examination of different protocols for assigning Stars suggests that the proposed multi-step classification criteria can provide the first approximation to Stars for taxa with limited geographic information. When geographic information is scarce, such as in the case of Kew WCSP, the additional guideline maximises the proportion of taxa with Stars without overestimating rarity. It is recommended for the Star system in general that classifiers adopt conservative estimates of Star categories. The idea is that bioquality hotspots are based on sound and stable information, and that first estimates may later rise rather than fall in the face of taxonomic change and better-resolution data.

Incorporation of taxonomic relatedness in Star assessment is important in Japan, due to the high number of infraspecific taxa. For some species, only infra-specific taxa are recorded in Japan. Such species are often either under revision in sources other than Flora of Japan or distribution information is not available. In other instances, the geographic distribution either of the species or of the taxon in question or other infraspecific taxa is incomplete. A taxonomic revision is really required before a higher Star could be confidently allocated to these taxa. With respect to infraspecific taxa, selective downgrading by applying the proposed guideline is likely to minimise fluctuation (this applies to infra-selective method in Figure 2.6).

Relative ranking within Japan of community-level global rarity, i.e. GHI, is unlikely to be affected irrespective of a chosen method for Star classification when compared against the ranking of the default scenario (Figure 2.7). Analyses of the ranking of prefecture GHI using five methods compared

with the default suggest that directions of changes in GHI are consistent across regions for all methods (Table 2.7). Therefore, the choice of classification methods would be unlikely to change decision-making regarding priorities within Japan based on score ranking.

One should, however, carefully question these methods when interpreting absolute GHI, which will affect ranking on a global basis comparing different projects. Taxonomic adjustment by infra-selective method lowers overall prefecture scale GHIs by 19 on average (Figure 2.7). The largest decrease in scores after adjustment by taxonomic relatedness was found in prefectures with relatively high scores by the default method, e.g. Hokkaido, Nagano, and Shizuoka. These prefectures contain mountain ranges, where locally adapted and variable taxa are known to exist at high altitudes (Kato and Ebihara, 2011). This implies that high scores may be partially attributed to the high proportion of infra-specific taxa. A total of 270 Black Star taxa were downgraded to Gold by the infra-selective method, compared to the default.

Star classification by following 1) the keys; 2) additional keys for taxa with limited geographic information; and 3) taxonomic adjustment using the guideline proposed by infraspecific-selective method is confirmed to be the valid option for calculating GHI. It is expected that these steps would minimise the risk of large fluctuations due to taxonomic uncertainty or data limitation, and can be compared confidently with GHI scores calculated elsewhere in the world

2.9.4 Selecting optimal data to calibrate weights for Stars

The integration of different data sets: Horikawa dot maps for endemic species and TDWG L3 count for Green Star species, to calibrate estimates of mean species geographic range sizes and Star weights for the Japanese flora was shown to generate comparable results with the proposed standards derived from the tropical Africa (Table 2.10; Table 2.11). In other words, the Keys to Stars have been set appropriately. The calculated weight ratios for endemic species relative to standard mean range size for Green Star species of 72 are congruent with the suggested 27:9:3:1 ratios (Table 2.10). For Green Star

species, there was a bias towards the rarer Green Star species if only Japanese endemics were selected to measure species' geographic range sizes for this category in Horikawa dot maps. Therefore, the use of mean Green species range size from Horikawa data should be avoided, and it is recommended to adopt the estimate of 72 for this category following the standard protocol (Hawthorne, 2012).

Comparison of 1-degree grid count and 100-km grid count using conifer data showed that there is negligible difference between them. Both resolutions are valid measurements for Japan and therefore countries at similar latitudes. This is a useful fact given that the quality and quantity of available distribution data are often the main constraint in this kind of analysis (Araújo *et al.*, 2005, Petřík *et al.*, 2010). More work is needed for higher altitudes such as in Europe to further validate this finding.

Extrapolation of Green Star species' mean geographic range size using TDWG L3 count is suggested, with reservations, as an alternative solution to verify whether the number of 1-degree grid or 100-km grid occupied is in the vicinity of the suggested 72. Using the linear regression model, it is expected that TDWG L3 count and 100-km grid is in 1:3 ratio. In the Japanese case, a predicted 100-km grid count of 68 for Green Star species using this method is close to the suggested 72. More widespread Green Star weeds would be expected bring the average up, compared to the conifer data set examined. This calibration method should only be applied to Green Star species. For rarer species such as Black and Gold Star species, occurrences in TDWG L3 areas are expected to be as low as 1. Given that TDWG L3 vary substantially in terms of the number of 1-degree grid (and thus 100-km grid) cells contained, so applying the calibration for non-Green Star species would give unreliable results.

The geographic range sizes of Green Star species are expected to vary widely, and more than other Star categories, because these widespread species include many in the right-hand tail end of the frequency distribution for species range size (Gaston, 1994). An accurate calibration of weights in relation to Green Star species is difficult unless species distributions are recorded to better resolution than TDWG level-3 codes. TDWG information was argued to be one of the most complete data sets currently available and easily accessible covering a variety of plant taxa at a global level (Joppa *et al.*, 2011, Lughadha *et al.*, 2005). Therefore, using the proposed calibration technique to convert TDWG level-3

codes into 100-km grid count is probably a logical solution for the time being. However, given that TDWG areas are too irregular to be nearly as satisfactory for weighting Stars as the 1-degree grid or 100-km grid, it is proposed that Star classifiers should continue to use the 100-km or 1-degree grid options wherever possible. The use of TDWG data can be recommended for checking weights of Stars, especially to check whether the ranges of Green Star species using a draft Key to Stars is of the right order.

Caution should be taken over Black Star species which are predominantly found in small islands (Kier *et al.*, 2009). Half (54 of 108 species) of Black Star species are only found in small island groups. The majority of the land area in the small islands of Ryukyu, Izu, Ogasawara and Kazan account for less than 5% of their 1-degree grid cells, except for Amai-oshima island (9%), Okinawa-jima island (6%), and Ishigaki-jima island and Iriomote-jima island (5% in total). This may have led to an overestimate of the 1-degree grid or 100-km grid (and hence a too-low weight) occupied by these Star categories relative to that of Blue and Green Star species which are widespread in mainland Japan. However, this is the standard of the system, and species of any Star are rarely found covering even all four quarters of a grid cell because habitable areas are inevitably smaller than the grid cell size because of limited land cover, topography and changes in vegetation type (e.g. rivers). Ruling out a range of factors that affect range size measurement is practically difficult.

2.9.5 The Star system for species-based conservation assessment

The practicality of the Star system is apparent when compared with IUCN Red List of Threatened Species (Table 2.8). The goals of the two systems as conservation assessment tools are different. The Star system evaluates the global rarity of taxa in terms of geographic range sizes and taxonomic distinctiveness, with an eye on using the weights to calculate GHIs. The IUCN Red List combines five criteria relating to species population, range size and the rate of decline or fluctuation, to measure the 'threat' of extinction. While the IUCN system aims to identify species at greatest extinction risk and

therefore in many cases in most need of conservation action, the Star system focuses mainly on a taxon's global rarity interest (Hawthorne and Abu-Juam, 1995, Mace *et al.*, 2008).

The global rarity rank of the Star system has been assigned for 86.5% of accepted taxa in Japan by one non-taxonomist, the author, in a couple of years including the time spent on the development of the Star criteria for Japan. Initial assignment of taxa to Stars took about 10 days, equivalent to 80 to 100 person hours. In addition, there were two extra months' work (roughly 480 person hours) for revision and checking. This fine-tuning involved verification of taxonomic status with other references, reallocation of Stars for taxonomic relatedness, and searching for information of species' geographic distributions from alternative resources for taxa with incomplete data. Only 2.1% of accepted taxa have been assessed in the IUCN approach which has been in place for over 20 years with hundreds of specialists involved in investigation (IUCN, 2010b).

The Japanese government has promoted national-level assessment of threatened species which includes assessment of 2,018 vascular plant species (Japan Integrated Biodiversity Information System, 2010). The significant limitation in such a list is that identified species are only of local conservation concern, i.e. within Japan. There was some disagreement in taxonomic status and scientific names of some taxa between the government list and the Flora of Japan database compiled, only leaving 1,372 taxa as accepted in the Flora of Japan database. Similarly with IUCN's Red List, there was no clear pattern between the Japanese Red List and the Star system except for Black Star taxa which were listed as threatened in much higher proportion than the other Star categories. This implies, reasonably, that the rarest of taxa are more likely to be prone to extinction than others. This is an interesting finding that supports conservation of Black Star species due to their high extinction risk as well as the intrinsic rarity value of taxa. Global rarity evaluation using the Star system would be a useful assessment tool that can reveal new aspects of conservation in addition to these existing systems.

2.9.6 Conclusion

The Star system has already been assessed for 30,000 taxa globally, though limited to a handful (15) of countries (Hawthorne, W. D., personal communication). This sum already outweighs the total of 12,914 taxa assessed to date by the IUCN (IUCN, 2010a). There is a good scope for quick expansion of the assessment coverage by the Star system given that the achievement to date has been made by just a few individuals. The Star system attempts to maximise the number of taxa assessed by allowing for successive approximation and using conservative estimates where data are uncertain (Hawthorne, 2012). This enabled the assignment of Stars to many taxa with limited distribution information in Japan. It is relatively simple to implement as it mainly uses range size and taxonomy as criteria.

Application of the Star system is made simple in terms of data requirement and the level of expertise. Adjustment of Star rankings by taxonomic relatedness following the proposed protocol would be sufficient and probably the best practical approach to incorporate taxonomic uncertainties and distinctiveness. Taxonomic adjustment as suggested in this study enables us to distinguish at least some of the 'taxonomically rare (i.e. genetically unusual and phylogenetically isolated taxa) plants' (Hawthorne and Abu-Juam, 1995). There has been an increasing advance in the application of phylogeny to conservation assessment (Mace *et al.*, 2003), but phylogenetic examination would involve intensive laboratory and computational work. Incorporation of phylogenetic analysis into the Star system can be investigated in future work, but is beyond the scope of this study. Simple categorisation of rarity at four levels means it is relatively easy to modify rarity status in response to future changes in taxonomic opinion. The Star system is a practical approach that attempts to maximise and efficiently achieve assessment of global rarity status of as many taxa as possible using existing data.

The first complete database of Flora of Japan that is available to non-Japanese speakers, with Stars and other details, means it can significantly contribute to conservation priority setting, not only in the context of national policy planning in Japan, but also in global assessment. It is expected that this new database will enhance general understanding of Japanese flora as well as its importance in terms of global rarity.

3 The Japanese hotspot redefined using the bioquality approach

3.1 INTRODUCTION

3.1.1 Japan as a biodiversity hotspot

The two most widely recognised community-level priority setting approaches are Conservation International (CI)'s biodiversity hotspots and World Wildlife Fund (WWF)'s ecoregions (Brooks *et al.*, 2006). The whole of Japan is one of CI's 31 biodiversity hotspots (Conservation International, 2009b, Mittermeier *et al.*, 2005). One of the reasons for this 'hotspot' status is that 30% to 40% of the plant species in Japan are thought to be endemic to the country (Conservation International, 2009b). Japan contains nine terrestrial ecoregions (excluding Kamchatka–Kurile meadow and sparse forests, and South Sakhalin–Kurile mixed forests, both near the Russian border) identified by WWF's ecoregion approach (World Wildlife Fund, 2010). Of these, one vegetation type, the Nansei-shoto archipelago forest is one of the Global 200 conservation priority ecoregions (Olson and Dinerstein, 2002, Olson *et al.*, 2001).

When one tries to define conservation targets on a local management level, neither CI's biodiversity hotspot or WWF's ecoregion approach provides practical insights on how global priorities should feed into the local level. CI's hotspots are defined by broad-scale endemism and the rate of habitat loss (Conservation International, 2009a). However, both indices lack standardised measurements of area or reference conditions of original habitats (Brooks *et al.*, 2002, Mace *et al.*, 2000). This means that the designation of Japan as a priority area is not comparable with other hotspots, nor is it possible to divide it into priority areas for local management. The ecoregion approach gives a list of representative vegetation types as defined and analysed by WWF, but it fails to provide a quantitative assessment protocol to compare priorities within or between ecoregions (Jepson and Whittaker, 2002). Therefore, it is not possible to justify what makes the Nansei-shoto archipelago forests outstandingly important compared to others in or outside Japan.

According to the government statistics, a total of 14.3% of land area in Japan is currently under legal protection at national, quasi-national or prefectural levels (Ministry of the Environment of Japan, 2010b). This figure is not small from a global perspective (Jenkins and Joppa, 2009), but the protected area coverage within Japan has been pointed out to be uneven with respect to the representation of forest community types across the country (Kamei and Nakagoshi, 2006). Furthermore, the designation of these protected areas lacks reference to global priorities. The criteria for designation of protected areas use terms such as 'representative landscape from international, national or local interests' (Ministry of the Environment of Japan, 2012b) which are somewhat vague and subjective. Therefore, the Japanese protected area network does not adequately cover the globally important species and ecosystems in the country because of the following three weaknesses: (1) biological data are simply not available to non-Japanese scientific communities (Higuchi and Primack, 2009), rather than being deficient as highlighted by some authors (Kier *et al.*, 2005, Yesson *et al.*, 2007); (2) global prioritisation approaches such as CI's biodiversity hotspots or WWF's ecoregions are too crude to identify conservation targets at a local management level (Ferrier *et al.*, 2009) and do not focus on global rarity in quantitatively comparable ways; (3) there is no national framework for identifying areas of high conservation priority at a national scale.

There is a clear need to establish a conservation prioritisation system at a national level in Japan that reflects its global significance in sufficient detail to plan conservation practices at a site level. The challenge of developing a national prioritisation system is not unique to Japan. For example, Médail and Quezél (1999) investigated endemic plant species richness at the regional level in the Mediterranean Basin to identify ten hotpots. Each of the ten hotspots is home to over 2,000 species per 15,000 km^2 with at least 10% narrow endemics (species that are only found in the hotspot or in the same biogeographic area, surrounding the hotspot), covering as a whole 22% of the total surface of the Mediterranean Basin. A study in China by Zhang and Ma (2008) identified hotspots based on species richness and the number of threatened species on a province and then county basis. This work used the IUCN Red List of Threatened Species as a measure of conservation importance, despite the fact that

this approach is not designed for community-level assessment. These approaches, although useful for national priority setting, may not produce results that can be compared directly between regions of different sizes.

Reid (1998) suggested that priority areas in terms of 'hotspots' may be defined based on high concentrations of globally rare species as well as species richness and other variables. Global rarity may refer to restricted geographic range, habitat speciality, or scarcity (Gaston, 1994). Range size is the most frequently adopted measurement of rarity as well as being practical owing to the relatively abundant data available for examination (Gaston and Fuller, 2009, Newton and Oldfield, 2008). Range size, as an estimator of rarity, has been shown to be a useful metric for assessing conservation value at regional level (e.g. Linder (2001) for Africa and Crisp *et al.* (2001) for Australia); and the bioquality approach itself focuses on global rarity (e.g. Mexico, (Gordon *et al.*, 2004); Cameroon, (Tchouto *et al.*, 2006)).

I apply the bioquality approach for the first time to the flora of Japan to identify global priorities on the ground. An important feature of the bioquality approach is the integration of species-based conservation assessment into community-level scoring (Box 3.1). The bioquality score called the Genetic Heat Index (GHI) is measured for each biological community, and is based on the concentration of high conservation value species, i.e. global rarity, within the community (Hawthorne, 2012). A community in this case refers to plant assemblages of a given area, such as survey plots or a county.

Box 3.1 Summary of bioquality approach: the Star system and the Genetic Heat Index (GHI)

A taxon's global rarity is classified into four level ranked groups called Stars. Community score: Genetic Heat Index (GHI) is calculated using the following equation.

$$\mathbf{GHI} = \frac{((\boldsymbol{wBK}\times\boldsymbol{nBK})+(\boldsymbol{wGD}\times\boldsymbol{nGD})+(\boldsymbol{wBU}\times\boldsymbol{nBU})+(\boldsymbol{wGN}\times\boldsymbol{nGN}))}{(\boldsymbol{nBK}+\boldsymbol{nGD}+\boldsymbol{nBU}+\boldsymbol{nGN})} \times \mathbf{100}$$

Star	Black	Gold	Blue	Green
Weight (*w*)	$\frac{aGN}{aBK}$	$\frac{aGN}{aGD}$	$\frac{aGN}{aBU}$	$\frac{aGN}{aGN} - 1$

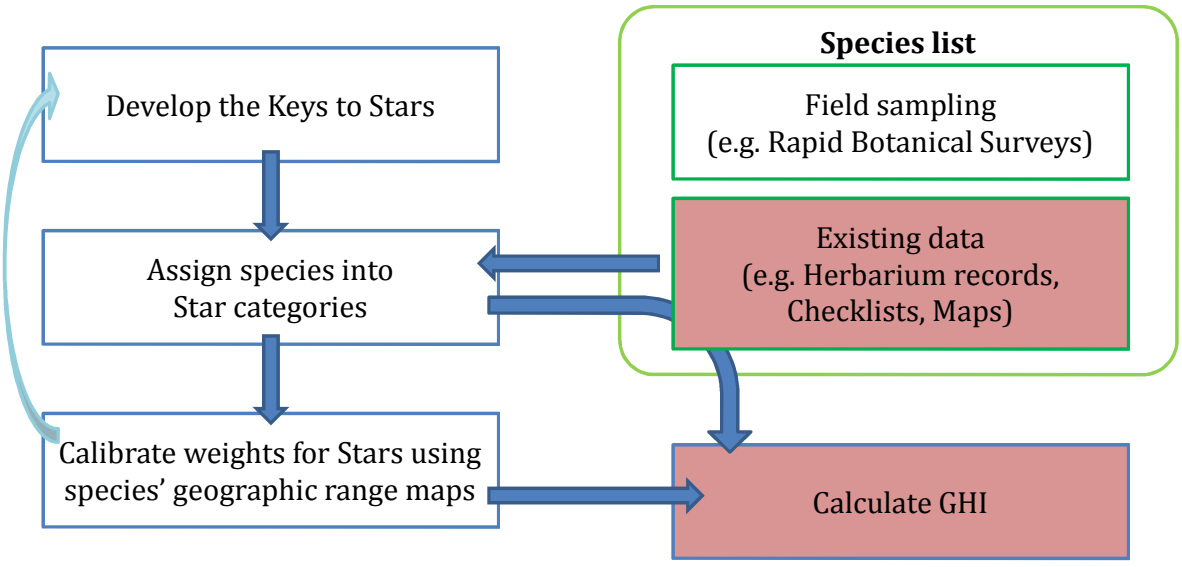
Where *a* is the average number of degree squares (i.e. area) occupied by the component species of a Star, *w* is a weight given for a Star category and *n* is the number of species for each Star category in a study area. Stars are abbreviated as BK = Black; GD = Gold; BU = Blue; GN = Green.

Weights calibrated for the Japanese flora based on analyses in chapter 2 are:

Black = 27; Gold = 9; Blue = 3; Green = 0.

In this chapter, community-level global rarity score GHI is calculated using two different data sets: the Flora of Japan prefectural species' occurrence data, and Horikawa dot maps.

Route to bioquality assessment using the Star and Genetic heat Index (GHI)



3.1.2 Examining scalability of the bioquality approach

The goal of this chapter is to identify spatial patterns of hotspots using available data through application of the bioquality approach to the Japanese flora. However, in many countries including Japan, botanical records are patchy in terms of taxonomic and geographical representation (Isaac *et al.*, 2004, Lughadha *et al.*, 2005). Data quality of distribution maps is also often variable (Rondinini *et al.*, 2006). Some well-studied areas may have distribution records at the level of a few hundred metres while others may only be available at very coarse resolution, e.g. one degree grid squares (Gaston and Fuller, 2009). To address these challenges, techniques to compare and merge different data sets recorded at different resolutions to produce the best quality bioquality hotspot map are investigated here. Specifically, two data sets are examined that are different in terms of species pool recorded and spatial resolution (Table 3.1):

1) Prefecture level Flora of Japan: Distribution information of approximately half (over 4,800) of the plant taxa in Japan, excluding monocots, is available in the Flora of Japan database, yet range description is often as coarse as the level of districts or prefectures at best.

2) Horikawa dot maps: Presence records of 862 selected taxa across a grid of 1,418 of 10′ latitude by 15′ longitude cells, referred to as 'geoquadrats' and compiled by Horikawa (1972, 1976). This data set is smaller, in terms of species pool sampled, than the other, but is mapped at a finer resolution than prefectures – there are on average 27.5 geoquadrats per prefecture.

3.2 RESEARCH QUESTIONS

In this chapter the following questions are addressed:

1) Where are the hotspots of plant bioquality in Japan?

2) Are spatial patterns of bioquality hotspots congruent between maps created by different data sets?

3) How can data at different spatial resolutions be combined to make a master map of Japan's bioquality hotspot(s)?

An additional question regarding the agglomeration technique that was developed to compare two different maps at varying spatial resolution is also examined:

4) How much variation in calculated GHI is observed using different techniques of agglomeration?

The structure of this chapter is as follows: firstly, characteristics of the Japanese vegetation are outlined. In the methods section, the two data sources used are described and problems in relation to the proposed agglomeration technique are addressed. The results are divided into three parts: 1) bioquality hotspot maps generated by two data sets (section 3.5); 2) analyses of congruence of GHI between two maps, and on the effect of agglomeration techniques on GHI (section 3.6); 3) based on the outcome, protocols to enhance the fine-resolution bioquality map by estimating GHI on data deficient areas (section 3.7). In the conclusion, I discuss the implications for the development of a national conservation prioritisation system for Japan with particular focus on recommendation for local sampling to further investigate the identified hotspots in detail, which will be discussed in Chapter 4.

3.3 METHODS

3.3.1 Sample plot data

Two sample plot data sets were prepared in the form of list of species in designated plots (Table 3.1):

1) Prefectural level Flora of Japan: 4,830 taxa with Stars containing within-Japan distribution information in the Flora of Japan (FOJ) database (see Chapter 2 for full description on database development) were parsed into presence/absence data for the 51 botanical prefectures. The set of prefectures and island groups are termed botanical prefectures in this study. In addition to political prefectures, the island groups of Ryukyu, Ogasawara, Kazan, Izu and Kuriles are identified as

botanical prefectures. The Amami islands in Kagoshima prefecture are included in the Ryukyu Islands botanical prefecture.

2) Horikawa dot maps: 821 taxa with Stars from 1,385 geoquadrats with any species occurrence records were extracted as plot samples using Horikawa geoquadrat maps (Horikawa, 1972, 1976).

Table 3.1 Summary of the data sets used for identification of bioquality hotspots at national level.

Map type	No. of 'sample plot' or unit area	No. of species mapped
(1) FOJ- Prefectures	46 prefectures and 5 island groups (the Kuriles, Izu, Ryukyu, Kazan, Ogasawara)	4,830 species with Stars out of the total 8,262 accepted taxa in the database
(2) Horikawa dot maps	1,385 geoquadrats of a total of 1,418 mapped by Horikawa (1972, 1976). Each geoquadrat is 10′ latitude by 15′ longitude.	821 taxa with Stars out of 862 mapped (30 moss species were excluded, 3 taxa synonymised and merged to accepted names, 8 no Stars assigned)

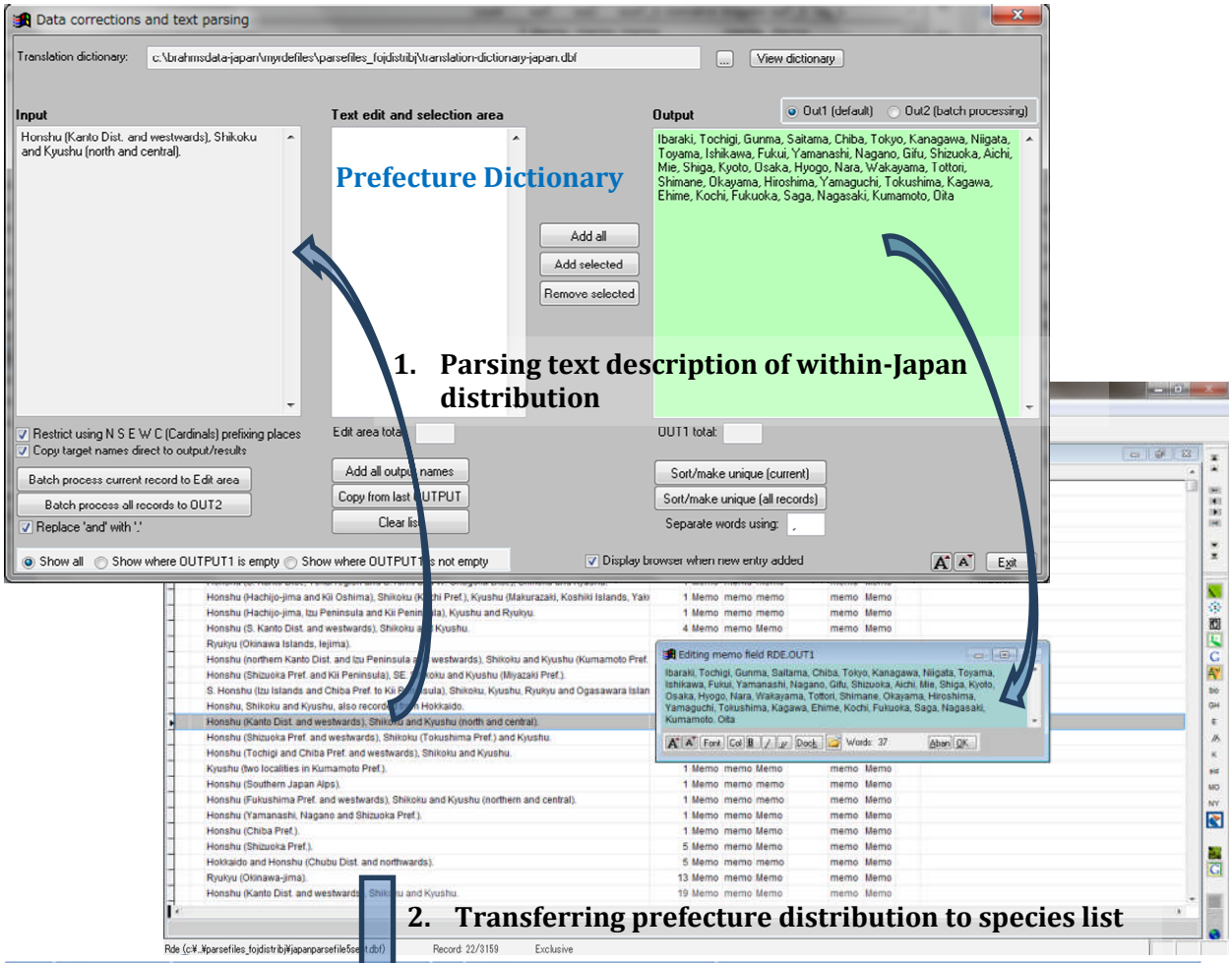
3.3.2 Data source 1: Flora of Japan

The following two new BRAHMS functions (Filer, 2012) were developed in collaboration with Denis Filer to parse text descriptions of within-Japan species distribution to produce tabulated data listing species for each botanical prefecture.

1. **Semi-automated recognition of species distribution by prefecture name.** Using a manually created location dictionary file, a parse table was generated with an input field holding a text description of the species distribution and an output field folding a codified list of prefectures corresponding to the description (Figure 3.1). In the FOJ, the distribution of widespread species is mostly described in terms of large geographic units such as districts (e.g. Honshu or Shikoku). The fairest estimate of prefectures occupied for these coarse level descriptions is to select all of the prefectures within the larger geographic units. For example, if the original description states '*Shikoku*', the output is interpreted as all four prefectures in Shikoku: '*Tokushima, Kagawa, Ehime, and Kochi'*. In contrast, more detailed locality information was often available for species with

restricted distributions, such as individual mountain ranges of prefectures. This means that species distribution data from the FOJ is a mixture of more and less detailed information. This limitation in the data can create uncertainty, or some fuzziness of pattern in the calculated hotspots; however this uncertainty is expected to be limited because the majority of rare species in the FOJ, which are the important species in hotspot identification, have more detailed locality information, at least to the prefecture level.

2. **Transfer of data into a sample plot database.** Once all of the distribution information was translated into a list of prefectures for each species, the data were transferred into a plot database. This step generates a species list for each botanical prefecture, or sample unit.



Spnum	family	species	star	distribj	parsedata
4909	Verbenaceae	Callicarpa shikokiana Makino	BK	Honshu (Hiroshima Pref.), S. Shikoku (Kochi Pref.) and Kyushu (Nagasaki and Kagoshima Pref.).	Hiroshima, Kochi, Nagasaki, Kagoshima
5012	Labiatae	Scutellaria amabilis Hara	GD	C. Honshu (Pacific Ocean side from Tokyo to Mie Pref.).	Tokyo, Kanagawa, Shizuoka, Aichi, Mie
5044	Scrophulariaceae	Gratiola japonica Miq.	GN	Honshu (southward from Miyagi Pref.) and Kyushu.	Miyagi, Yamagata, Fukushima, Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Toyama, Ishikawa, Fukui, Yamanashi, Nagano, Gifu, Shizuoka, Aichi, Mie, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama, Tottori, Shimane, Okayama, Hiroshima, Yamaguchi, Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima
5113	Scrophulariaceae	Pedicularis keiskei Fr. et Sav.	BK	C. Honshu (Kiso Mountain Range, Akaishi Mountain Range, Mt. Yatsu and Chichibu Mts.).	Yamanashi, Nagano, Shizuoka, Saitama
5149	Acanthaceae	Hemigraphis okamotoi Masamune	GD	Ryukyu (Miyakojima).	Ryukyu
5169	Lentibulariaceae	Pinguicula ramosa Miyoshi	GD	C. Honshu (Kanto Dist.).	Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa
5171	Lentibulariaceae	Utricularia minutissima Vahl	GN	Honshu (Tokai region).	Gifu, Shizuoka, Aichi, Mie
5182	Campanulaceae	Adenophora maximowicziana Makino	BK	Shikoku (Ehime and Kochi Pref.).	Ehime, Kochi
5433	Celastraceae	Euonymus lutchuensis T. Itô[o^]	BK	S. Kyushu to Ryukyu.	Kumamoto, Miyazaki, Kagoshima, Ryukyu
5494	Elaeocarpaceae	Elaeocarpus japonicus Sieb. et Zucc.	GN	Honshu (Kii Peninsula and western part of Chugoku Dist.), Shikoku, Kyushu and Ryukyu.	Mie, Nara, Wakayama, Shimane, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime, Kochi, Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima, Ryukyu
5562	Elaeagnaceae	Elaeagnus murakamiana Makino	GD	Honshu (Tokai region and Kinki Dist.) and Shikoku.	Gifu, Shizuoka, Aichi, Mie, Mie, Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama, Tokushima, Kagawa, Ehime, Kochi
5565	Elaeagnaceae	Elaeagnus yoshinoi Makino	BK	Honshu (Chugoku Dist.).	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi
5606	Violaceae	Viola faurieana W. Becker	GN	Honshu (from Aomori to Fukui Pref. on Japan Sea side).	Aomori, Akita, Yamagata, Niigata, Toyama, Ishikawa, Fukui
5615	Violaceae	Viola alliariifolia Nakai	BK	Hokkaido (Mt. Daisetsu and Sapporo).	Hokkaido

Species List

Figure 3.1 Illustration of parsing functions developed in the BRAHMS. The prefecture dictionary file is used to identify the distribution of taxa at the prefecture level from text descriptions (two windows above) and transferred to a species list (bottom).

3.3.3 Data source 2: Horikawa dot maps

Presence records of 862 taxa in 1,418 'geoquadrats' (Horikawa, 1972, 1976) were prepared through digitisation, georeferencing and resampling using ArcGIS and QuantumGIS. (A full description of data preparation is provided in Chapter 2.) The list of 821 taxa with Stars, across all geoquadrats generated 167,562 presence records; these were transferred to the BRAHMS, where the 1,385 geoquadrats that had more than one species record were treated as the sample plot data.

Geoquadrat samples were further reduced to 1,153 by omitting those with fewer than 40 species for GHI calculation, following the standard Rapid Botanical Survey (RBS) protocol (Hawthorne, 2012). For samples with this few species, the inclusion or exclusion of individual species due to sampling error has too great an effect on GHI. For 265 geoquadrats with fewer than 40 taxa, methodologies to fill in the gaps on the map are investigated in later sections (see page 117 for analyses) and the revised bioquality map is presented in Figure 3.15.

3.3.4 Comparison of bioquality maps generated by two maps: agglomeration techniques

The sample plot data generated from the prefecture–FOJ data and the Horikawa geoquadrats were independently examined to identify potential bioquality hotspots in Japan. Comparing the results of the two analyses presented challenges because the two data sources are different in terms of species pool recorded and the spatial resolution of the sample units (Figure 3.2). If spatial patterns of hotspots were congruent between the two maps, the result strengthens confidence in both, and the fine or coarse resolution maps can be used where appropriate. In order to test this, a technique to compare two maps needed to be developed.

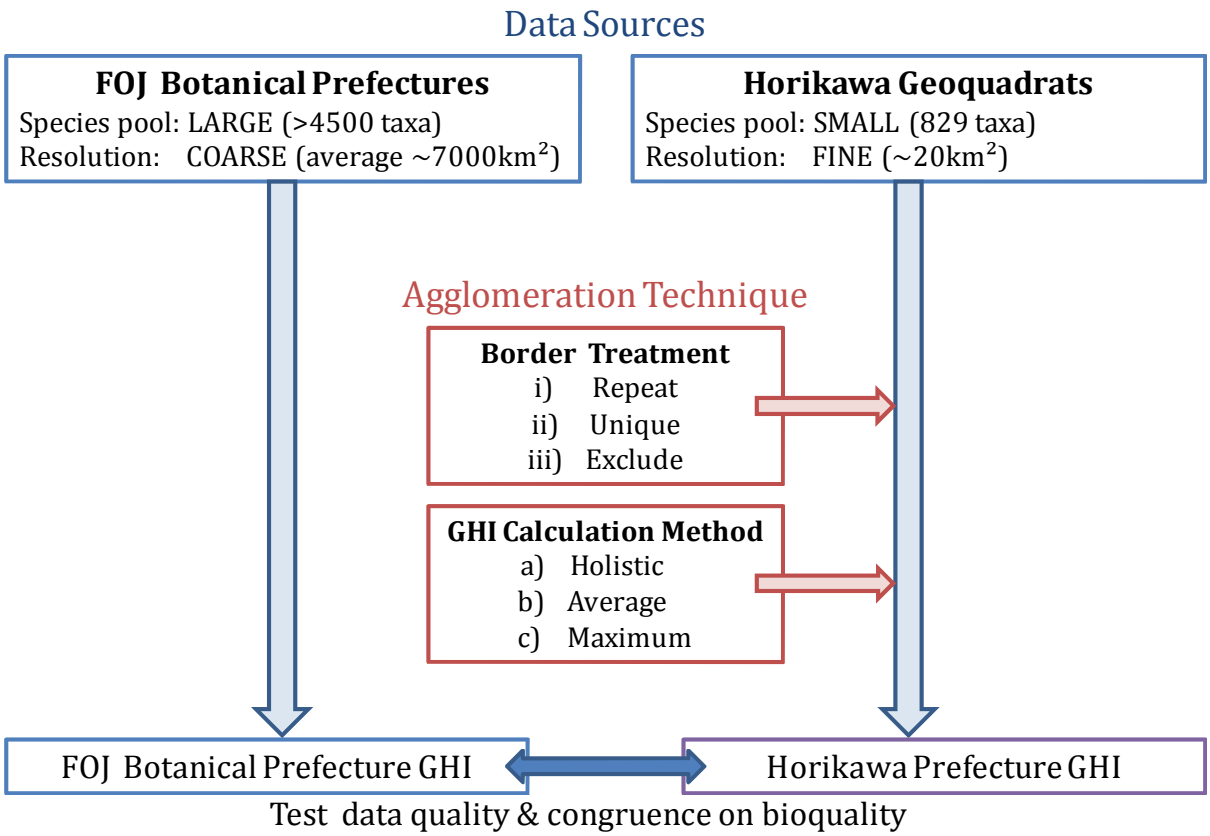


Figure 3.2 Flow of testing representation of bioquality between the two data sets using proposed agglomeration technique. Fine resolution Horikawa maps were merged to prefecture unit by choosing options in the two-step agglomeration technique.

It was hypothesised that Horikawa dot map plots represent a random subset of the FOJ sample plots. The hypothesis is tested as follows. Geoquadrats are merged to create larger geographic units equivalent to prefectures, with GHI at the same spatial resolution as the FOJ prefectures. Using Horikawa's agglomerated geoquadrats at the prefecture level and prefectural FOJ data, the correlation between the two maps in terms of ranking of GHI at coarse resolution level was analysed.

The conversion of sample plot size from fine-resolution maps to coarser prefecture maps has two problems: the delineation of intersecting boundaries, and the calculation of GHI. First, the square Horikawa geoquadrats often intersect with irregularly shaped prefecture boundaries. There is no information available to determine whether species recorded in a geoquadrat that intersects more than one prefecture is present in all or only one of these prefectures (Figure 3.3). Misinterpretation of

boundaries can lead to commission or omission errors in species presence records, affecting overall prefecture scores.

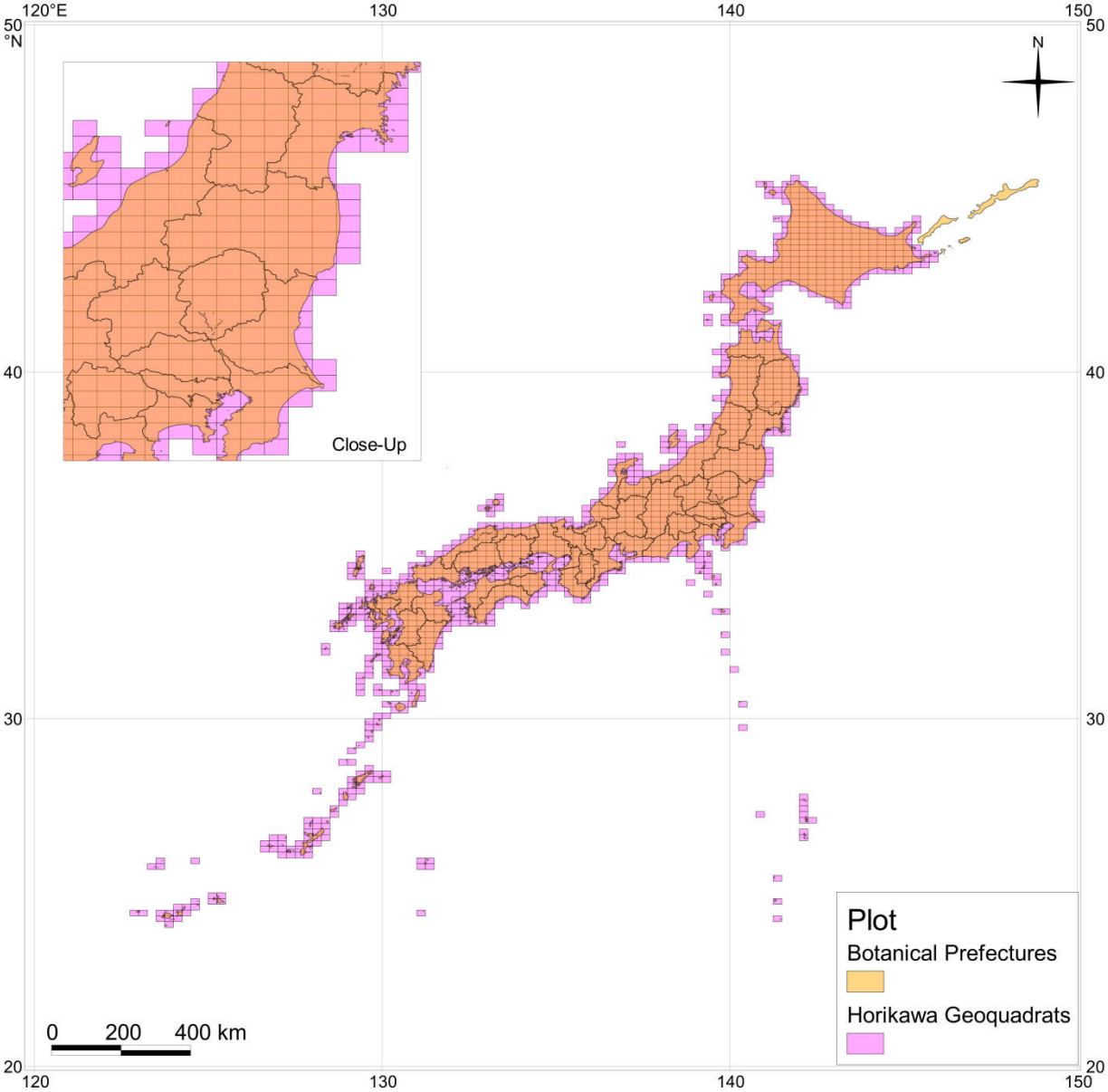


Figure 3.3 Map showing how Horikawa geoquadrats (purple grids) and prefecture boundaries (orange) intersect.

Theoretically, several options could be applied to geoquadrats that straddle prefecture boundaries:

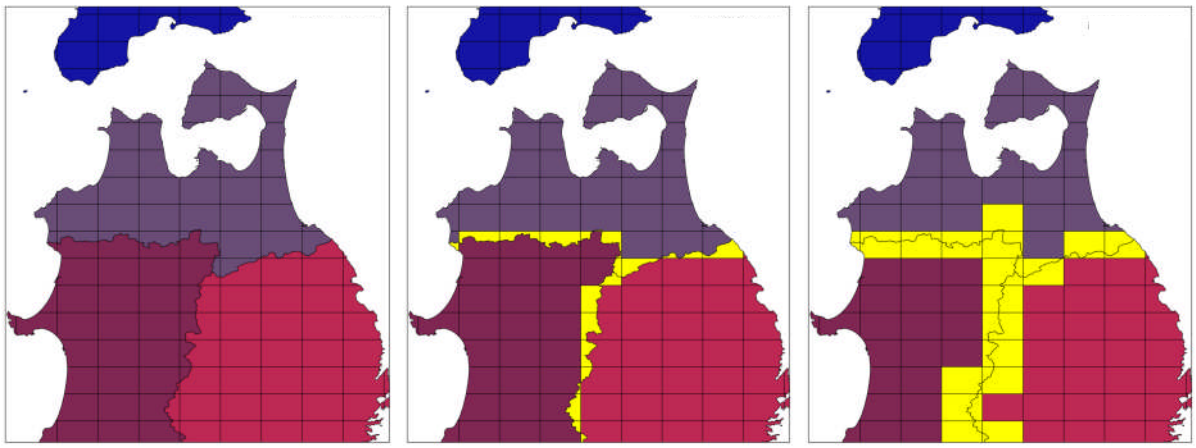
1. 'Border repeat' contains all border-crossing geoquadrats in all relevant prefectures (Figure 3.4 (i)). This allows duplicated use of data in multiple samples, and preserves the maximum amount of data.

2. ‘Border exclude’ dismiss all such examples (Figure 3.4 (iii)). This method is likely to lose important species distribution data.

3. To give a weight to the subset of geoquadrats according to the area occupied by intersecting prefectures. For instance, if 60% of an area in a geoquadrat was partitioned to prefecture A and the remaining 40% to prefecture B, contribution of geoquadrat GHI to the two prefectures may be divided accordingly. Both this and the next method are prone to misrepresenting species’ distributions because the area of habitat available for species would not necessarily be equivalent to the area of the geoquadrats and prefectures.

4. ‘Border unique’ selects one prefecture with the largest area coverage of the geoquadrat may be selected to produce unique list of geoquadrats corresponding to prefectures (Figure 3.4 (ii)).

5. Environmental variables and their spatial variations within each geoquadrat or prefecture could be examined and species could be allocated to prefectures that contain the most apparently suitable habitat. This method is both labour-intensive and still error-prone. It would be extremely difficult or impossible to collect and evaluate all the information necessary to determine habitat and environmental requirements for all of the recorded species.



i) Border Repeat ii) Border Unique iii) Border Exclude

Figure 3.4 Example illustration of border treatments: i) ‘border repeat’, ii) ‘border unique’, and iii) ‘border exclude’. Prefectures are identified by colours. Areas highlighted in yellow designate geoquadrats in corresponding prefectures that were filtered out by the border treatment.

The second issue with scaling up from finer resolution data is the calculation of GHI from agglomerated geoquadrats. Standard GHI at a sample level is calculated on the basis of species' presence or absence. Summing them to a broader sample unit might involve taking:

a) 'Holistic' GHI calculation method takes a single checklist of species for the broader area (prefectures) using the species pool of the smaller samples within them (geoquadrats), and give a score for the species list. This checklist is unweighted, i.e. presence/absence of species only as opposed to the inclusion of abundance measurements for recorded species (weighted). This method seems fairest for comparing scores at prefecture level, as only an unweighted check-list is available for the FOJ prefectural data;

b) 'Average' GHI of all smaller samples (geoquadrats) within a prefecture. Sample GHIs are calculated independently for individual geoquadrats;

c) 'Maximum' GHI of independently calculated GHI for the smaller samples.

Note that scores (b) and (c) have limited scopes for comparison at the broader scale because unweighted species lists are not available for the agglomerated prefectures. However, it can be argued that if one did want a prefecture-scale score to reveal hotspots based on smaller samples within them, either of these techniques has the potential to be more useful than holistic GHI.

The following combinations of border treatments and GHI calculation have been selected to investigate the effect of agglomeration techniques on observed GHI at coarse resolution. Agglomeration techniques take the two steps (Box 3.2):

Box 3.2 Two-step agglomeration technique examined

Step 1: Border treatments

i) **Border repeat**: For geoquadrats straddling prefectural boundaries, species in these geoquadrats are repeatedly counted in multiple prefectures.

ii) **Border unique:** For geoquadrats straddling prefectural boundaries, the single prefecture which occupies the largest area of the geoquadrat is assigned that geoquadrat.

iii) **Border exclusion**: Geoquadrats straddling prefectural boundaries are excluded.

Step 2: GHI calculation for estimating prefecture scale GHI based on geoquadrat scale data

a) **Holistic GHI** is calculated from a unique list of species generated for each prefecture.

b) **Average GHI** of all geoquadrats included in a prefecture.

c) **Maximum GHI** score of all geoquadrats included in a prefecture.

Selection of geoquadrats against prefectures and calculation of GHI was run using scripts developed in R (Appendix B).

3.3.5 Analyses

Bioquality hotspots were calculated and mapped using Quantum GIS software version 1.8.0 (The Quantum GIS project, 2012). Prefecture GHIs showed a right-tailed distribution (Shapiro–Wilk normality test: $P < 0.0001$ for all data: FOJ GHI, Holistic, Average and Maximum Horikawa GHI by Border Repeat method). Based on this result, Kendall's rank correlation analysis using R package 'Kendall' version 2.2 and Wilcoxon's signed-rank test (paired), where possible, were used to compare between FOJ-prefecture GHI and agglomerated Horikawa GHI using R (version 2.14.1). (The script is given in Appendix B.)

Outlier prefecture samples with respect to the proportion of species pool represented were identified prior to the comparison between agglomerated Horikawa GHI and prefecture–FOJ GHI. Outliers here refer to prefecture samples with a disproportionately small proportion of taxa recorded relative to the total taxa sampled in the data set, making GHI unreliable to analyse. Whether or not prefectures with small numbers of taxa matched between the two data sets was also examined.

3.4 RESULTS

3.5 Hotspot maps of Japan unveiled – primary outcomes

3.5.1 Data representation in terms of Star categories

In terms of taxonomic representation of the two data sets, prefectural data contained a slightly lower proportion of Green Star taxa while the other three Star categories were slightly higher in proportion than those across all accepted taxa in the database (Figure 3.5). By contrast, the Horikawa dot maps had a slightly higher proportion of Black and lower Gold Star taxa represented than the complete database. These are relatively small variations in proportional representation of Star categories in the different data sets.

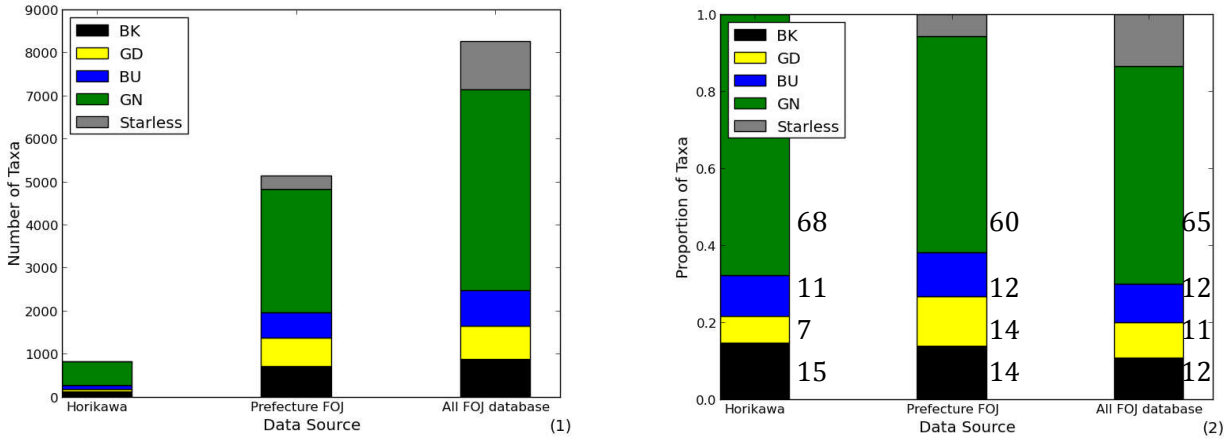


Figure 3.5 (1) The numbers and (2) proportions of Black, Gold, Blue, Green and Starless (without Stars) species in Horikawa dot maps, FOJ-prefectures and all accepted names in the Flora of Japan database. Values of percentage proportions (%) excluding Starless taxa are shown on (2).

3.5.2 Spatial patterns of GHI

Using the FOJ–prefecture data, the highest scoring areas were the small island groups of Ogasawara (GHI: 1005), Izu (647) and Ryukyu (372), followed by Kagoshima (254), Hokkaido (188) and Nagano (184) prefectures on mainland Japan (Figure 3.6). Apart from these high scoring prefectures, GHI in most of mainland Japan ranged from 70 to 180, with the lowest in the Kuriles (45). The low scoring prefectures were predominantly in coastal industrial areas such as Osaka (72), Hiroshima (79) and Okayama (80) (Figure 3.6).

Using the Horikawa geoquadrat data, every geoquadrat with GHI over 200 except one was concentrated in the southern part of Japan – mainly in the Ryukyu Islands (Figure 3.7). The highest-scoring areas were: Tokuno-shima island (the highest GHI of the island: 268), Yakushima island (264), Awaguni-jima island (262), Amami-oshima island (255) and Okinawa-jima island (255). The geoquadrat covering the Yubari mountain range in Hokkaido scored 202, the highest in mainland Japan. Mountains in mainland Japan tend to have high proportions of rare taxa. Other examples include Mt. Chokai-san (GHI: 154), the Ōu Mountains (the highest GHI around the mountain range: 127), the Japanese Alps (the highest GHI in the ranges: 124) and the Shikoku Mountains (the highest GHI: 121). The lowest GHI values were observed mostly in the lowlands of mainland Japan such as Hokkaido, the Kanto Plain, the Echigo Plain (Niigata prefecture) and cities (e.g. Tokyo, Tsu, Osaka, Hiroshima) (Figure 3.7).

Initial observations on the spatial pattern of GHI in the two data sets showed that there was a larger region of low scoring areas visible in the finer resolution data (Horikawa dot maps), and there were more specific local areas with high scores within prefectures. The greater variance of GHI values is to be expected from the finer resolution data, because they are effectively weighted averages of smaller areas. Widespread species within prefectures are counted more frequently than rare ones in individual geoquadrats, leading to generally lower Horikawa GHI than prefecture GHIs. High GHI in localised areas on the finer resolution data caused by the concentration of rare species essentially gave greater weight to these species in species assemblages than low scoring areas.

The locations of hotspots and cold spots however seem very concordant between the two maps. There was a general increase in GHI values towards lower latitudes, i.e. warmer climates. Some prefectures containing high mountain ranges with high GHI on Horikawa dot maps also had higher GHI than lowland on FOJ–prefecture map. The relationship between the two is next examined more formally by aggregating the fine-resolution data to the same prefecture level, as discussed in the methods, after removing outliers with too few species to be reliable.

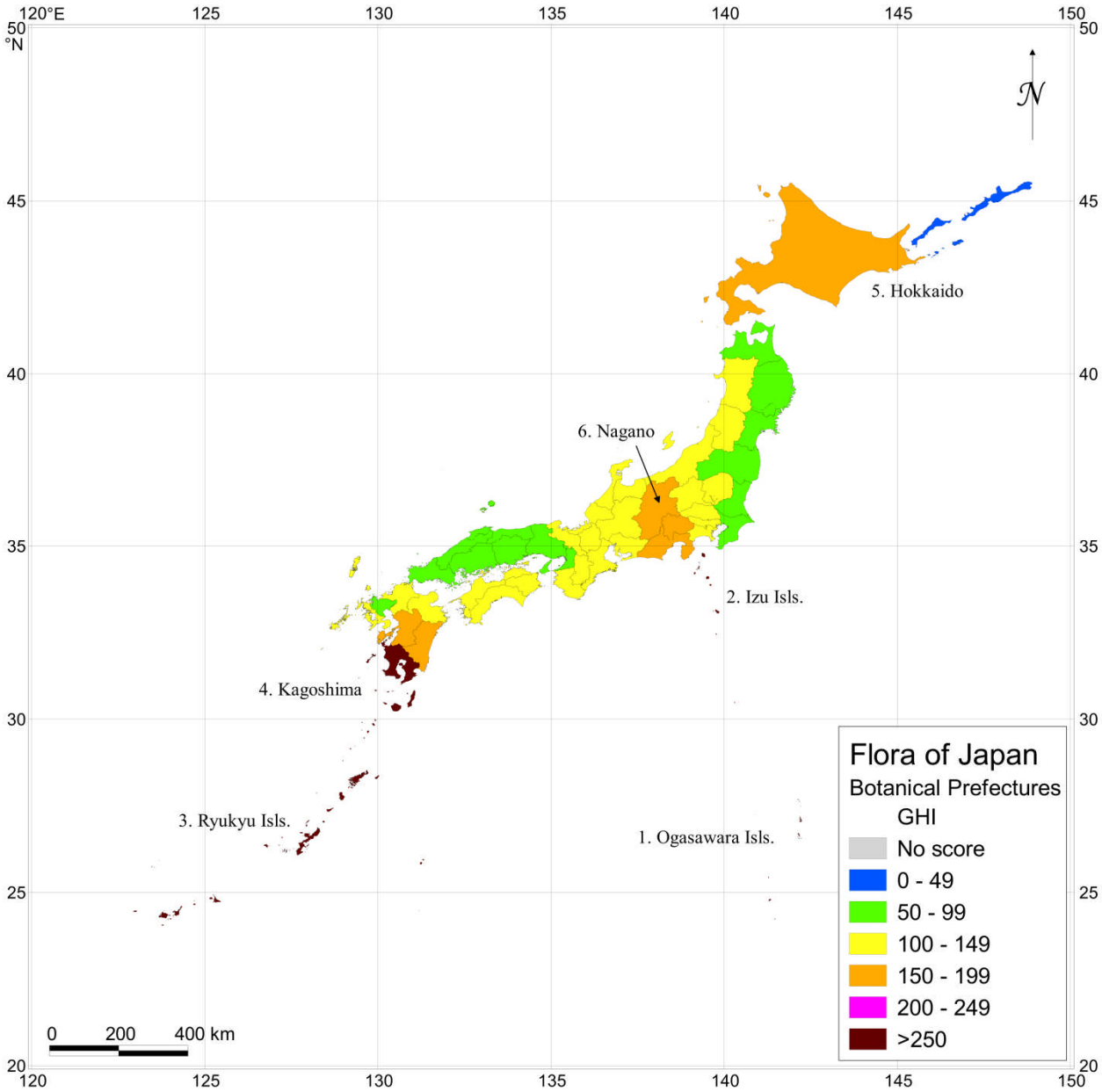


Figure 3.6 Map of Flora of Japan prefecture GHI. 51 botanical prefectures were used as sample units. The six highest-scoring botanical prefectures are numbered in descending order of GHI rank.

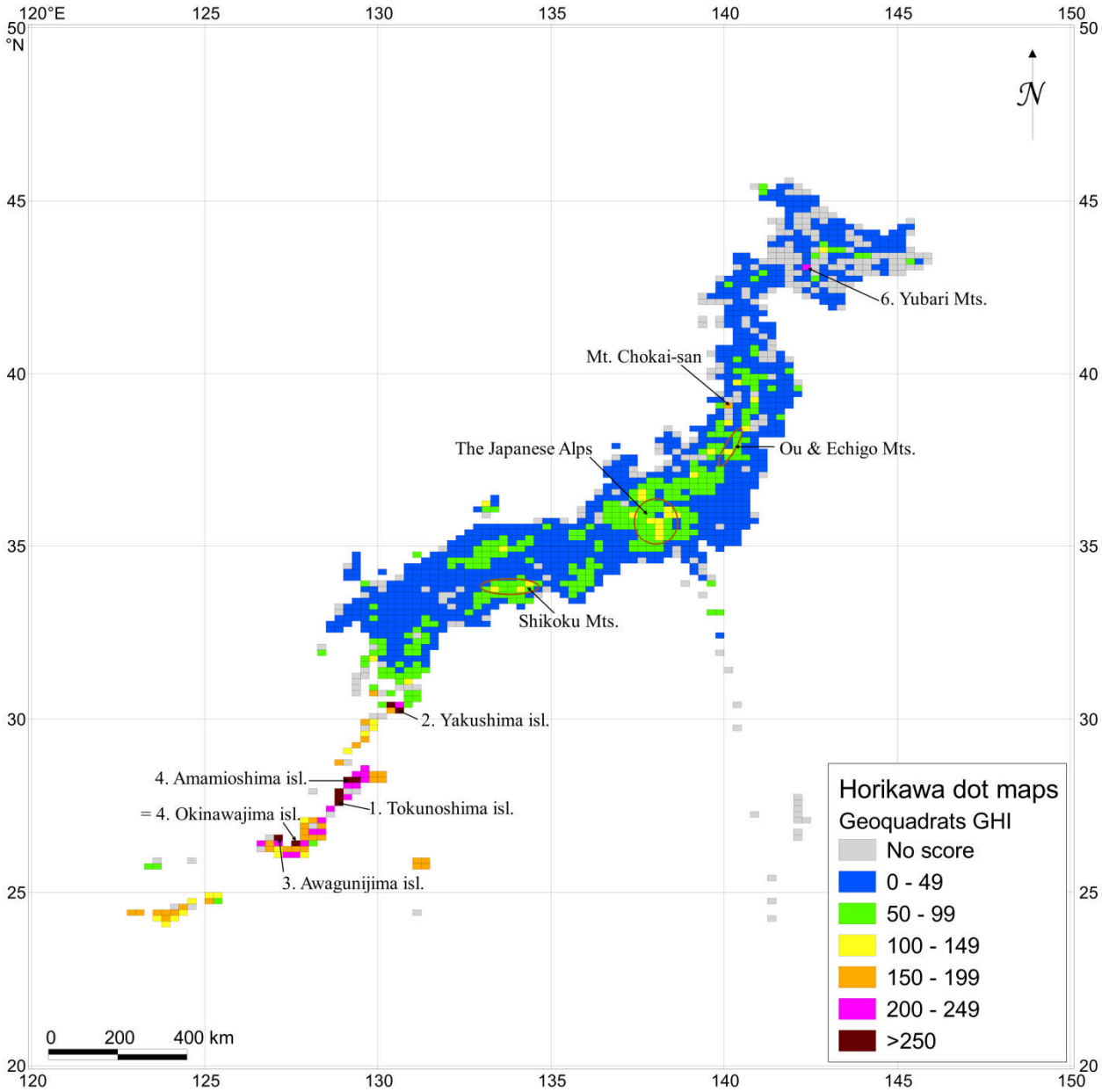


Figure 3.7 Map of Horikawa geoquadrat GHI. 265 geoquadrats contained fewer than 40 total taxa recorded and were treated as plots with no species (no score). The top six geoquadrats are numbered in descending order of GHI rank. Other potential hotspot areas are also indicated.

3.6 Congruence between the two maps and comparison of agglomeration techniques

3.6.1 Testing congruence between prefecture–FOJ and Horikawa dot map data

3.6.1.1 Identification of outlier prefectures

The holistic method was selected for summarising GHI from Horikawa geoquadrats to compare with the FOJ species pool in search of outlier prefectures, i.e. prefecture samples with too few species for GHI to be reliably calculated for either data set. Although various GHI summarising methods are compared below, the choice of this summarising method was made because the number and identity of species per botanical prefectures are in effect a holistic summary, and form the fairest comparison with data derived by joining finer-resolution data sets.

Two prefectures with less than 7.5% of the total species pool both in FOJ and Horikawa dot maps were identified as outliers (two largest red circles in Figure 3.8), on the basis of a large discrepancy between scores calculated from the two data sets.

- Izu Islands, in which 103 taxa (2.1% of the total 4,830 taxa sampled in the FOJ data) were recorded in the FOJ, yielding a GHI of 640; compared to 204 taxa yielding a GHI of 60 for the same area by agglomerated Horikawa data (Figure 3.8).

- Ogasawara Islands where 256 taxa and GHI of 1005 were sampled using FOJ data; as opposed to 62 taxa (7.5% of 829 taxa sampled in Horikawa data) were recorded as a whole in Horikawa dot maps with GHI of 493.

All seven geoquadrats and seven out of 16 geoquadrats in the Ogasawara and Izu islands, respectively, contained fewer than 40 species. These outlier prefectures have the smallest species lists, and have the largest difference in GHI between the two data sources. For the Izu Islands, the low species representation in the FOJ data is suspected to be due to incomplete listing of species occurrences on these islands. Practically, it is difficult to specify species occurrence on Izu islands for many widespread species of mainland Japan for which the distribution is often only described at the district

level. Therefore, there is a potential bias towards greater recording of range-restricted species in FOJ data, such as endemics to the Izu Islands. Neither Izu nor Ogasawara intersect with other botanical prefectures; results were therefore the same for all border treatments, and were the smallest prefecture-scale samples in either of the data sets.

The botanical prefectures of Izu and Ogasawara islands were thus omitted from further analyses on agglomeration techniques. The Kazan Islands and the Kuriles were not recorded in Horikawa dot maps; these areas were therefore also excluded in further analyses.

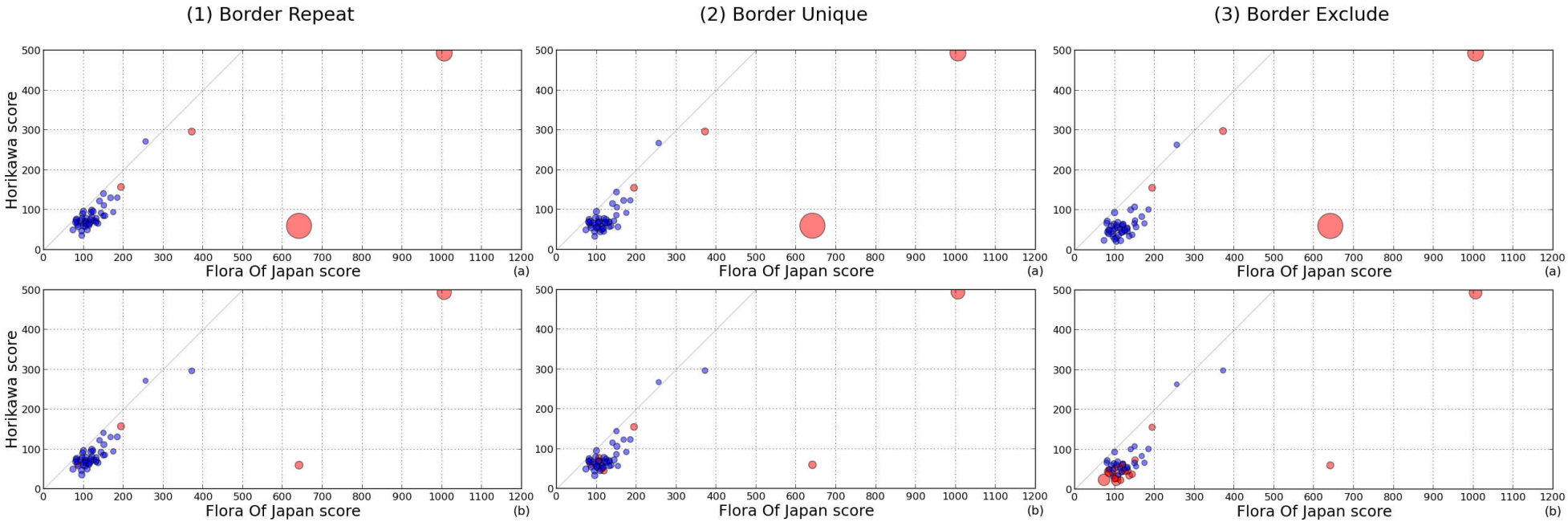


Figure 3.8 1) Border repeat; 2) Border unique; 3) Border exclude methods of holistic Horikawa GHI against FOJ scores. Data points are pr efecture-scale GHI. The size of each point is in inverse proportion to a) the number of taxa sampled for the corresponding FOJ prefecture against the total species pool in FOJ and b) the number of taxa sampled for corresponding Horikawa prefectures against the total species pool in Horikawa maps. The bigger the point, the smaller proport ion of species pool is recorded. Data points in red are the smallest samples in terms of the number of taxa recorded: a) < 1500 (31% of total) for FOJ and b) < 270 (33% of total) for Horikawa dot maps. 1:1 ratio line of both score types is drawn for reference.

3.6.1.2 Comparison of GHI between FOJ and agglomerated Horikawa dot maps

When differences in absolute GHI were compared, all nine cases of agglomerated Horikawa prefectures were significantly lower than FOJ prefectures with median GHI of 114.55 (Wilcoxon's signed rank test was all significantly different between the two data sets (Table 3.2). The FOJ data set lacks monocots and so for these families there was insufficient data to determine species occurrences across prefectures. A total of 47 species of monocots assigned with Stars were recorded in Horikawa, accounting for 5.7% of 821 species analysed. Monocots tend to be more widespread than average (Chapter 2), thus by omitting them, FOJ was expected to score a slightly higher than true GHI, and therefore also higher than GHI calculated from Horikawa data, assuming the latter is a random subset of all species.

FOJ-derived GHI's are generally slightly higher than agglomerated GHIs for the same prefectures, but in terms of ranking of GHI values, the two assessments correlated well, with some variation in the level of association depending on agglomeration techniques (Table 3.2). The 'Border Repeat' holistic GHI agglomeration technique produced the highest association with FOJ GHI in terms of relative ranking (Figure 3.9; Table 3.2). Horikawa prefecture GHI calculated by the Border Repeat agglomeration method showed higher correlation with FOJ GHI than the other two border treatments across all three calculation methods. GHI using holistic calculation method was most highly correlated to the ranked FOJ scores of the three calculation methods in all border treatments.

Table 3.2 Summary statistics of comparison between Horikawa and FOJ prefecture† scale GHIs. Horikawa prefecture GHI calculated by different border treatments and GHI calculation methods were compared with FOJ prefecture GHI. Border treatment: i) Border repeat; ii) Border unique; iii) Border exclude. Calculation methods: a) Holistic, b) Average, c) Maximum. Data points corresponding to Figure 3.9 are also shown. s.d.; standard deviation. Kendall tau rank correlation coefficient (* $P < 0.0001$, ** $P < 0.01$, * $P < 0.05$, n.s.; not significant). All Wilcoxon's signed rank test were significantly different with $P < 0.0001$.**

Agglomeration technique		Median GHI of agglomerated cells	Mean GHI ±s.d. of agglomerated cells	Kendall tau rank correlation coefficient (τ)
i)	a) Holistic GHI ●	74.59	88.77 ±48.05	0.508***
	b) Average GHI ♦	42.85	46.30 ±30.93	0.308**
	c) Maximum GHI ▲	87.90	101.65 ±48.12	0.392**
ii)	a) Holistic GHI ●	68.47	81.50 ±49.28	0.367**
	b) Average GHI ♦	39.19	43.80 ±31.74	0.241*
	c) Maximum GHI ▲	80.88	94.68 ±48.37	0.326**
iii)	a) Holistic GHI ●	54.69	67.63 ±52.43	0.345**
	b) Average GHI ♦	34.63	39.63 ±25.84	$0.165^{n.s.}$
	c) Maximum GHI ▲	67.64	77.06 ±51.44	0.271**

†FOJ–prefecture GHIs had a median score of 114.55 and a mean score of 136.75 (standard deviation 89.42).

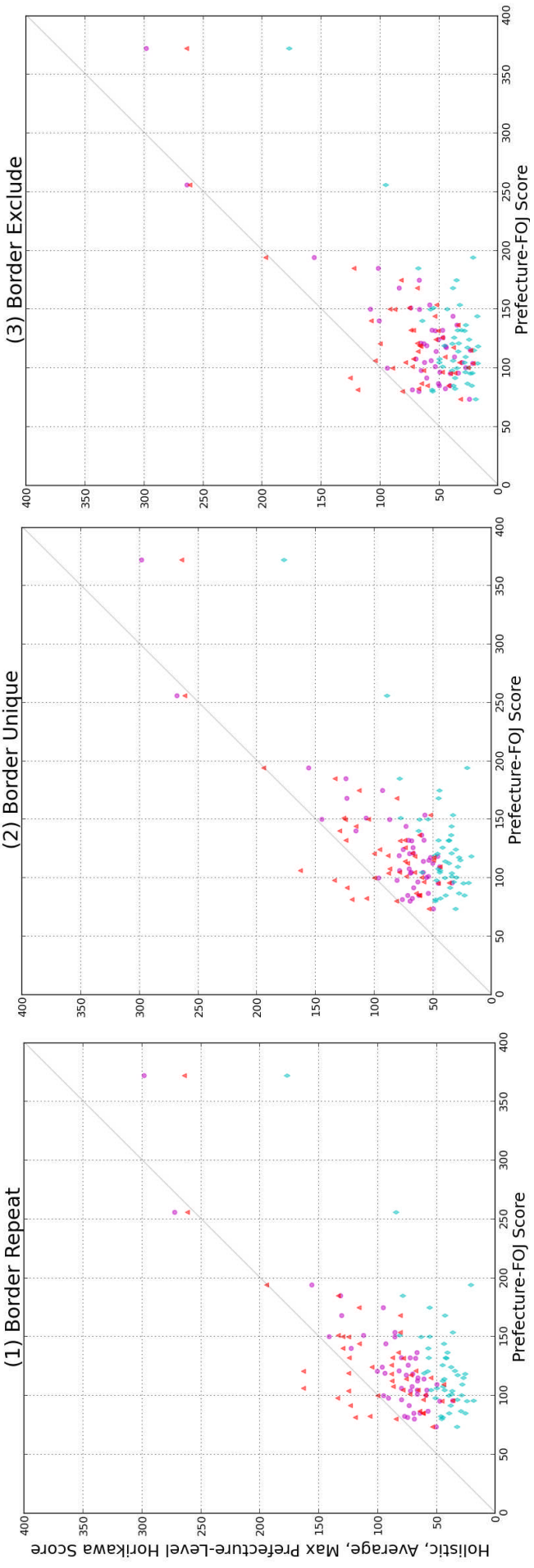


Figure 3.9 1) Border repeat, 2) border unique and 3) border exclude methods, comparing FOJ scores and holistic (●), average (◆) and maximum (▲) Horikawa prefecture scores. Data points represent prefecture GHI. 1:1 ratio line of GHI between two data types is drawn for reference.

3.6.2 Testing agglomeration techniques

3.6.2.1 The effect of border treatment on agglomerated GHI

GHI was highly correlated between any pair of border treatments irrespective of its method of calculation (Figure 3.10). Compared to Border Repeat, Border Unique treatment underestimates GHI on average by 7.72 over the three calculation methods and Border Exclude similarly decreased by 17.21. Border Exclude also underestimated GHI by 12.70 on average against Border Unique. This suggests that both Border Unique and Border Exclude treatments tend to lose species that contribute to GHI.

It should be noted that Border Exclude method omitted 26.5% (376 out of 1,385 geoquadrats with more than one record) of geoquadrats. This has reduced species representation by losing 25 species from the Border Exclude data set. Omitted geoquadrats collectively contained 17 Black, 4 Gold, 0 Blue and 4 Green Star species not represented in any of agglomerated geoquadrats by this method. Tokyo as a prefecture was also lost by this border treatment. The Border Exclude treatment has a consistently smaller species pool than the other two, reduced on average by 71.37 or 49.07 taxa in holistic GHI compared to Border Repeat and Border Unique, respectively.

Given that Border Exclude generates the lowest GHI of all treatments, geoquadrats on the prefectural boundaries were predicted to contain a disproportionately high proportion of rare species compared to non-intersecting geoquadrats. This pattern is suggested to relate to the delineation of prefectural boundaries on mountain peaks. High altitude mountains were predicted to be bioquality hotspots by Horikawa dot maps (Figure 3.7), and prefectures containing those mountains were also high in GHI (Figure 3.6). Hence, Border Repeat, which maximums the species occurrence data on either side of intersecting prefectures, is likely to produce higher GHI than other border treatments.

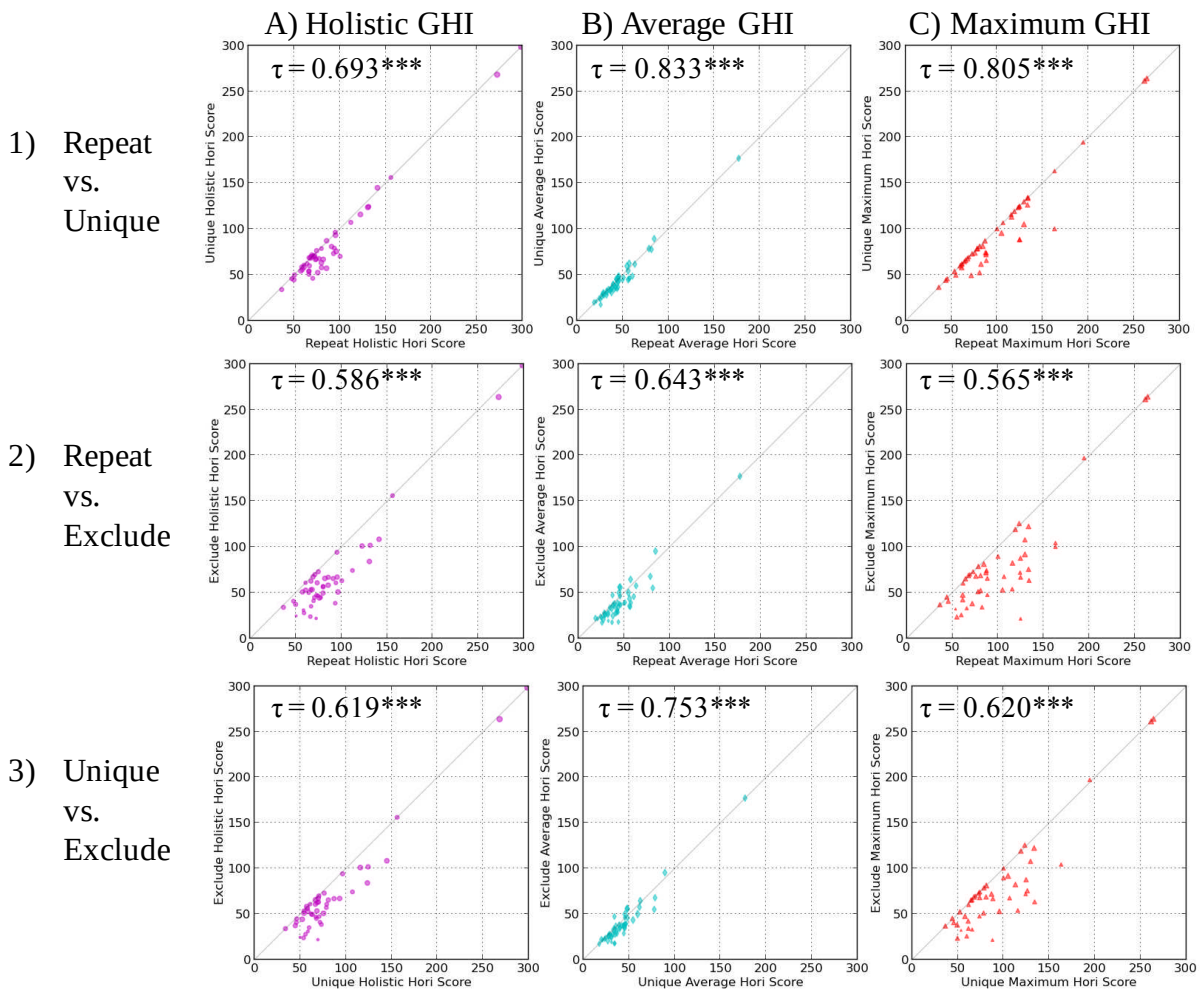


Figure 3.10 Comparison of border treatments (rows) between: 1) repeat and unique; 2) repeat and exclude; 3) unique and exclude. The same GHI calculation method was compared on each column: A) holistic (●); B) average (♦); C) maximum (▲). Horikawa GHI is abbreviated as Hori score. Data points represent selected botanical prefectures. The size of data point is proportion of species pool of *y*-axis data relative to that of *x*-axis data. τ; Kendall tau rank correlation coefficient (****P* < 0.0001). 1:1 ratio line of GHI between two data types is drawn for reference.**

3.6.2.2 The effect of GHI calculation method on agglomerated GHI

Both average and maximum Horikawa GHIs were highly correlated with holistic GHI for all border treatments in terms of rank order of GHI (Figure 3.11). Average Horikawa GHI for prefectures was consistently lower than holistic GHI for the same prefectures across all border treatments, with an overall mean difference of 36.47. This is because widespread species are found more frequently in geoquadrats per prefecture on average compared to high-scoring rare species. Low-scoring species which are widespread in the prefecture, i.e. Blue or Green Star taxa, are in effect being counted more than once by the average calculation method. For the holistic GHI with a unique species list, there is no such weighted species abundance that affects the relative contribution of component species to the community score.

Maximum GHI deviated from holistic GHI by −50 to +85, irrespective of border treatments (Figure 3.11). Difference between maximum GHI and holistic GHI was 11.84 on average for all border treatments. Holistic GHI includes all widespread species recorded inside the prefecture, thus lowering the overall score while maximum GHI picks up the highest geoquadrat GHI within the same area. If a geoquadrat aligns well with a portion of the prefecture area with a high concentration of rare species, and the prefecture as a whole otherwise has many widespread species concentrated in other quadrats, the prefecture Maximum GHI is expected to exceed the prefecture holistic score. The other scenario is that ecologically different rare species may be scattered across the prefecture, for example with a few rare species in one mountain top and a few different ones along a coast line. In such cases, the holistic GHI will absorb all the rare species within the area, raising the overall GHI even though individual geoquadrats have relatively low scores because of the relatively small proportion of rare species per geoquadrat. Maximum GHI could therefore become lower than holistic ones.

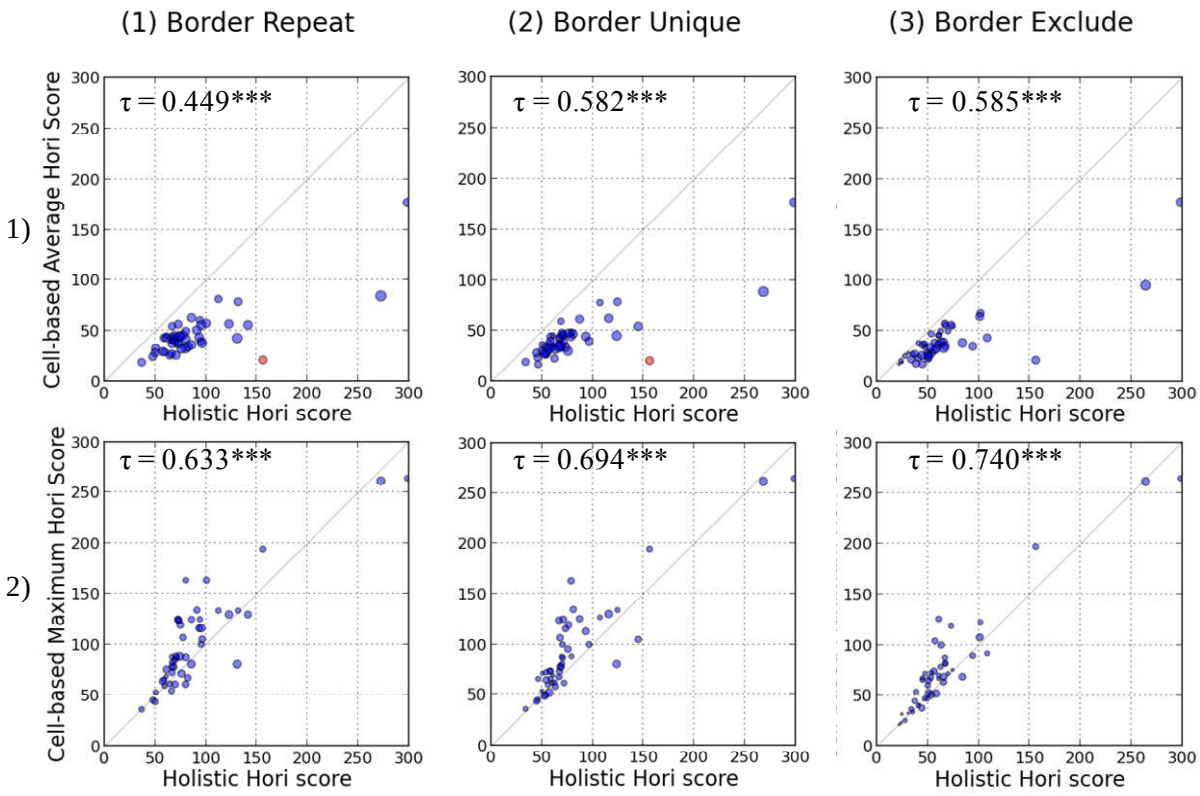


Figure 3.11 Comparison of GHI calculation methods between: 1) holistic and average; 2) holistic and maximum. The same border treatment is used on each column: 1) repeat, 2) unique and 3) exclude. Horikawa GHI is abbreviated as Hori score. Each data point represents selected botanical prefectures. The size of each data point is the difference in the number of taxa sampled between holistic data (*x*-axis) and *y*-axis data. Prefectures either in average or maximum calculation method with less than 25% of mean species pool of holistic GHI are highlighted in red. τ; Kendall tau rank correlation coefficient (****P* < 0.0001). 1: 1 ratio of GHI between two data types is drawn for reference.**

3.7 Improved bioquality hotspot map of Japan

3.7.1 Fine-tuning data-deficient areas

Three options were proposed to estimate GHI for 265 geoquadrats with fewer than 40 Star-rated species (Box 3.3).

Box 3.3 Protocol to estimate GHI on sample plots with fewer than 40 species (data deficient areas)

Three options for estimating GHI on data-deficient areas and the example cases to which options were applied (Figure 3.12):

1. **Neighbourhood GHI**

   Inspect species composition and geography – mainly topography and land types – around the neighbouring samples, and adopt the score or colouring most similar to the data-deficient sample plots.

   Case 1: Sporadically scattered along the coast or on plains, mostly in mainland Japan

2. **Agglomerated island GHI**

   Adopt an agglomerated GHI for small areas which, when merged to one, can be geographicly and ecologically distinguished as a single unit, e.g. for single small islands. This option may be preferred in areas where the majority of neighbouring samples have insufficient species to apply option 1.

   Case 2: Ogasawara Islands

3. **Neighbour-joint mainland GHI**

   Merge neighbouring samples into larger units if samples with insufficient species pool collectively cover a large and geographically homogenous area in mainland Japan. Using the suggested agglomeration technique, calculate GHI for these larger units.

   Case 3: Hokkaido

4. **No score given**

   Where individual plots or groups of plots were geographically isolated, such as small oceanic island, and thus have no comparable GHI in the vicinity, no estimate may be taken due to high uncertainty.

   Case 4: Izu Islands, Kazan Islands, Minami Daito-jima island, Senkaku Islands, Iwotori-shima island

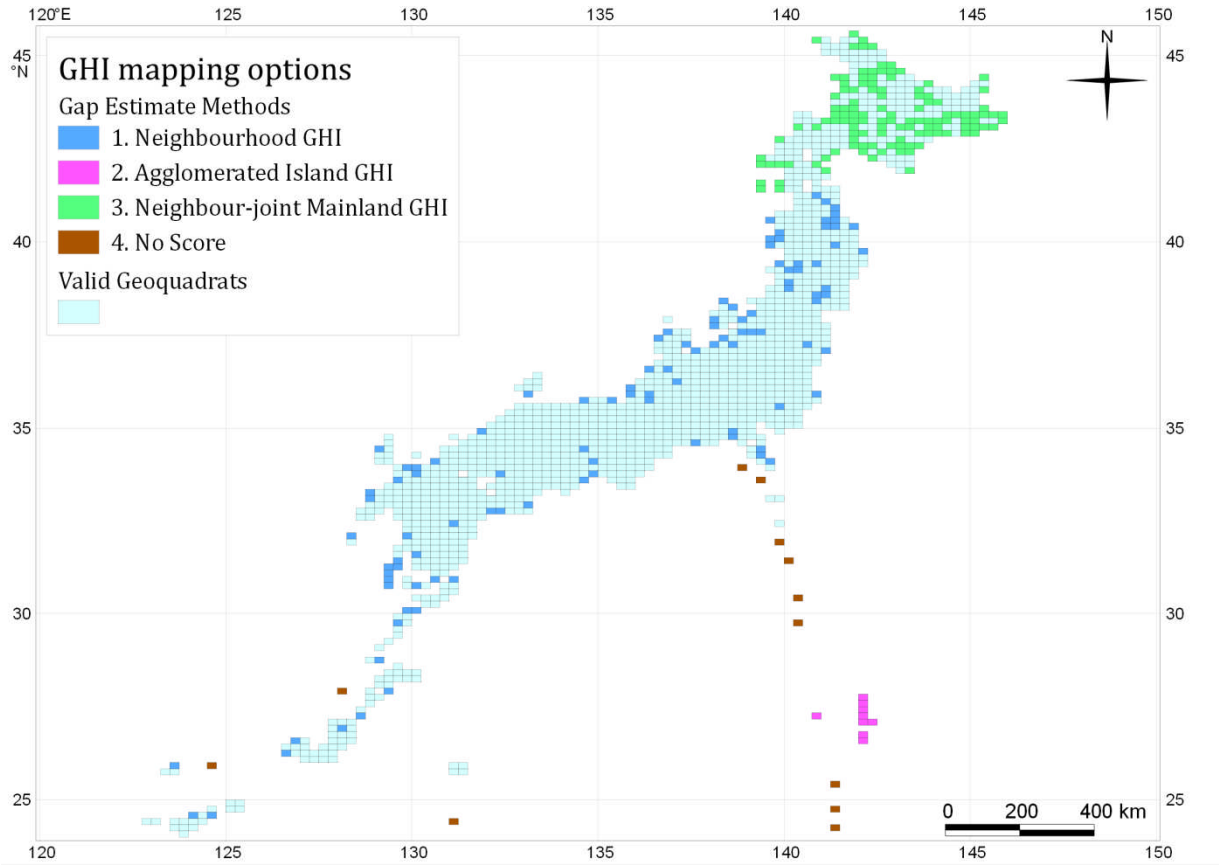


Figure 3.12 Horikawa geoquadrats with fewer than 40 species (filled squares) highlighted by different estimate mapping options. GHI for data-deficient geoquadrats is estimated by: 1) neighbourhood GHI, 2) agglomerated island GHI, 3) neighbour joint mainland GHI, and 4) no score given. Valid geoquadrats refer to geoquadrats with 40 or more species for which GHI was calculated using the standard protocol.

Option 1 (neighbourhood GHI) was applied to 105 geoquadrats, mainly along the coastline of mainland Japan. Individual inspection of these geoquadrats by overlaying topography maps and comparing neighbouring areas, plus consideration of the few species that were recorded in the species-poor geoquadrats, suggested no reasons to assume the GHIs would be different from that prevailing in geoquadrats nearby (Figure 3.13).

Nine quadrats in the Ogasawara Islands were assigned an agglomerated GHI of 494 using option 2. This was lower than FOJ–prefecture GHI of 1005. GHIs calculated for two major island groups of Ogasawara (Chichi-jima Islands, 773; Haha-jima Islands, 798) using checklists and survey data (Shimizu, 1994, Tanimoto *et al.*, 1995), were also higher than the agglomerated Horikawa score. Despite these variations, all data demonstrated that the Ogasawara group potentially contains extremely high GHI. Further botanical surveys are necessary to produce GHI at a site level to validate these

scores. The adoption of agglomerated GHI was considered to be sufficient to provide an overview across Japan, though these estimated cells are marked as such in the resulting map (Figure 3.15).

Approximately 40% of geoquadrats in Hokkaido (119 of 294) had fewer than 40 taxa recorded, and these geoquadrats were estimated using option 3. Six neighbouring Geoquadrats (in a 3 × 2 lattice arrangement) were merged to a **quarter degree grid** (30′ latitude by 30′ longitude grid cell), and an agglomerated GHI was calculated for this larger-resolution grid (Figure 3.14). Hokkaido as a whole contained a total of 253 taxa with 10 Black, 8 Gold, 17 Blue and 218 Green Stars. The majority of rare taxa were found sporadically across Hokkaido, resulting in the higher agglomerated score of 158 compared to the average of 21 for geoquadrats within the prefecture. For 69 quarter degree grid cells, mean Star-rated species count per grid cell increased to 94 with only 9 such cells still with fewer than 40 taxa, all of which were along the coastline with few neighbouring geoquadrats to join. The average GHI of quarter-degree grid cells was 25, similar to that of geoquadrats, supporting the idea that a large part of Hokkaido has homogenously low GHI. Two mountain ranges – Yubari and Daisetsu, on the east of Yubari – showed the highest GHI of 99 and 75 respectively at quarter degree grid resolution.

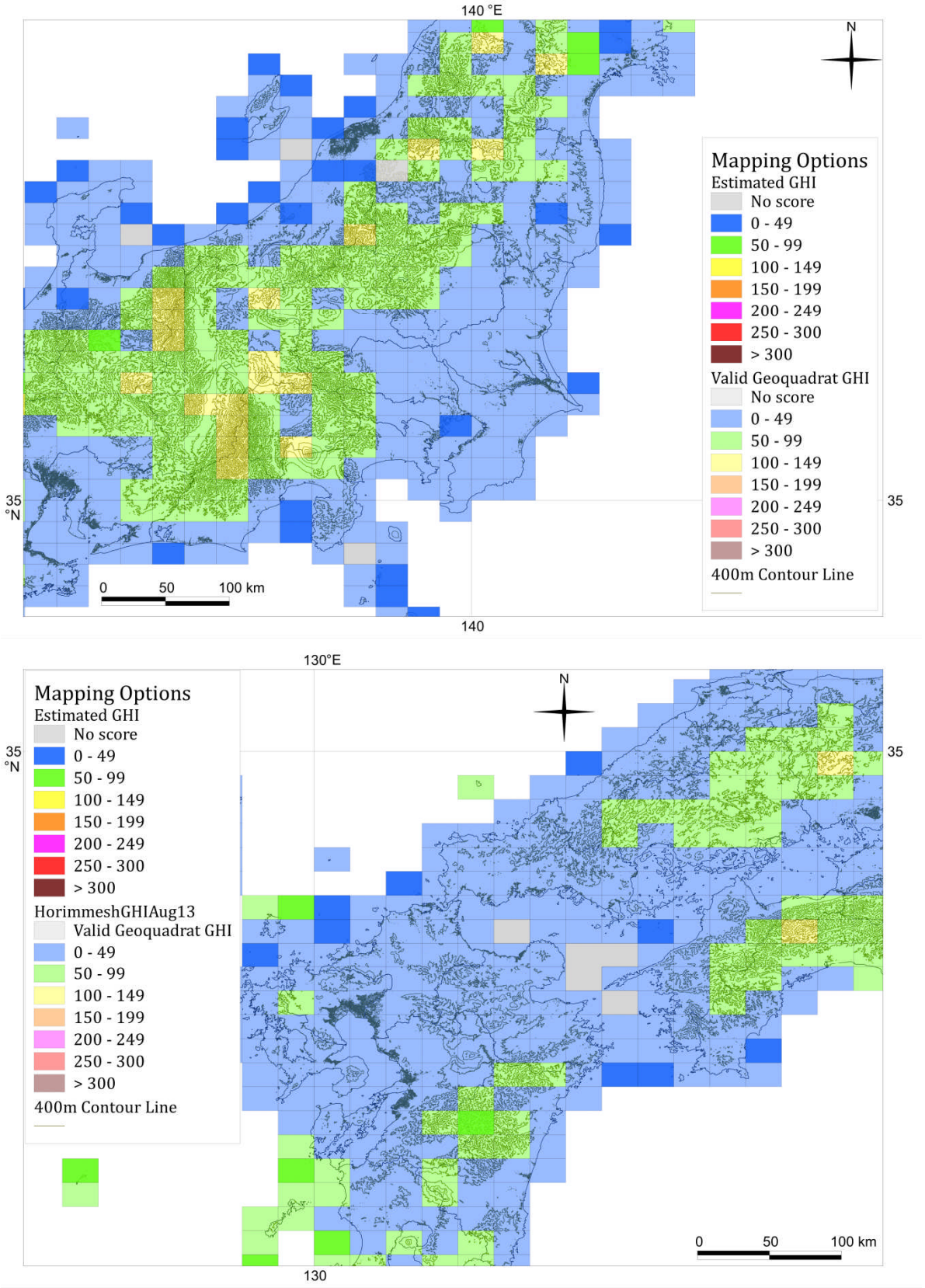


Figure 3.13 Estimated GHI using option 1 (neighvbourhood GHI) on topography map for Central Honshu (top) and Kyushu (bottom). 'Valid geoquadrat' refers to a geoquadrat with 40 or more Star-rated species for which actual geoquadrat GHI is shown in pale colours.

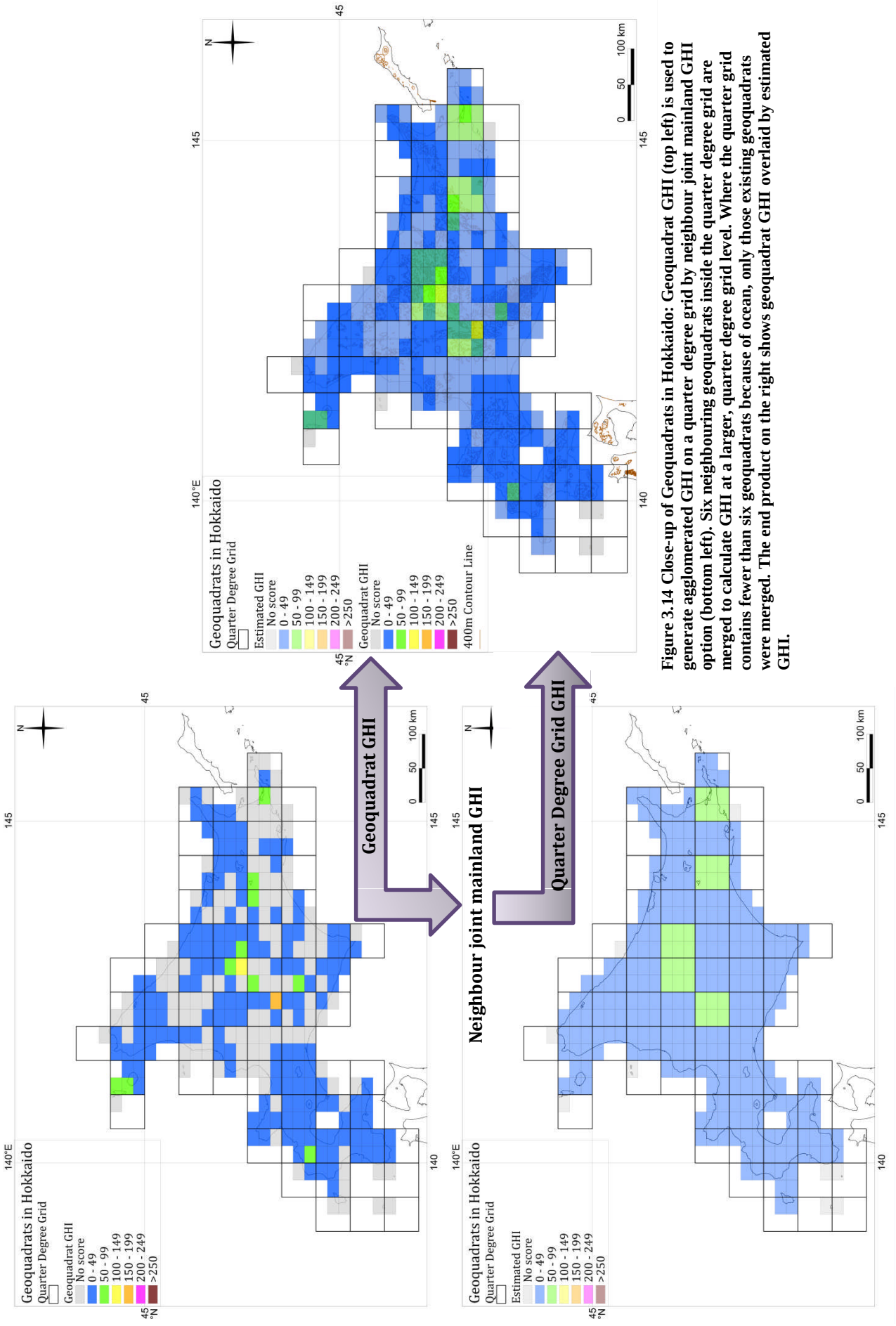


Figure 3.14 Close-up of Geoquadrats in Hokkaido: Geoquadrat GHI (top left) is used to generate agglomerated GHI on a quarter degree grid by neighbour joint mainland GHI option (bottom left). Six neighbouring geoquadrats inside the quarter degree grid are merged to calculate GHI at a larger, quarter degree grid level. Where the quarter grid contains fewer than six geoquadrats because of ocean, only those existing geoquadrats were merged. The end product on the right shows geoquadrat GHI overlaid by estimated GHI.

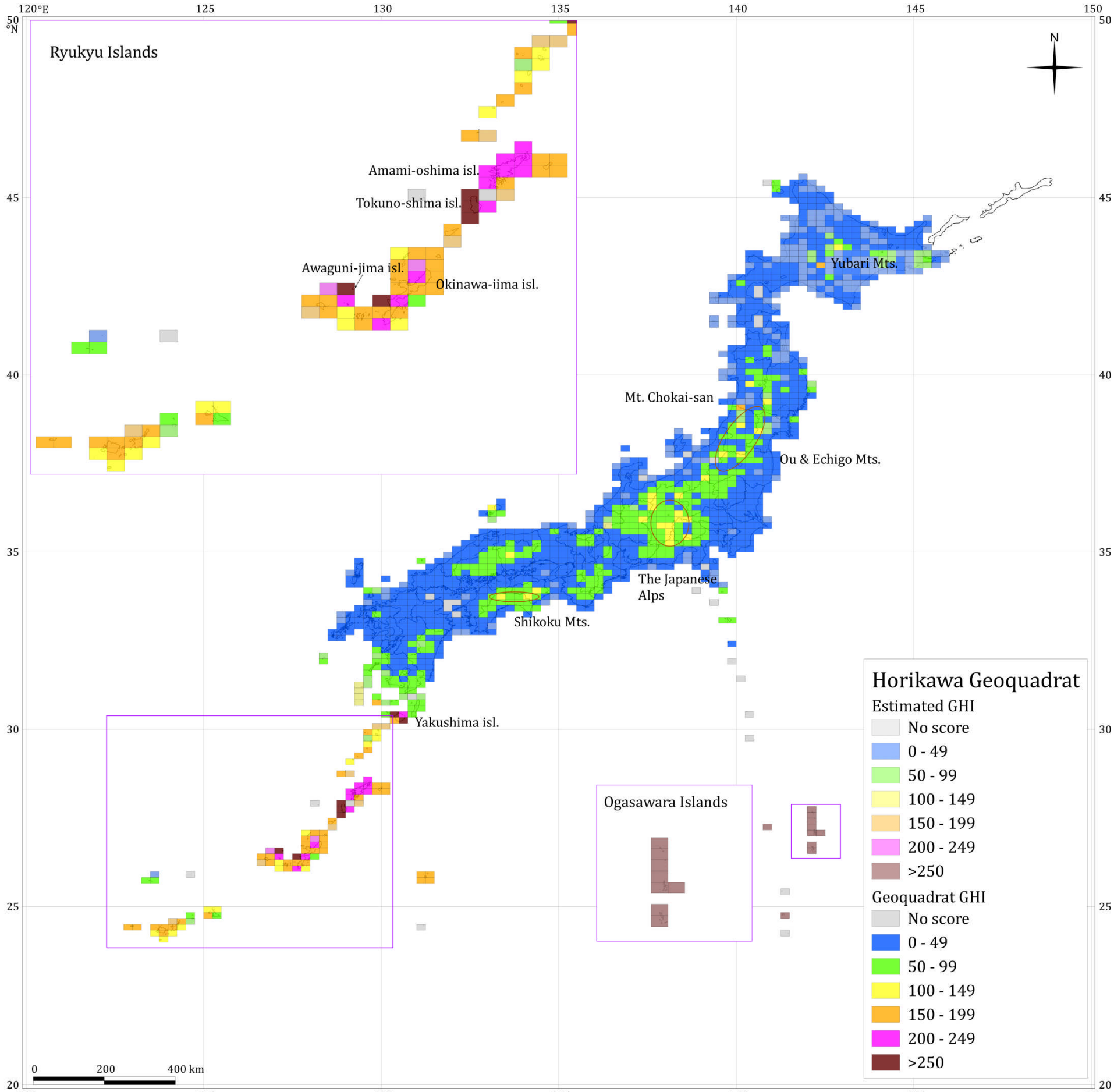


Figure 3.15 Horikawa geoquadrat GHI (Horikawa GHI) superimposed on inferred GHI (Estimated GHI) using three options suggested. Inferred GHI was generated by any of the following options: 1) neighbourhood GHI; 2) agglomerated island GHI; 3) neighbour joint mainland GHI. 12 geoquadrats on isolated islands and areas with extremely few species records even in the surroundings remained without GHI (option 4: no score given).

3.8 DISCUSSION

3.8.1 Spatial patterns of bioquality hotspots in Japan

Bioquality hotspots are generally concordant between maps based on prefectural FOJ data and those based on Horikawa geoquadrats (Figure 3.6; Figure 3.7). Two main findings from these coarse resolution maps are that the Ryukyu and Ogasawara island groups are island hotspots, and that the high mountain ranges of mainland Japan are also likely to be rich in globally rare species. This outcome supports previous findings by other studies at local (Aramoto et al., 2005, Shimizu, 2003) and national levels (Kato and Ebihara, 2011). The national-scale analysis by Kato and Ebihara (2011), however, only focuses on endemic species richness.

This study is the first to investigate the 'genetic heat' of hotspots in a quantitative way, using a four-level categorisation of global rarity for species (the Star system), and by summarising species rarity to a community score (GHI). It should also be highlighted that similar spatial patterns of bioquality hotspots were observed by two independent data sources despite differences in species pool and resolution of the sample unit. This is a significant finding demonstrating the predictive power to locate bioquality hotspots.

3.8.2 Island hotspots

The Ryukyu Islands and the Ogasawara Islands were picked out as bioquality hotspots – areas with high GHI – using both the data sets examined. Both of the island groups are subtropical but the ecological and geographical factors affecting the high proportion of rare taxa are different between the two island groups.

The volcanic Ogasawara Islands have never been connected to continents (Ito, 1998). The total number of native plant taxa of the island group is relatively low at 400 – a third that of the Ryukyu Islands – yet approximately 40% of taxa are believed to be endemic to the area (Shimizu, 2003). The total land area of the islands is approximately 66.56 km2 (Geospatial Information Authority of Japan (GSI), 2011d). The largest of about 20 Ogasawara Islands, Chichi-jima island, is approximately 24 km2 and has its

highest point at 498 m a.s.l (Ito, 1998). Land area as well as the diversity of habitats is considerably lower than other endemic-rich volcanic islands such as the Canary Islands (7,500 km2) or the Hawaiian archipelago (16,640 km2) (Ito, 1998, Whittaker et al., 2005). Such small land cover combined with geographical separation of the islands from the continent are expected to account for low total species richness on the Ogasawara Islands as predicted by the theory of island biogeography (MacArthur and Wilson, 1967). This explains the low number of taxa sampled in the Horikawa dot maps (fewer than 40 taxa sampled, Figure 3.7) while FOJ data yielded a high GHI score of 1005 based on 262 taxa. 32.4% of these taxa in FOJ data are believed to be endemic to the islands, which is in agreement with existing estimates (Shimizu, 2003). Some Black Star species in the Islands include Dendrocacalia crepidifolia (Asteraceae), Machilus boninensis (Lauraceae), Ficus boninsimae (Moraceeae), Calanthe hattorii (Orchidaceae), Pandanus boninensis (Pandanaceae) and Tarenna subsessilis (Rubiaceae), most of which are found in forest habitats.

By contrast, the most recent separation of the Ryukyu Islands from the Asian continent and Japan occurred during the Pleistocene, starting with the isolation of central Ryukyu and then the split of south Ryukyu from Taiwan by approximately 20,000 years ago (Hotta, 2003, Ota, 1998). A study by Nakamura et al. (2009) which investigated the distribution patterns of 1,815 plant species on 26 islands across the Ryukyu Islands suggested that similarity in species composition of individual islands was negatively correlated with the geographical distance between the islands. The results obtained in this chapter show an influence of isolation on GHI in these islands. The southernmost Yaeyama islands in the vicinity of Taiwan, and the northernmost Takeshima and Ioujima islands at the southern tip of mainland Japan, respectively, showed relatively low GHI (Figure 3.7) while many islands in central Ryukyu have high GHIs. This variation in GHI in northern, central and southern island clusters matches with the patterns of similarities in species composition across the Ryukyu Islands (Nakamura et al., 2009). It is hypothesised that the geographical isolation of the central Ryukyu Islands has contributed to the evolution of endemics to the area. Islands in the vicinity of mainland Japan or Taiwan have probably been more prone to gene flow between the larger areas, resulting in a higher abundance and proportion of widespread species in these areas (Hotta, 2003).

Following these findings, the Ryukyu Islands have been selected as one of the key study sites for detailed sampling and further investigation on the relationship between bioquality and biogeographical factors across the islands in Chapter 4.

3.8.3 Mountain hotspots

Bioquality assessment on Horikawa geoquadrat suggests that high mountain ranges in mainland Japan such as Mt. Yubari and Mt. Chokai-san are potential bioquality hotspots, albeit with lower GHI than the Ryukyu and Ogasawara island groups. Geoquadrats with slightly 'warm' GHI of 100 to 149 are found on the major mountain ranges such as the Japanese Alps, Ōu, Echigo and Shikoku mountain ranges (Figure 3.7). The high-scoring geoquadrats do align with lines of mountain ranges across mainland Japan. This pattern indicates that some localities within these areas would probably contain even hotter spots that are currently diluted possibly by lowland flora in the same geoquadrat. Given their higher GHI than completely lowland geoquadrats, these mountain ranges are suggested as focal areas for further examination on the ground.

3.8.4 Testing data quality of different data sets

A comparison of agglomerated Horikawa GHI at prefecture scale and FOJ GHI found that GHIs are correlated in terms of rank order. This is especially true if the finer-resolution Horikawa data is combined into prefecture-scale GHIs using the Border Repeat holistic agglomeration technique outlined above (Table 3.2).

Some variation in GHI values observed between the two data sources was a sampling effect due to map resolution. At coarse resolution, such as with FOJ prefecture samples, some large areas containing areas rich in rare species (such as high mountain ranges) tend to have high GHI compared to agglomerated holistic GHI from fine-resolution maps. This effect is apparent in agglomerated GHI for Hokkaido where there was a large disparity between agglomerated GHI (158) and average GHI of individual geoquadrats with 40 or more species records (20.36) (Figure 3.9). GHI at coarse resolution

should be interpreted with care, but could still be useful as a guide to select regions that would merit ground testing of GHI within them, using fine-scale sampling (discussed in Chapter 4).

When merging multiple samples to a larger area of misaligned shape, the treatment of intersecting boundaries seemed to have a limited effect on agglomerated GHI, except when borderline samples were excluded entirely from the larger summary. This 'Border Exclude' method was investigated in the belief it might be the truest or 'cleanest' of all border treatment possibilities, as it is the only protocol for which there is no chance species will be recorded for a prefecture in which they do not in fact occur. However, the Border Exclude treatment showed consistently lower GHI than the others. Nearly 30% of geoquadrat samples were dropped using this method, and the results suggest the bioquality of these cells was higher than typical for the adjacent prefectures. 21 of the 25 omitted species were rare (either Black or Gold Star species). This probably reflects the fact that Japanese prefectures are often divided on the contour of mountain ranges where rare taxa are often concentrated (Kato and Ebihara, 2011). Therefore, excluding these samples misses out important species with respect to global rarity.

There was little difference between the Border Repeat and Border Unique treatments. Although the choice between these two is therefore expected to cause limited effect on agglomerated GHI calculations, the correlation with FOJ GHIs was stronger for Border Repeat than Border Unique methods. Border Repeat measurement gives the best estimate of global rarity by agglomeration for Japanese prefecture-level GHIs.

Maximum GHI is perhaps more appropriate where one needs to highlight prefectures which include hotspot vegetation on a less detailed map, where individual geoquadrats are too small to see clearly. However, two prefectures – Kagoshima and the Ryukyu Islands – had lower maximum GHI than holistic GHI. While small hotspot islands such as Yakushima Island may have induced a great increase in the overall score for Kagoshima, different rare taxa in individual islands of Ryukyu contribute to high prefecture-scale scores.

Holistic GHI provided an optimal method for comparing the ranking of GHI with the coarser-resolution FOJ data. Maximum GHI of included geoquadrats is the best indicator to suggest focal areas for future study on the ground to pinpoint the location and examine the detailed anatomy of hotspots.

Coarse resolution FOJ sampling provides a general overview of bioquality across Japan, but is prone to blur hotspots by mixing species that are, in reality, found in distinctly different habitats. This data set also slightly exaggerates GHI due to the underrepresentation of grasses, which are generally more widespread than average for all vascular plant species. Allowing for this bias, the finer-resolution Horikawa dot map is reasonably concordant, and is likely to be more accurate as a source of distribution data for the sampled species pool. For this reason, it is chosen here as the basis of a final national hotspot map.

The analysis of spatial patterns of plant communities from a global rarity perspective at multiple resolutions by integrating different data sets is a novel approach. The effect of sample plot size on diversity estimates is widely recognised (Crawley and Harral, 2001), but much of the research interest to date has focused only on the number of species per se – e.g. Guilhaumon et al. (2008) – and has often dismissed the ecological importance of component species in the area (Brooks et al., 2006). Downscaling coarse resolution species distribution maps to finer resolution patterns has gained increasing research interest (Bombi et al., 2012, Sales-Luís et al., 2012). The major problem with down-scaling is the assumption that climatic and environmental factors affecting coarse-resolution species distributions also regulate fine-resolution patterns (Araújo et al., 2005), which is often not the case (Willis and Whittaker, 2002). Nevertheless, Araújo et al. (2005) demonstrated that spatial patterns of rarity hotspots of plant and vertebrate in Europe predicted at finer c. 10 km by 10 km grid resolution revealed more detailed patterns that were blurred in the original 50 km by 50 km resolution maps. This finding, though their definition of rarity is a regional range size measurement, is reflected in this study. Species distribution modelling is computationally demanding and the advantage of the GHI approach is that accurate distribution maps are not necessarily required in calculation. Although comparison between GHI agglomeration techniques and the modelling approach would be an interesting research

question, it must remain as a future research interest for time being. Meanwhile, the agglomeration technique developed in this study is a relatively simple and quick method to alter spatial resolution of plant community data and has demonstrated its ability to compare different data sets at various resolutions.

3.8.5 Producing high-quality bioquality maps by estimating GHI on data-deficient areas

The three options investigated for predicting GHI of samples with fewer than 40 Star-rated taxa on the geoquadrat map resulted in a smooth presentation of bioquality patterns without obstructing important hotspot areas (Figure 3.15). Of course, these estimates are more speculative scores than others, and so are distinguished as such on the map. Application of three options for this purpose was also practical – it only involved a few days fine-turning work to fill in all the gaps nationally. A recommendation to improve this procedure would be to combine the proposed options with analytical tools such as ordination analyses to suggest the floristic affinities of species-poor geoquadrats using similarities in species composition between samples. For the purpose of presenting rough spatial patterns of bioquality hotspots, exercises performed here (Figure 3.13; Figure 3.14) seemed a satisfactory first approximation. Closer examinations of similarities in species composition within the national context would be useful in the future to investigate environmental or ecological factors related to the observed bioquality patterns.

3.8.6 Conclusions

This work has for the first time applied a bioquality approach to reveal spatial patterns of hotspots in Japan. The subtropical island groups of Ryukyu and Ogasawara are the hottest bioquality hotspots at national level. In mainland Japan, mountain ranges scored high GHI relative to lowland areas. These findings with further ground testing in the field can provide a strong scientific basis for national-level conservation planning. The bioquality can also be related to that of other global hotspots; the work has demonstrated Japan's hottest hotspots are equivalent to other hotspots (GHI over 300) around the world,

such as on the mountain peaks of Trinidad and Tobago (Baksh‐Comeau et al., in press.) and the lowland wet evergreen forests of West Africa (Hawthorne, 1996).

Examining spatial patterns of hotspots at multiple resolutions would be of particular use for local management practices. Methodologies used in some existing studies to identify important areas within acknowledged hotspots are region-specific (e.g. Médail and Quezél (1999), Zhang and Ma (2008)). Yet such fine level analysis of hotspots is crucial in providing information necessary for implementing conservation practice on the ground. The key highlight of bioquality assessment is that the evaluation is focused on global rarity and that the methodology is standardised so that it can be applied and compared across the world. The scalability of the bioquality approach, as examined in this study using two different data sets measured at varying resolutions, is also a big advantage that enables priority setting to be scaled from global to local levels and vice versa.

In the following chapter, this scalability of the bioquality approach is applied to ground survey data, using case studies in two contrasting parts of Japan's landscape. Bioquality assessment based on field survey data is the most practical resolution from conservation management perspectives and it is where bioquality was originally developed and has the maximum potential for application. By contrast, global and national-level analyses are useful starting points for priority-setting at a coarse resolution. This chapter on the national examination of spatial patterns of bioquality hotspots using two data sets has demonstrated that plant community evaluation using the Genetic Heat Index revealed important insights on which areas to target for further evaluation of potential conservation priorities.

4 Case studies in the field: GHI assessment of selected landscapes

4.1 INTRODUCTION

4.1.1 High-resolution examination of bioquality hotspots

Understanding the significance of individual sites under conservation management is one of the key interests for decision making by policy makers and conservation practitioners. There is a mismatch between global priorities set by existing conservation organisations, such as Conservation International (CI) or the World Wildlife Fund (WWF), and the local management-level agenda (Dinerstein et al., 2007, Rodrigues, 2007). Global and national priority-mapping is useful for visualising important areas of concern and their spatial patterns at a glance, and to help prioritise global or national resource allocation on conservation activities. However, the problem is that these large areas are generally not the level at which conservation takes place in practice. Protected areas and other conservation actions are implemented at a local scale which is often as small as a few hectares up to a few hundred square kilometres. Decision-making on management practices may depend on socioeconomic factors as well as on the biological importance of the area. It is crucial for scientists to provide tools and evidence that are transferable between global and local scales in order to help priority setting at a management level.

The purpose of this chapter is to investigate and illustrate how the bioquality approach can be used to evaluate conservation values at a local site level in the national context. Firstly, priority areas under the current national conservation policy should be re-assessed locally to incorporate the GHI – and therefore global rarity – as one of the key indexes of biodiversity value. Secondly, areas with a high concentration of rare species in a coarse-resolution analysis of the prefectural Flora of Japan database and Horikawa geoquadrats should also be investigated at a local level. It is expected that fine-resolution analyses using survey data will reveal detailed spatial patterns of high-ranking plant communities which deserve greater attention for conservation. The question here is whether or not the bioquality hotspots suggested at a national level indeed contain fine-scale hotspots.

Three case study areas selected for landscape-level analysis of hotspots are;

1) The *satochi*-satoyama, priority landscape proposed by the Japanese national conservation policy;

2) The Ryukyu Islands, one of the hotspots inferred by the Flora of Japan database analysis;

3) The Utaki sacred groves of the Ryukyu Islands, one of the inferred hotspots and areas of special interest which has been surveyed in the past.

4.1.2 The *satochi-satoyama* landscape in the National Biodiversity Strategy

Japan's National Biodiversity Strategy (Ministry of the Environment of Japan, 2007), a core government policy statement for biodiversity conservation, identified three key themes of particular concern: 1) species loss and habitat degradation due to development pressure; 2) neglect of management in traditional rural landscape called the satochi-satoyama; and 3) spread of invasive species (Ministry of the Environment of Japan, 2007).





Figure 4.1 Typical view of the *satochi-satoyama* landscape (top on previous page; in Yasato town, Ibaraki; 2009 survey site) and of forest patch (bottom; in Kagesawa, Shimodate town, Ibaraki; 2009 survey site).

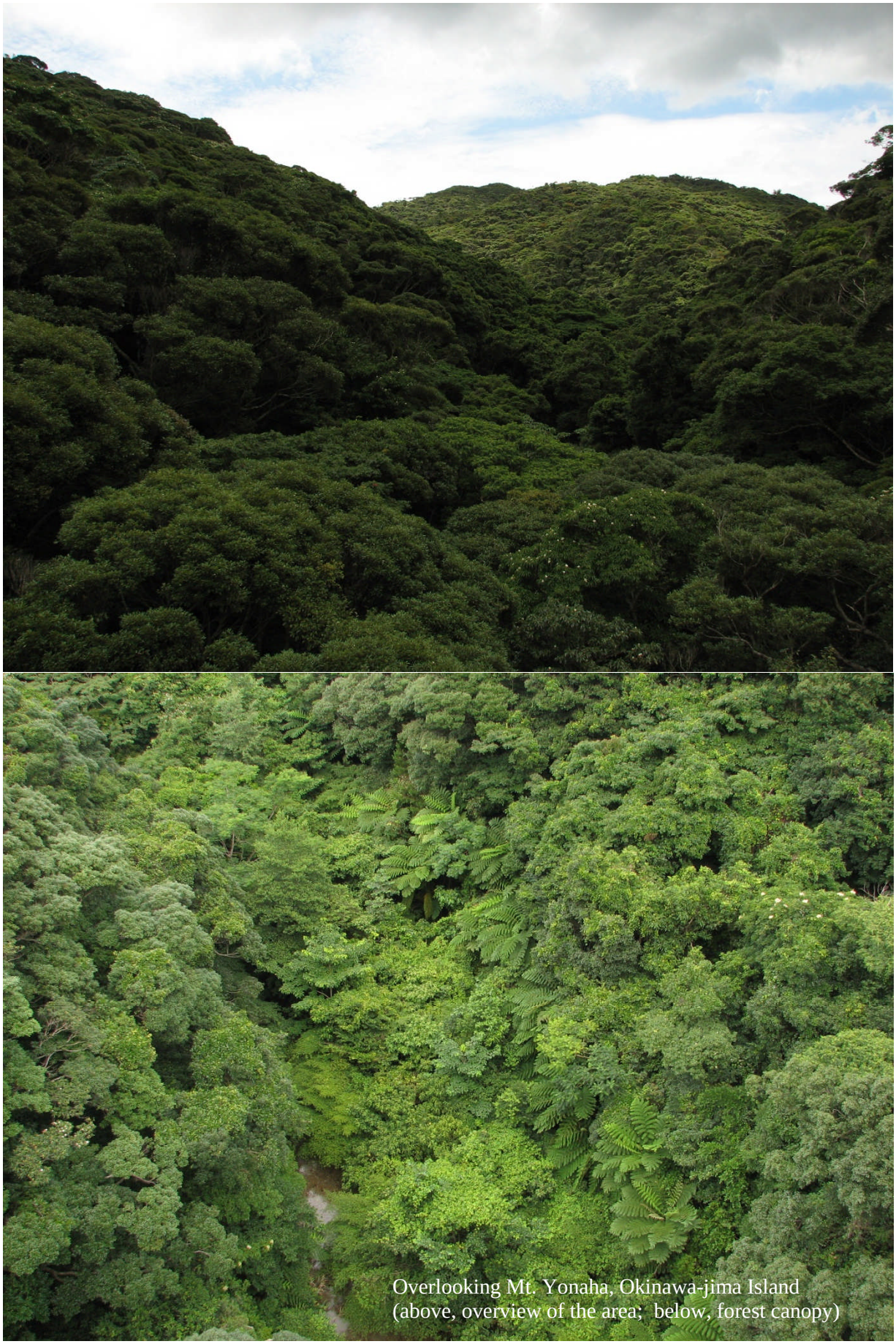
The *satochi-satoyama* is a landscape mosaic (Figure 4.1) comprised of patches of rice paddies, coppice forest, grassland, cropland and human settlement (Grossman, 2004, Takeuchi *et al.*, 2003, Yamamoto, 2001). *Satochi* means 'village' (*sato*) and 'land' (*chi*) and its more commonly used synonymous word *satoyama* means 'village' (*sato*) and 'mountain' (*yama*). It refers to a village community in which livelihoods are in close association with wildlife (Grossman, 2004, Ministry of the Environment of Japan, 1995). The government defines this landscape as an area with a population density of 50–300 people per km^2 and with forest cover of less than 80% (Ministry of the Environment of Japan, 1995). Based on this definition, this traditional rural landscape covers 45% of total land (or 50% of secondary forests and 55% of the total agricultural area) in Japan (Ministry of the Environment of Japan, 1995, 2006).

The Japanese government launched 'the s*atoyama* initiative' together with 51 other institutions (both governmental and non-governmental) at the Conference of Parties to the Convention on the Biological Diversity (CBD) in 2010 to promote this notion of conservation of rural agricultural landscapes to the world (Ministry of the Environment of Japan and United Nations University, 2011). There is, however, much more attention to social aspects than to biodiversity conservation *per se*. Maintenance of 'diverse ecosystem services and values' (Ministry of the Environment of Japan and United Nations University, 2011) is highlighted as one of the key objectives, yet examination of conditions and changes in ecological properties of the landscape in response to economic and demographic shifts in these areas is limited in the framework (United Nations University, 2012).

The scientific justification for the prioritisation of this landscape in the Japanese context is weak and requires re-evaluation, particularly in relation to biodiversity value including plant global rarity, i.e. bioquality. Many studies showed a unique species composition within plants, birds and invertebrates in the satochi-satoyama landscape (Katoh et al., 2009, Kitahara, 2004). Some of these species are red-listed at the national level (Ichinose and Katoh, 1999, Inoue, 2001, Kusumoto et al., 2006, Leksono et al., 2006, Mukai et al., 2005, Ohwaki et al., 2008, Takeda et al., 2006, Yamaura and Katoh, 2007). A study overlaying a vegetation map with species occurrence maps based on 10 km2 grid cells revealed that 49% and 55% of satochi-satoyama grid cells have more than five species of nationally defined Red Data listed animal and plants, respectively (Ministry of the Environment of Japan, 2008, Ueda, 2002). However this is a crude estimate, with no reference to the number of other species in the sample areas or the habitat features of the area concerned, beyond its dominant vegetation type being secondary forest. There has been an increasing public interest in conservation of this traditional landscape (Kotera, 2008), yet the importance of the landscape, particularly of the forests in relation to the presence of globally rare species has not been explicitly studied (Katoh *et al.*, 2009, Takahashi, 2009). Its significance in relation to Japan's hotspot status has not been scientifically explored.

4.1.3 Conservation planning in the Ryukyu Islands: the inferred bioquality hotspot

The conservation status of vegetation in the Ryukyu Islands is currently poor, apart from a few designated conservation areas. The WWF highlighted the area as 'Nansei-shoto archipelago forest' in its Global 200 ecoregions. Coarse-resolution bioquality maps suggested high GHI for the island flora as a whole (Chapter 3), yet it was only in October 2010, when the Japanese government revised the plan for national parks, that forest vegetation in the Ryukyu Islands became finally listed as a new priority area for future examination (Ministry of the Environment of Japan, 2010c). This outcome was based on national-scale analysis of spatial patterns of endemic species richness (Kato and Ebihara, 2011), natural vegetation, areas with high extinction risk of threatened species, and areas containing habitat specialist species (Ministry of the Environment of Japan, 2010c). This gap analysis provided a good overview of the areas that are both currently under-protected and high-ranking in terms of the conservation factors examined. However, it lacks a detailed description of what important species or vegetation is found at the level of individual management units and where they are found. Designation of conservation areas within the area is still in progress with little information given to the public since the initial announcement. Further investigation of important conservation attributes, such as global rarity using ground survey data of vegetation, is crucial for fine-level designing of protected areas.



Overlooking Mt. Yonaha, Okinawa-jima Island
(above, overview of the area; below, forest canopy)



Figure 4.2 Views of the northern part of Okinawa-jima Island, the Ryukyu Islands overlooking Mt. Yonaha (two photographs on the previous page); and typical forest vegetation in Mt. Nago (top of this page) and at the summit of Mt. Katsuu (with Koji Miyagi) (bottom of this page).

4.1.4 Ecological importance of sacred groves: the *Utaki* sites of the Ryukyu Islands

Natural sacred groves – patches of land protected by local traditions for worship or as burial sites – have been pointed out as potentially important conservation sites (Bhagwat and Rutte, 2006). These areas often provide habitats for locally rare species owing to long-term protection by local communities, often involving restriction of access and direct management or exploitation of resources (Bhagwat and Rutte, 2006). Such local tradition still persists today in many areas including the *Utaki* sacred groves in the Ryukyu Islands and Shinto shrines in mainland Japan (Fukada, 2008, Ishii *et al.*, 2010, Okinawa prefectural board of education, 1978). The cultural and biological significance of Shinto shrines has been studied in mainland Japan (Ishii *et al.*, 2010), and shrine vegetation has been used as reference conditions for forest restoration (Miyawaki, 2004).



Figure 4.3 An Utaki sacred grove, Mt. Nago in Okinawa-jima Island, the Ryukyu Islands.

The *Utaki* sacred groves are scattered across almost all of the Ryukyu Islands (Okinawa prefectural board of education, 1978). These are burial sites for families and serve as a place for the veneration of

indigenous gods and ancestors. Local communities have historically protected and maintained the *Utaki* sacred groves in the Ryukyu Islands. There is, however, no English-language literature on ecological studies on the *Utaki* sacred groves to date. Even in Japan, research on these sacred groves from conservation perspectives has rarely been conducted, partly due to strict restriction on access to the area (Kokubugata, G., personal communication). Investigation of the significance of these sacred groves for biodiversity conservation will be valuable to both the wider scientific communities and the general public. The results should ensure future protection of the forest patches.

4.2 RESEARCH QUESTIONS

In this chapter, the significance of Japanese bioquality hotspots is investigated at a local level using Rapid Botanic Survey (RBS) and existing literature in two main test regions: the *satochi-satoyama* landscape in east Kanto district, and the Ryukyu Islands.

1) What are the bioquality scores of the selected case study sites? How do local patterns relate to the national patterns of which they are part?

2) What is the local variation in bioquality likely to be due to? What are the implications of the observed ecological and GHI patterns with respect to conservation management on a site basis?

4.3 METHODS

4.3.1 Site selection

Botanical surveys were performed in two Japanese landscapes (case studies 1 and 2); existing plant survey data and literature were collated for case study area 3 (Table 4.1). Survey plots in each study area were selected as outlined here. All data were compiled in the BRAHMS database and species names were verified with the Flora of Japan database. Full description of observed landscape units for RBS samples and national vegetation classification is provided in Appendix D.

Table 4.1 Summary of survey data in three study areas

Study area	No. of plots	No. of forest patches or vegetation types	Recorded landscape units
1: the *satochi-satoyama*, SE Kanto district	39 RBS samples	22 forest sites	3 (forest, grassland, riverine forest)
2: RBS in Okinawa-jima island	21 RBS samples	11 vegetation types	10 (forest, riverine forest, *Utaki*, coastal grassland, rocky Mt. summit)
3: the *Utaki* sacred groves of the Ryukyu Islands	498 Braun-Blanquet plots & 34 checklists	474 *Utaki* sacred groves	—

4.3.2 Case study area 1: The traditional rural landscape, *satochi-satoyama*

The *satochi-satoyama* landscape around the Tokyo metropolitan area was chosen because of high public interest in conservation of rural landscapes remaining around the countryside here (Figure 4.1). There are many relevant organisations working in the area, and many sites currently under conservation management, factors which facilitated the compilation of biodiversity data for this area. Community-managed semi-natural forest patches in south-east Kanto district were visited and selected for survey plots through contacting non-governmental organisations (NGOs) and local councils which have been working on restoring these forests. 39 RBS samples were surveyed in 22 forest patches between June and August 2009 (Figure 4.4). Unmanaged forest areas nearby which were once managed by traditional coppice practice became dominated by *Pleioblastus chino* (Gramineae) – a shrub-like bushy bamboo locally called '*sasa*' – showing different vegetation characteristics from managed forests. Forest sites with unmanaged patches were surveyed both on managed and neglected areas where possible.

4.3.3 Case study area 2: Various vegetation types in Okinawa-jima island, the Ryukyu Islands.

Okinawa-jima island; the largest island of the Ryukyus with approximately 1,208 km^2 land cover (Geospatial Information Authority of Japan (GSI), 2011c) was selected as a focal study area in the

Ryukyu Islands. The large island was the most practical and cost-efficient to conduct as many RBS as possible with limited time and human resources. The southern part of Okinawa-jima island is densely populated, hence a large area has been developed (Okinawa prefectural board of education, 2006) which makes the area unsuitable for surveying the potential bioquality hotspots expected on less disturbed vegetation. Forest cover on hilly parts extends from the central to the northern part of the island (Figure 4.2). Access is severely restricted on the central areas due to their occupation by the American military base. Therefore, the Primary study area selected was in the northern part of Okinawa-jima Island, with high forest cover on the mountains. Additional sites were also surveyed in the southern part of Okinawa-jima Island to examine variation in vegetation types and bioquality across the island. Survey plots were chosen in consultation with local forest researchers: Mr. Gushiken, Mr. Miyagi, and Mr. Kiuna at Okinawa Forestry Research Institute to ensure security in some areas which are high-priority protected areas or in military bases. 21 RBS samples were conducted in June and July 2010 (Figure 4.4).

4.3.4 Case study area 3: *Utaki* sacred groves of the Ryukyu Islands

Information for the *Utaki* sacred groves used in this study was extracted from government research reports published by Okinawa prefectural government which undertook extensive botanical surveys across the islands in the 1970s and 1980s (Okinawa prefectural board of education, 1978, 1979, 1980, 1981). Data collection in these sites has been extremely difficult due to restriction on access except for local residents, therefore only quick RBS sampling without specimen collection was performed in two *Utaki* sacred groves: Nago (Figure 4.3) and Urasoe in Okinawa-jima Island during the 2010 fieldwork. 474 *Utaki* sacred groves of a total 487 listed were surveyed by local field experts commissioned by Okinawa prefectural government. The Braun-Blanquet method had been employed in the majority of sites, with some smaller ones surveyed in the form of a basic checklist.

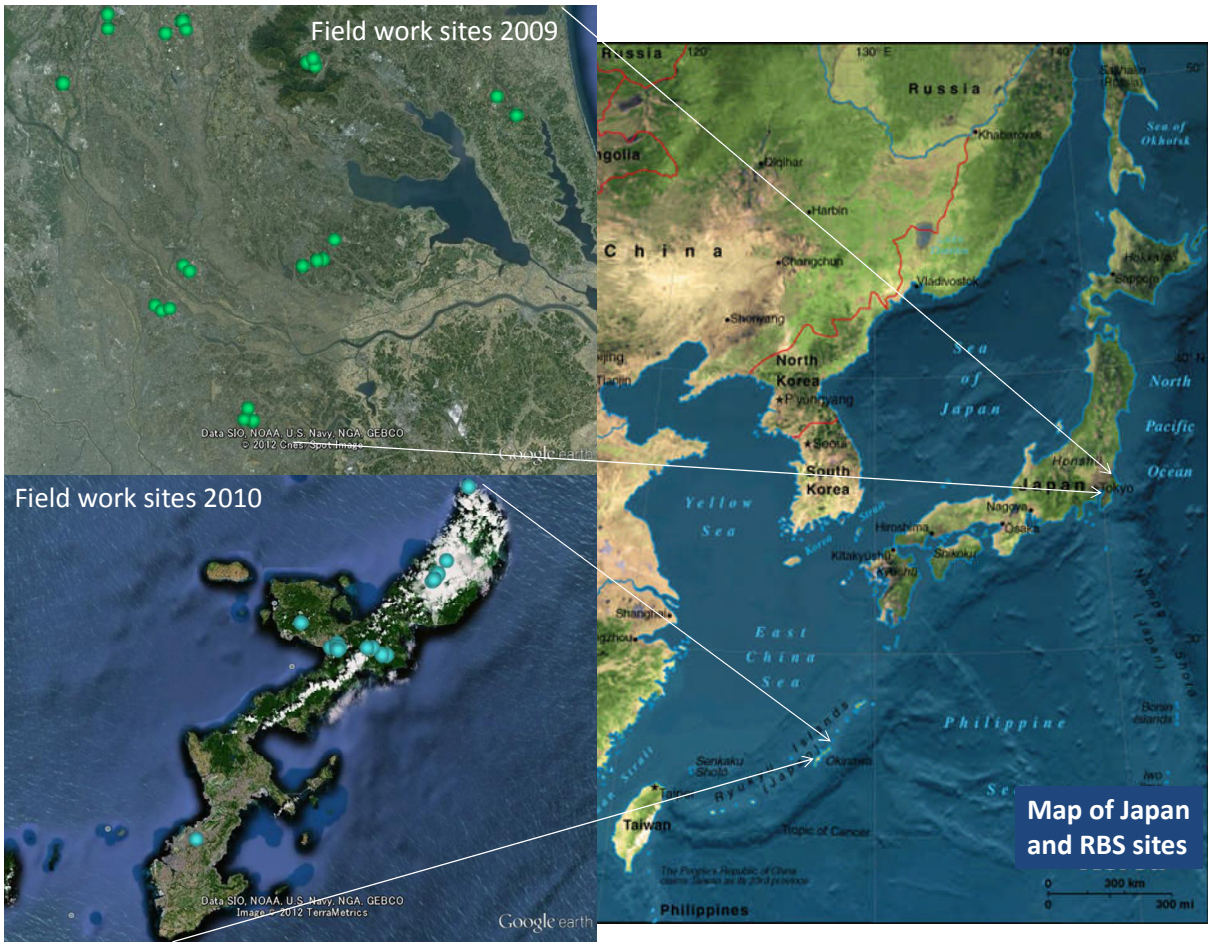


Figure 4.4 Maps of study sites for RBS samples in 2009 and 2010.

4.3.5 Sampling: botanical surveys

Rapid Botanical Survey (RBS) were employed in case study areas 1 and 2 (see Hawthorne and Abu-Juam (1995), and Hawthorne (2012)) based on the standard protocol. This survey method was selected for the following reasons. (1) It is flexible in amending the shape of survey area – RBS is plotless, rather than following a more stringent 'quadrat'-type plot in conventional survey methods. This was effective where allocating rectangular plot as often required by a quadrat based survey is not practical such as on steep slopes or riverine habitats. (2) It is efficient in sampling as many species as possible given limited time and human resources. The RBS sample area is not necessarily measured (Hawthorne and Abu-Juam, 1995), but almost all species in stated landscape units were recorded during these surveys in Japan. The absolute minimum requirement of the species inventory is 40 species, but it is

recommended that sampling progresses until almost all species in the focal, tightly defined landscape unit have been found.

Landscape units were chosen so that the spectrum of vegetation types in a given landscape is represented, with replication within each general forest type and landscape unit. Sampling started from the central point of the chosen sample area and spread outward. Species were recorded until the discovery rate fell below about one species in ten minutes following the general guideline (Hawthorne, 2012). This threshold was reduced to five minutes in unforeseen conditions such as changes in weather or when surveying on steep slopes. Estimates of local abundance were made in terms of three-level scores of 1, occasional; 2, locally common in sample area; and 3, dominant for individual species in each sample. All species with abundance 2 or 3, and more than 90% of species with local abundance 1 would be expected in a resample of the same area (Hawthorne, 2012).

Information on the ecology, conservation status and geographic distribution of species encountered in the RBS was collected and databased in BRAHMS alongside the taxonomic aspects described in Chapter 2. Taxonomic identification was completed with expert field taxonomists on the site by: Ms. Kakizaki and Mr. Tsukamoto for the 2009 *satochi-satoyama* survey and Mr. Miyagi at Ocean Exposition Commemorative Park Management Foundation for the 2010 Okinawa-jima Island survey. All specimens were verified by professional taxonomists at local herbaria after fieldwork collection by: Mr. Obata at Ibaraki Nature Museum for 2009, and by Mr. Iha and Dr. Kokubugata at Tsukuba Botanic Garden for 2010. In this study, an average of two to three hours botanical sampling was taken per designated plot area by a team of three or two. A few samples were forced to terminate recording due to time constraints or practical problems with access but the minimum inventory of 40 species was achieved in the majority of samples.

4.3.6 Sampling: beetle collection

Modified Flight Intercept Traps (FIT) (Ueda *et al.*, 2012) were also set up inside the RBS samples for study areas 1 and 2. The initial proposed purpose of beetle collection was to examine the ecological association, if any observed, between plant communities and beetles sampled. Due to the terminal illness of principal entomologist Mr. Makihara, with whom I co-organised sampling and specimen identification, the species catalogue was left incomplete for 2010 samples. A brief summary of FIT samples and the list of selected species identified are provided in Appendix F but no detailed analysis was conducted.

4.3.7 Analysis

GHI was calculated for individual RBS samples and for each *Utaki* grove with over 40 taxa. The GHI map produced using Horikawa geoquadrats was overlaid with sample GHI to investigate the congruence of bioquality patterns among different data sets.

Ordination analyses and similarity analyses were performed to reveal patterns in species composition and habitat types and their correlation with GHI scores for high scoring areas using PC-ORD v. 6 (McCune and Mefford, 2011). Habitat types (e.g. rocky mountain top forest, coastal grassland) were categorised based on field observation data. Vegetation types (e.g. *Quercus serrata* community, evergreen conifer plantation, *Psychotrio-Castanopsion sieboldii* community, *Pinus luchuensis* community) were also identified for each sample by overlaying available vegetation maps (Ministry of the Environment of Japan, 2012c). Topographical information for the *Utaki* sacred groves was obtained from 250-m resolution elevation maps of Japan, containing average, maximum and minimum altitude, slope and slope angle (maximum and minimum) (Geospatial Information Authority of Japan (GSI), 2011a). Detrended Correspondence Analysis (DCA) and Nonmetric Multidimensional Scaling (NMS) using Sorenson distance measure were run and the results were compared. NMDS without an assumption on unimodal species distribution was recommended particularly for cases where

environmental data are limited as in this study (Kent, 2012). Thus NMDS was preferably chosen if the graphical presentation of the results was indifferent from that by DCA.

At species level, the life forms of tree, shrub, climber (including lianas and vines), herb, and fern were assigned to species recorded in the Ryukyu Islands. The relationship between global rarity and life-forms was compared for these species.

4.4 RESULTS

4.4.1 Species representation in three study sites

Stars have been assigned for 92.6%, 84.1% and 86.8% of recorded species for study areas 1, 2, and 3 respectively (Table 4.2, Figure 4.5). One RBS sample in the study area 1 (unmanaged patch in the Ushiku Kessoku Nature Sanctuary) and one in the study area 2 (Cape Hedo plot) had fewer than 40 recorded species; hence GHI calculated for these two samples was regarded void. Approximately half of the *Utaki* sacred groves had fewer than 40 species recorded.

Table 4.2 Summary statistics of RBS samples and the *Utaki* groves

Study area	No. of samples with >= 40 spp.	Total no. of spp. & records	No. of spp. with Star status	Mean (± std.) of spp. per sample
1: the *satochi-satoyama*, SE Kanto district	38	419 taxa 3,431 rec.	388	82.47 (± 20.13)
2: RBS in Okinawa-jima island	20	370 taxa 1,710 rec.	311	70.50 (± 15.73)
3: the *Utaki* sacred groves of the Ryukyu Isls.	224	642 taxa 30,501 rec.	557	53.78 (± 12.40)

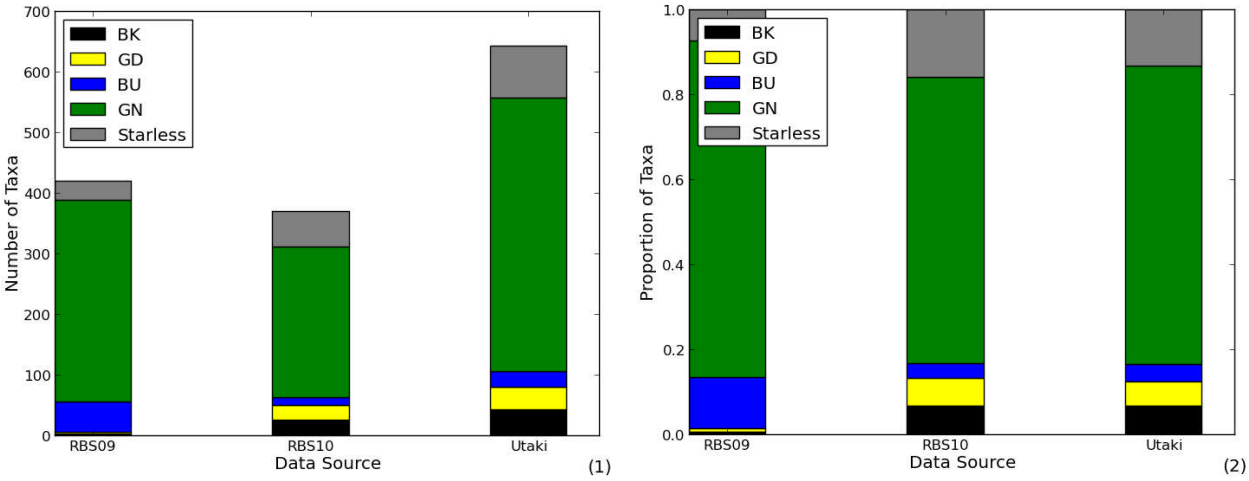


Figure 4.5 The number (1) and proportions (2) of species assigned Stars for three study sites: 1) RBS in the *satochi-satoyama* landscape, 2) RBS in Okinawa-jima Island, 3) the *Utaki* sacred groves. Stars are abbreviated as: BK = Black, GD = Gold, BU = Blue, GN = Green, Starless = no Stars assigned.

Prior to GHI analysis, species representation with respect to the number of species and subplot sampled was examined for all three study sites (Figure 4.6). Species–area curves showed that a species pool sampled had begun to level off for study area 3 and to a lesser extent for study area 1, while it is not the case for the study area 2 with the smallest number of samples of all areas. There were substantial constraints on sampling time and resources available for conducting RBS, thus shortcoming of the total species sampled was expected. Given this limitation, I focused on sampling more areas rather than collecting the complete species inventory. The results presented here should be considered as a subset of possible variations in bioquality predicted and by no means has this study tried to achieve generalisation of the patterns across the survey area. Nevertheless, by maximising the number of sample plots surveyed under the resource poor conditions, the findings demonstrated there are spatial variations in GHI values.

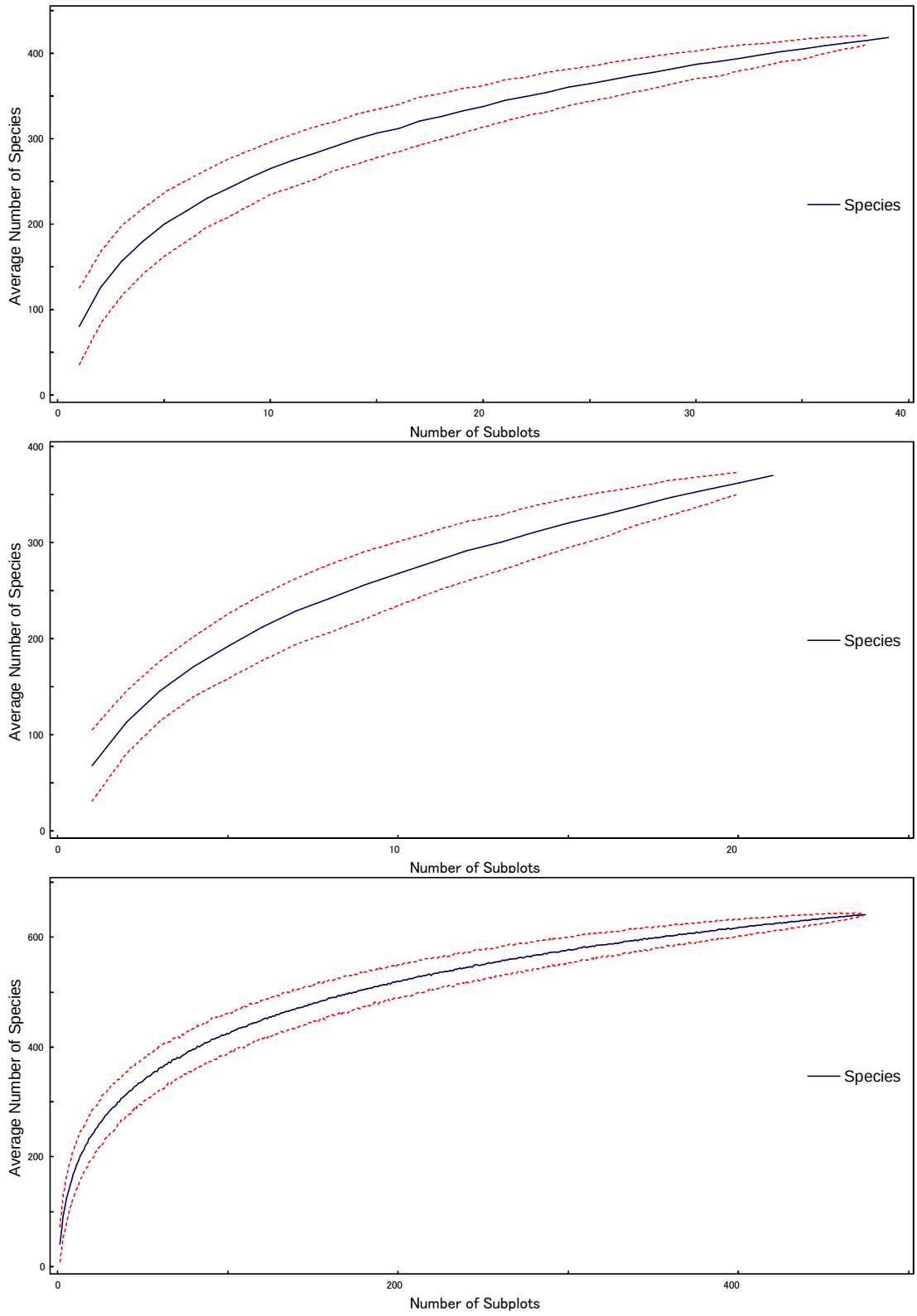


Figure 4.6 Species–area curves for study sites: 1) the *satochi-satoyama* (top); 2) RBS in Okinawa-jima Island (middle); 3) the *Utaki* sacred groves. Jacquard method was used for distance measure. Red dotted lines are lower and upper bounds of 95% confidence interval.

4.4.2 Genetic Heat Index (GHI) of three study areas

For study area 1, the highest GHI of 75 was recorded in Ushiku Kakogahara and the lowest 16 in Yuki kenko-no-mori (Figure 4.7). Five RBS samples on Okinawa-jima Island (study area 2) scored 300 and higher GHI with the highest 398 in the rocky limestone summit of Mt. Katsuu (Figure 4.8). While the second and the third highest score of 377 and 330 was recorded in laurel forests on Mt. Yonaha (272 m and 274 m a.s.l respectively), the lowest score for RBS samples in Okinawa-jima Island (GHI 105) was found in a riverside forest in the vicinity of these high-scoring samples.

Twelve *Utaki* groves exceeded GHI of 400 (Figure 4.9) , seven of which are on Okinawa-jima Island, two on Miyako-jima Island, one on each of Izena-jima Island, Kume-jima Island and Ishigaki-jima Island. Seven of 13 lowest-scoring sacred groves, with GHI below 120, were located on Ishigaki-jima Island and the other six on Okinawa-jima Island.

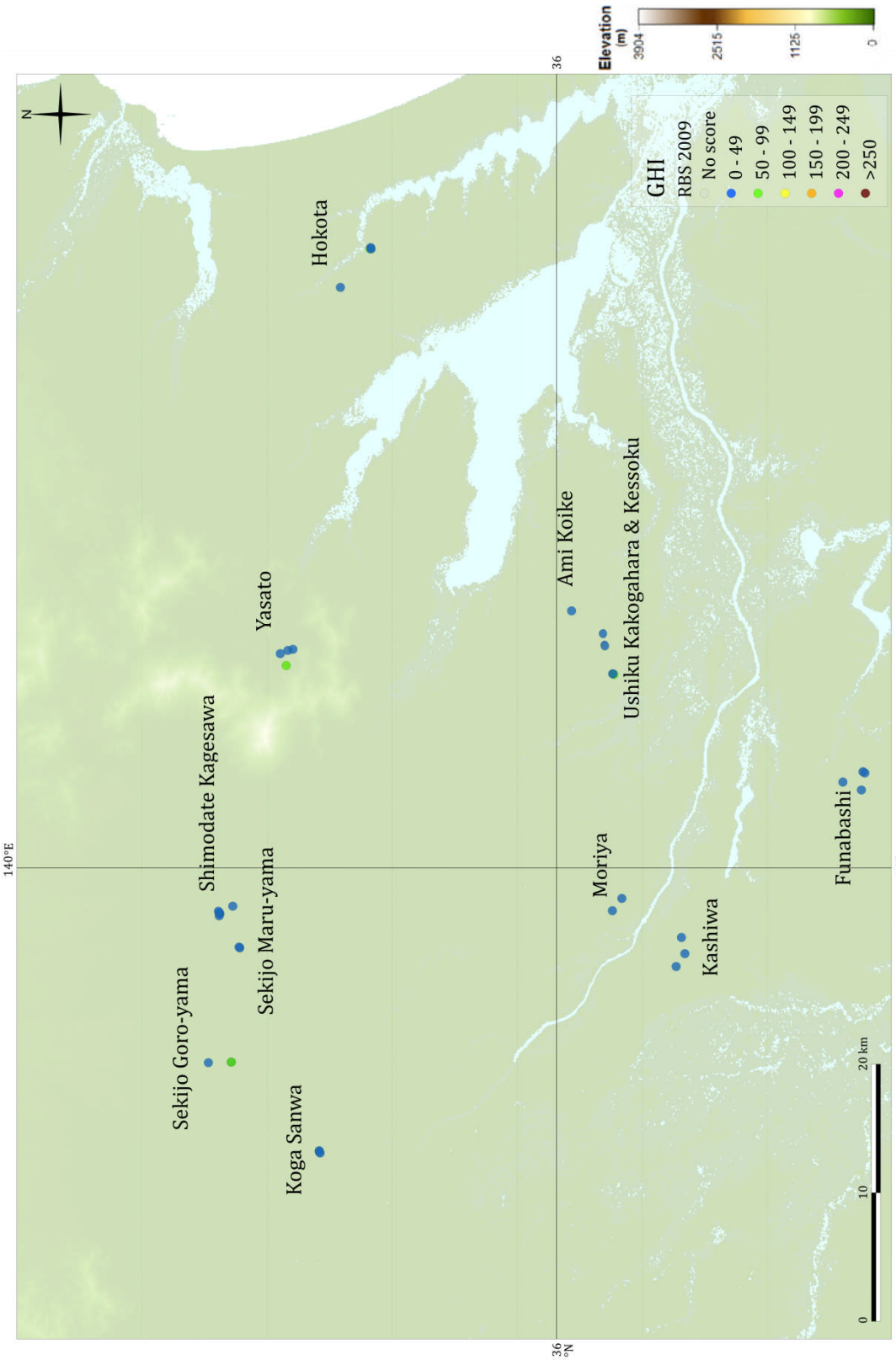


Figure 4.7 Plot GHI for the *satochi-satoyama* landscape 2009 RBS samples. Each point represents a RBS sample. One sample in Ushiku Kessoku (Nature Sanctuary) had fewer than 40 taxa.



Figure 4.8 GHI plot for Okinawa-jima 2010 RBS samples. Each point represents a RBS sample. One sample with fewer than 40 taxa was Cape Hedo.

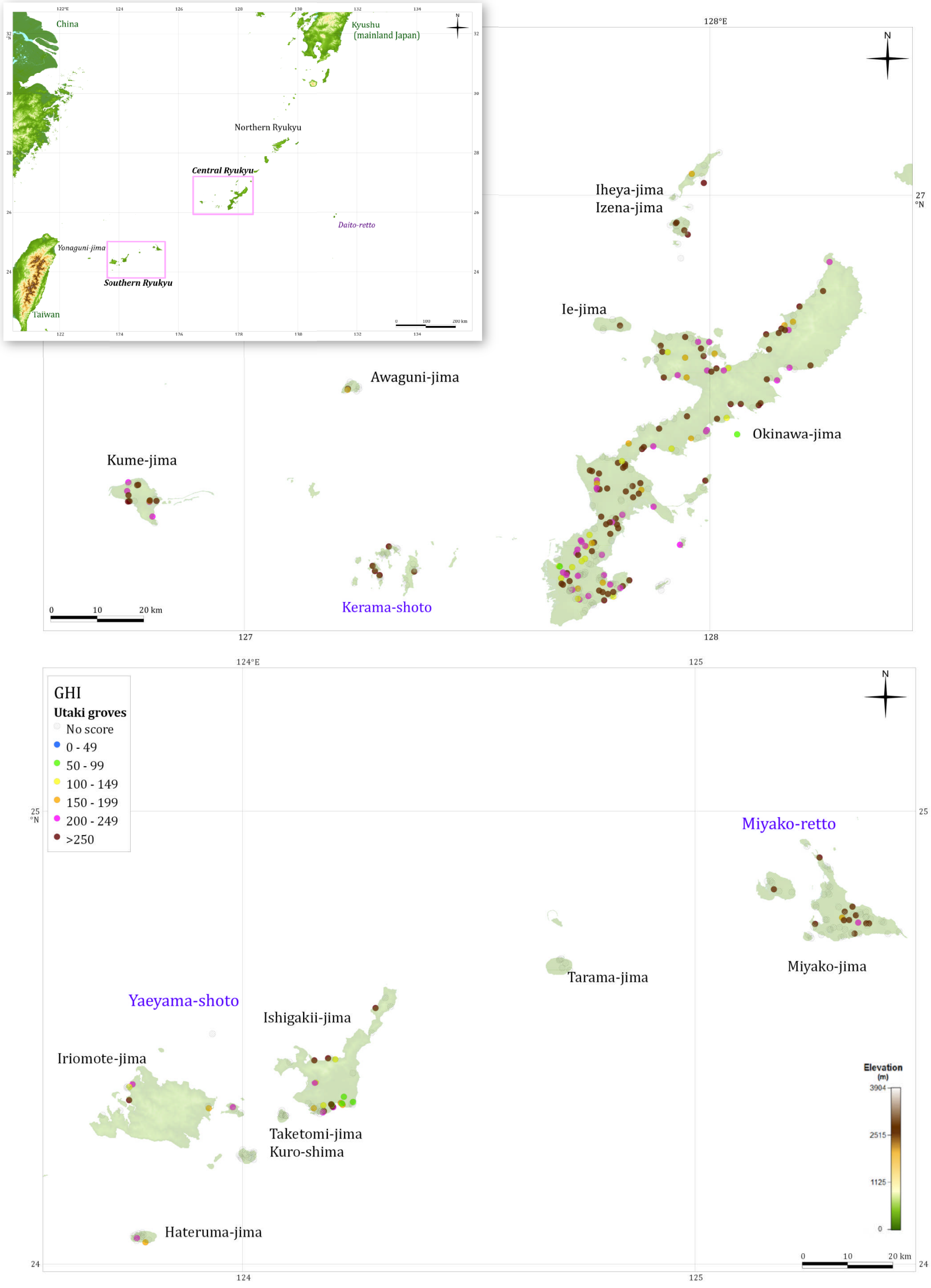


Figure 4.9 Site GHI for *Utaki* sacred groves, enlarged Central Ryukyu (middle) and Southern Ryukyu (bottom) are shown in pink rectangles on the overview map. Daito-jima Island and Yonaguni-jima Island are omitted in close-up maps. Names of selected individual islands are shown in black and island groups in purple. Each point represents an *Utaki* sacred grove. Samples with fewer than 40 taxa (no score) are shown with grey crosses.

In terms of species that contribute to high GHI in the Ryukyu Islands, the majority of 25 Black Star species recorded in RBS samples on Okinawa-jima Island are restricted to the Ryukyu Islands, or partially extend to the southern part of Kyushu. A similar pattern in species' geographic range was observed for 24 Gold Star species with half also found in Taiwan – but only restricted to the Ryukyu Islands and Taiwan. Many Black Star and Gold Star species were relatively locally common, i.e. frequently recorded in RBS across the Ryukyu Islands. 5 Black and 2 Gold Star species occurred in 10 or more RBS samples (Table 4.3).

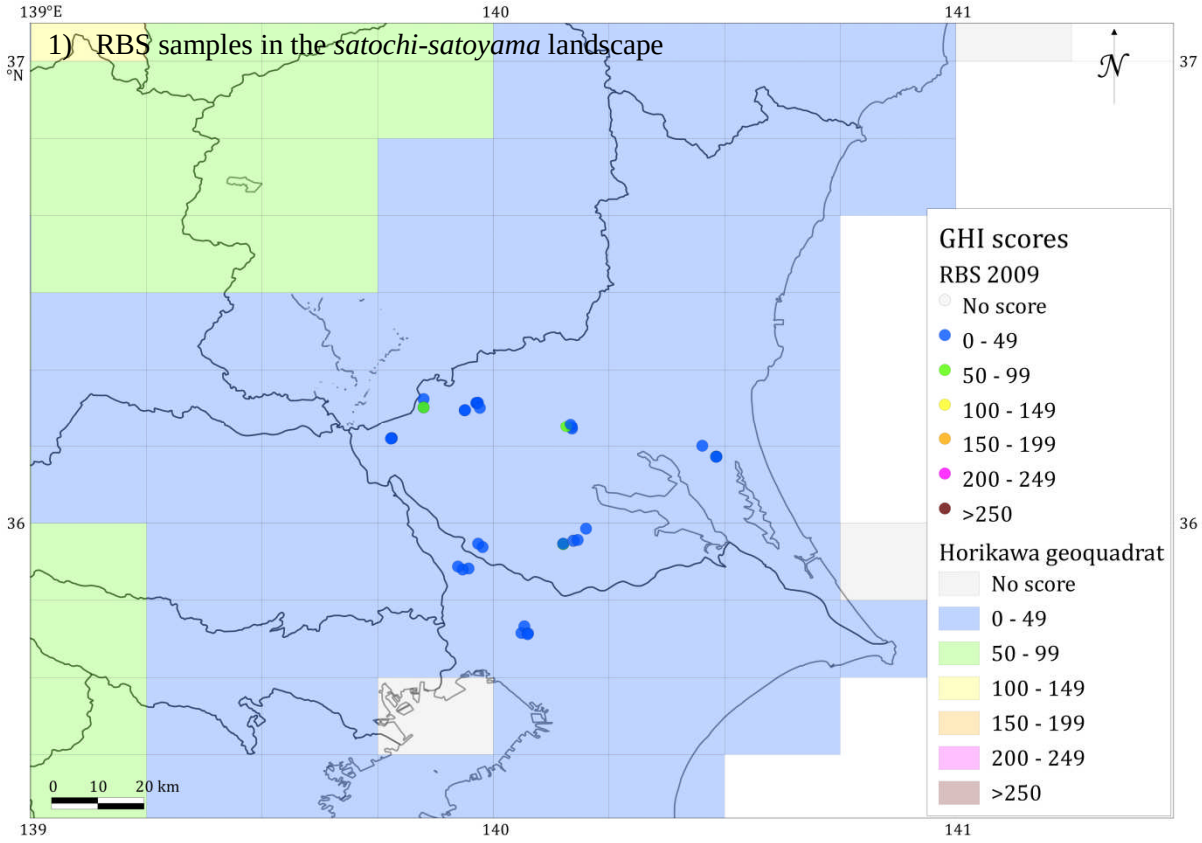
Most of these Black (17 of 25) and Gold (20 of 24) Star species in RBS samples were also found in the *Utaki* samples. About a third of the Black Star species (14 of 43 species) and a third of the Gold Star species (12 of 37 species) were recorded more than 20 times across the *Utaki* plots (Table 4.3). Some of the most frequently recorded species in the *Utaki* sacred groves that occur in coastal habitats were rarely encountered in RBS samples which were predominantly surveyed in montane forests. Such examples for Black Star species include: *Drypetes matsumurae* (Euphorbiaceae), *Cycas revoluta* (Cycadaceae), *Jasminum superfluum* (Oleaceae), and *Tylophora tanakae* (Asclepiadaceae).

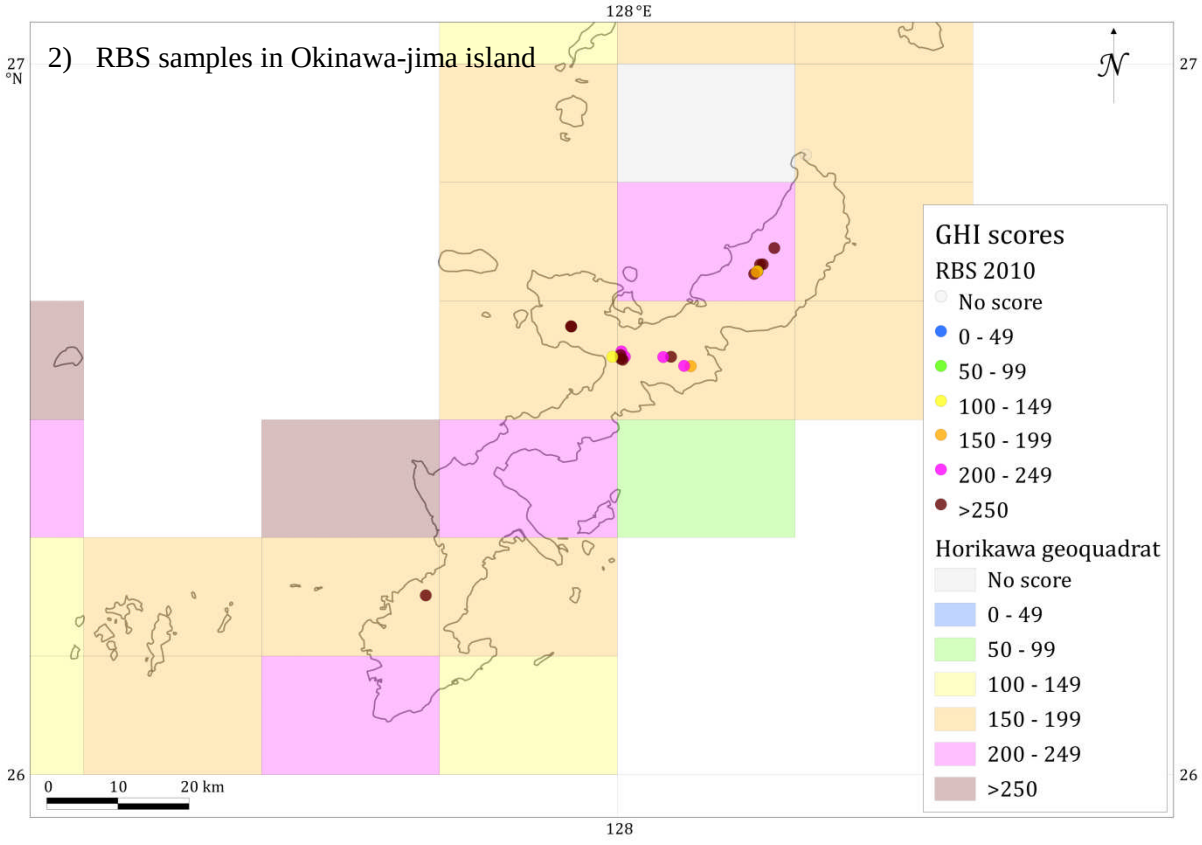
Two Black Star species recorded in RBS samples of the *satochi-satoyama* landscape; *Cerasus speciosa* (Rosaceae) and *Ribes sinanense* (Saxifragaceae) are suspected to be planted or naturalised because these species are known to be only found in the Izu Islands and in Nagano and Gunma prefectures of central Honshu. Four Gold Star species; *Rhododendron wadanum* (Ericaceae), *Cynanchum sublanceolatum* (Asclepiadaceae), *Cirsium nipponicum* var. *incomptum* (Asteraceae), and *Elaeagnus montana* var. *ovate* (Elaeagnaceae) all have restricted distributions on the Pacific Ocean side of central Honshu, and are forest species.

Table 4.3 Summary of selected frequently recorded rare species in RBS 2010 and the Utaki samples in the Ryukyu Islands. Black and Gold underlines represent Star rank. †= frequency of species occurrences out of 30,501 records in Utaki, 1,710 records in RBS 2010. Geographic range size sourced mainly from the Flora of Japan, and * from Kew WCSP. ‡= Endemic to Japan.

Species (family)	*Utaki*†	RBS†	Geographic range and some notes on habitats.
Drypetes matsumurae (Euphorbiaceae)	382	0	Yakushima and Ryukyu (Tokara Islands, Okinawa-jima, Iheya-jima, Miyako-jima, Iriomote-jima, Yonaguni-jima). In forests near seashore. ‡
Elaeagnus liukiuensis (Elaeagnaceae)	188	10	Ryukyu (southward from Amami-oshima). ‡
Cycas revoluta (Cycadaceae)	174	2	S. Kyushu and Ryukyu. On sunny rocks near the sea. ‡
Aristolochia liukiuensis (Aristolochiaceae)	174	14	Ryukyu (Amami-oshima, Tokuno-shima and Okinawa Islands). ‡
Symplocos tanakae (Symplocaceae)	110	6	Shikoku (Tokushima and Kochi Pref.) and Kyushu (Miyazaki and Kagoshima Pref., south to Tokara Islands). Warm temperate montane evergreen forests. ‡
Jasminum superfluum (Oleaceae)	108	1	Ryukyu (Okinawa-jima and Sakishima Islands). Edge of evergreen forests near the sea. ‡
Pinus luchuensis (Pinaceae)	91	18	Ryukyu*‡
Rhamnus liukiuensis (Rhamnaceae)	82	2	Kyushu (southward from Akuseki-jima) and Ryukyu (Amami Islands). ‡
Tylophora tanakae (Asclepiadaceae)	53	0	S. Kyushu (southward from Kagoshima Pref.) and Ryukyu. Evergreen forest edge near the sea. ‡
Vaccinium wrightii (Ericaceae)	41	8	Ryukyu (southward from Amami-oshima). Evergreen forests at lowlands. ‡
Arachniodes dimorphophylla (Dryopteridaceae)	6	13	Ryukyu (Okinawa-jima and Keramajima). Terrestrial on rather dry floor of light forests. ‡
Hydrangea liukiuensis (Saxifragaceae)	4	10	Ryukyu (Okinawa-jima). Evergreen forests. ‡
Smilax sebeana (Smilacaceae)	296	0	Japan (Kyushu), Ryukyu to Taiwan.*
Tarenna gracilipes (Rubiaceae)	266	13	W. & S. Kyushu, Ryukyu and C. & S. Taiwan. Evergreen forests in lowlands.
Celtis boninensis (Ulmaceae)	229	3	Honshu (Yamaguchi Pref.), Kyushu (west coast), Ryukyu and Ogasawara Islands. ‡
Acer oblongum var. itoanum (Aceraceae)	214	1	Ryukyu (southward from Amami-oshima). In subtropical evergreen forests. ‡
Citrus depressa (Rutaceae)	149	4	Ryukyu (southward from Amami-oshima) and Taiwan. Occasionally cultivated.
Arundinaria linearis (Gramineae)	107	7	Ryukyu.* ‡
Mussaenda parviflora (Rubiaceae)	66	7	Southward from Yakushima to Ryukyu and Taiwan. Evergreen forest edges; sea-level to 400 m.
Kalopanax septemlobus* subsp. *lutchuensis (Araliaceae)	47	2	Kyushu and Ryukyu. ‡
Ilex maximowicziana (Aquifoliaceae)	5	13	S. Kyushu (including Yakushima), Ryukyu and Taiwan.

4.4.3 Verification of broad-scale hotspot prediction at local management level using RBS





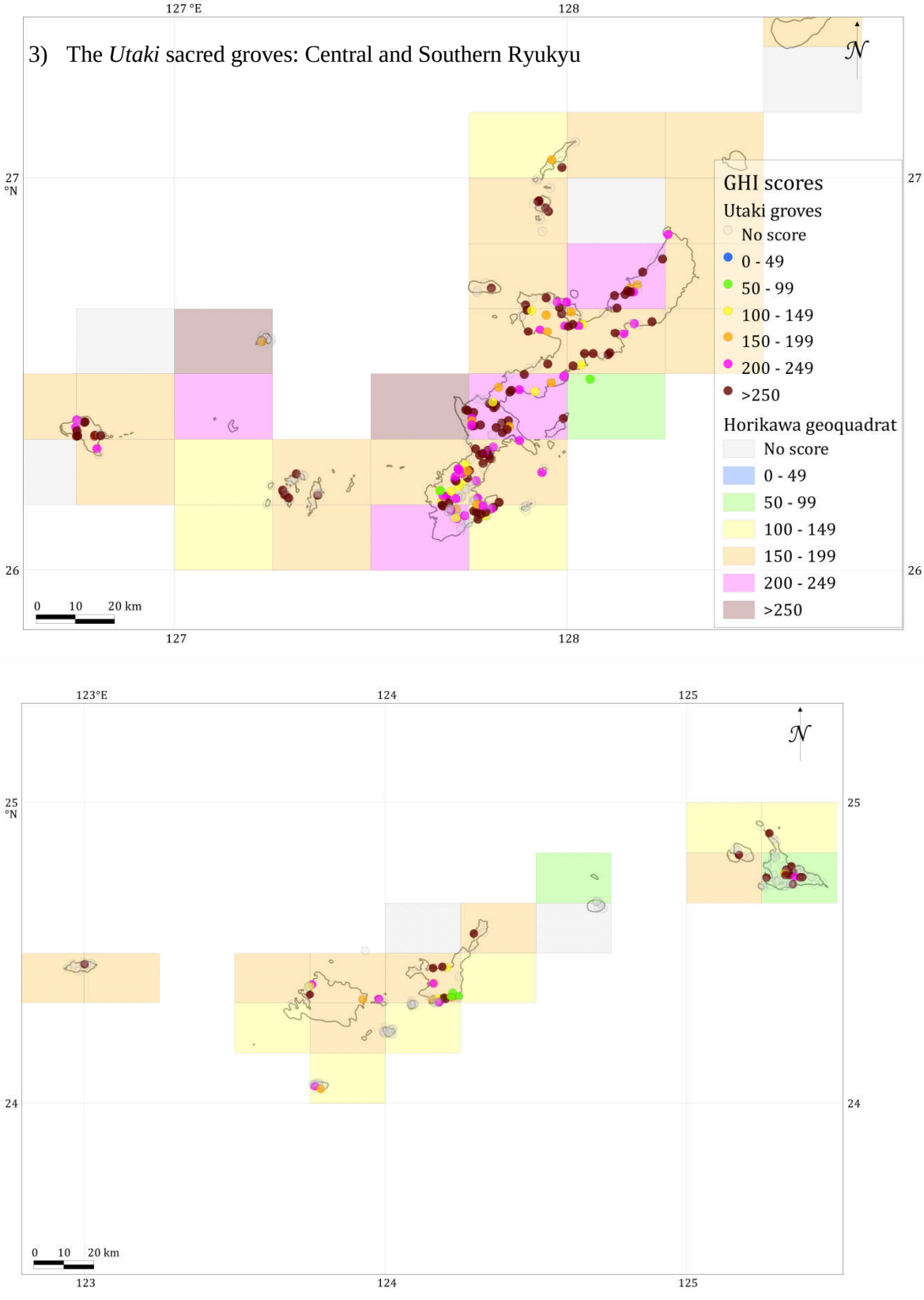


Figure 4.10 Comparison of GHI scores between Horikawa geoquadrats and 1) RBS09 *satoyama* sites, Kanto district (previous page), 2) RBS10 Okinawa-jima island (previous page), and 3) *Utaki* sacred groves of the Ryukyu Islands: Central (top of this page) and Southern (bottom of this page). Horikawa geoquadrat GHI (gridded cells) is overlaid by sample GHIs (points). Variation in GHI inside geoquadrats can be observed by similarities or differences in colours.

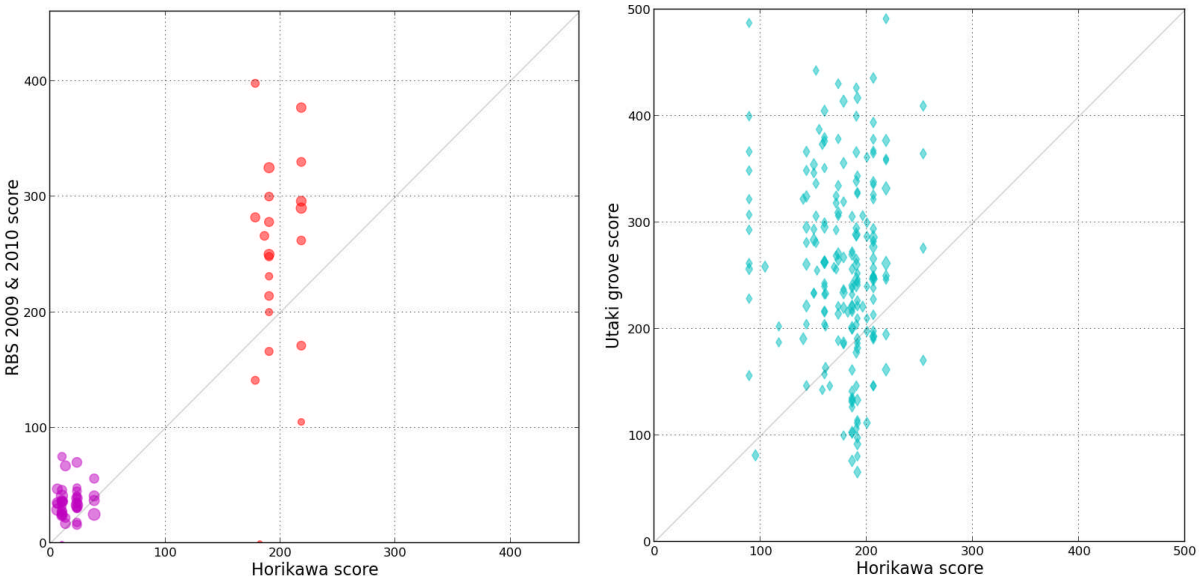


Figure 4.11 RBS Sample GHIs of RBS 2009 (magenta circle ●), 2010 (red circle ●) and *Utaki* groves (cyan diamond ♦) are plotted against Horikawa geoquadrat GHI for the geoquadrat that contaions that RBS sample (*x*-axis). Horikawa geoquadrat GHI that contains sample plots was selected for comparing scores. The 1:1 ratio line of equality for the two scores is shown for reference.

Sample GHIs on the ground were generally congruent with Horikawa geoquadrat GHI at coarser resolution with respect to categorical classification of scores at 50 GHI intervals across all study areas (Figure 4.10). Greater variations both to higher and lower ranges in GHI were revealed within the hotspot by the field samples compared to Horikawa geoquadrats (Figure 4.11).

4.4.4 The relationship between recorded biogeographical attributes and bioquality

Within Ryukyu Islands hotspots, the association between GHI and recorded ecological and/or geographical attributes was examined for RBS samples and for the *Utaki* groves. Cape Hedo was revealed as an outlier in terms of species composition using both NMS and DCA ordination methods (Figure 4.12, cluster analysis results in Appendix E). Results from DCA are shown in Figure 4.12Figure 4.12 because of clarity in displaying outlier sample plots compared to NMS. 19 out of 23 species recorded in Cape Hedo were only found in this sample. These are seaside species (e.g. *Cynanchum matsumurae* (Asclepiadaceae), Black Star; *Galactia tashiro* (Leguminosae), Blue;

Peucedanum japonicum (Umbelliferae), Green; *Crepidiastrum lanceolatum* (Asteraceae), Green; *Hedyotis strigulosa* (Rubiaceae), Green; *Vitex rotundifolia* (Verbenaceae), Green; *Tetragonia tetragonoides* (Aizoaceae), Green), hence were only sampled in this coastal grassland plot.

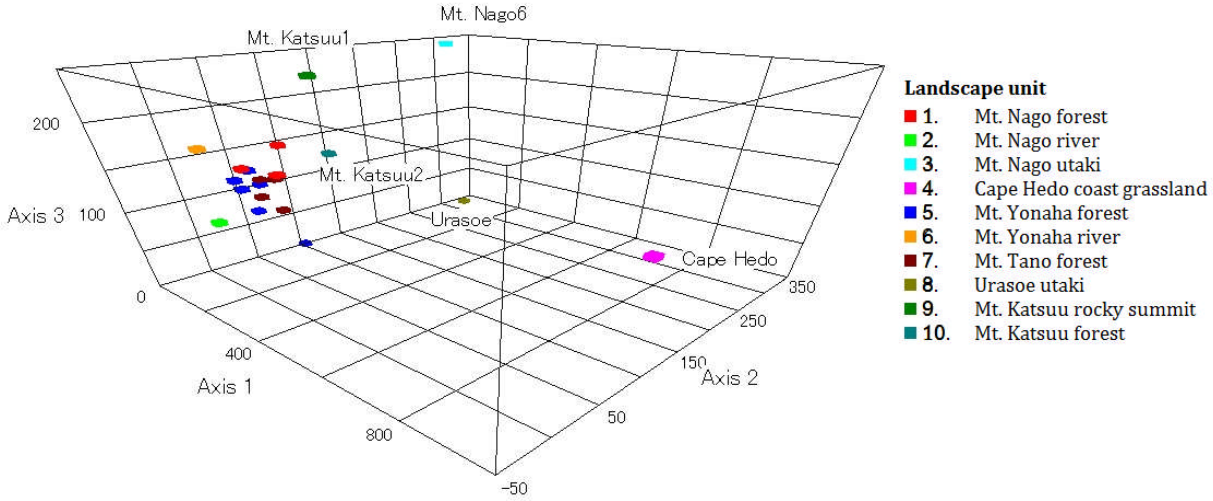
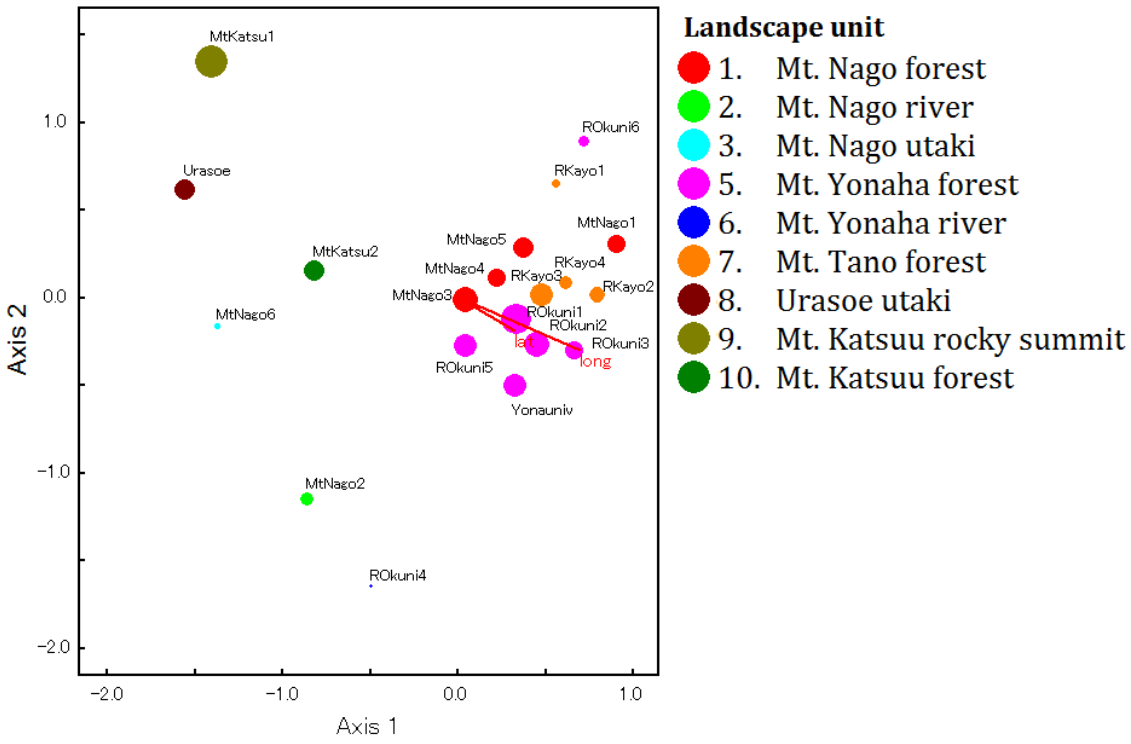


Figure 4.12 DCA result for all 21 RBS samples on Okinawa-jima Island, colour-coded in terms of 10 landscape units identified. Selected samples are identified by plot name



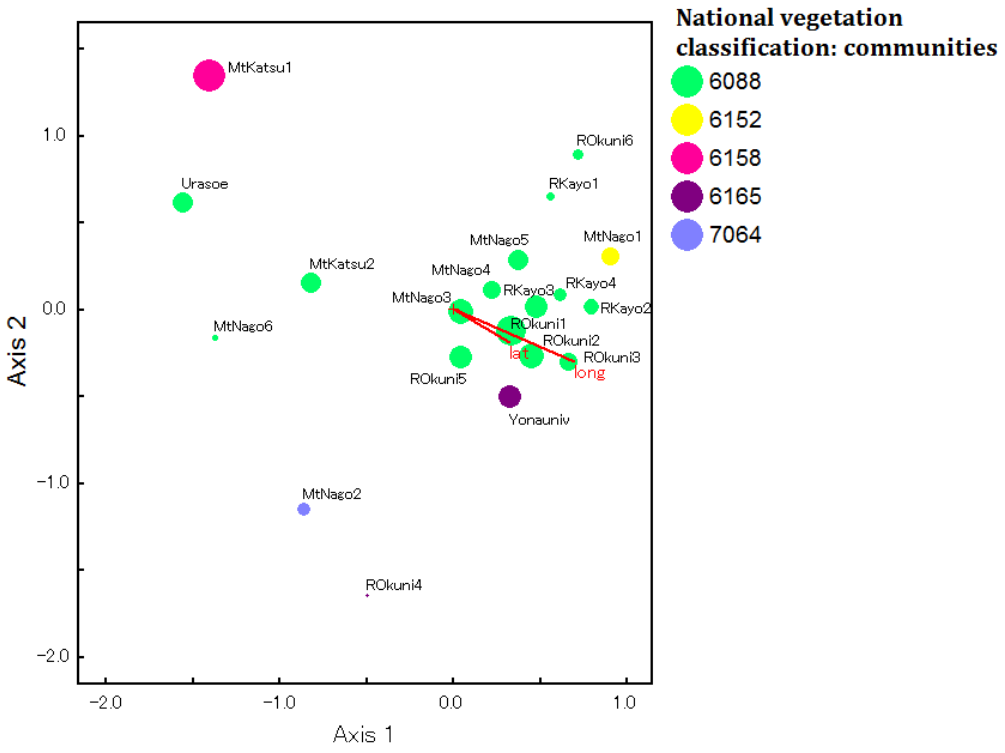


Figure 4.13 NMS result for 20 RBS samples excluding Cape Hedo in Okinawa-jima Island. Landscape units (top) and major plant communities defined by national vegetation classification (bottom) are colour coded. The size of each point is proportional to GHI. Plant communities are coded as: 6088, *Psychotria rubra–Castanopsis sieboldii* var. *sieboldii*; 6152, *Cycas revolute*; 6158, *Psychotria manillensis–Acer oblongum* var. *itoanum*; 6165, *Pinus luchuensis*; 7064, *Imperata cylindrica–Miscanthus sinensis* communities.

Samples showed some clustering of floristic similarity in relation to landscape units, while the national vegetation classification showed little association with RBS sample content or GHI, as most fall into one class (6088) (Figure 4.13). On the other hand, distinct habitat characteristics observed in the field, such as limestone vegetation (landscape units 9 and 10), *Utaki* forests (3 and 8), and riverine forests (2 and 6) were all distinguishable in terms of component species compared to other samples. The majority of samples in three different mountain ranges (Mt. Yonaha, Mt. Nago, and Mt. Tano) had similar species composition to each other. The *Cycas revoluta* and *Pinus luchuensis* communities of the national vegetation classification system, however, were found to be closely related to *Psychotria rubra–Castanopsis sieboldii* var. *sieboldii* community group of RBS samples.

A small association observed between the composition of forest habitats and latitude and longitude (Pearson's product-moment correlation coefficient and Kendall tau rank correlation for axis 1: latitude r^2 = 0.184, τ = 0.042; longitude r^2 = 0.399, τ = 0.295) is expected to reflect similarities in species

composition of extensive forest cover in the north-eastern area of Okinawa-jima Island, where most of mountain forest plots were sampled.

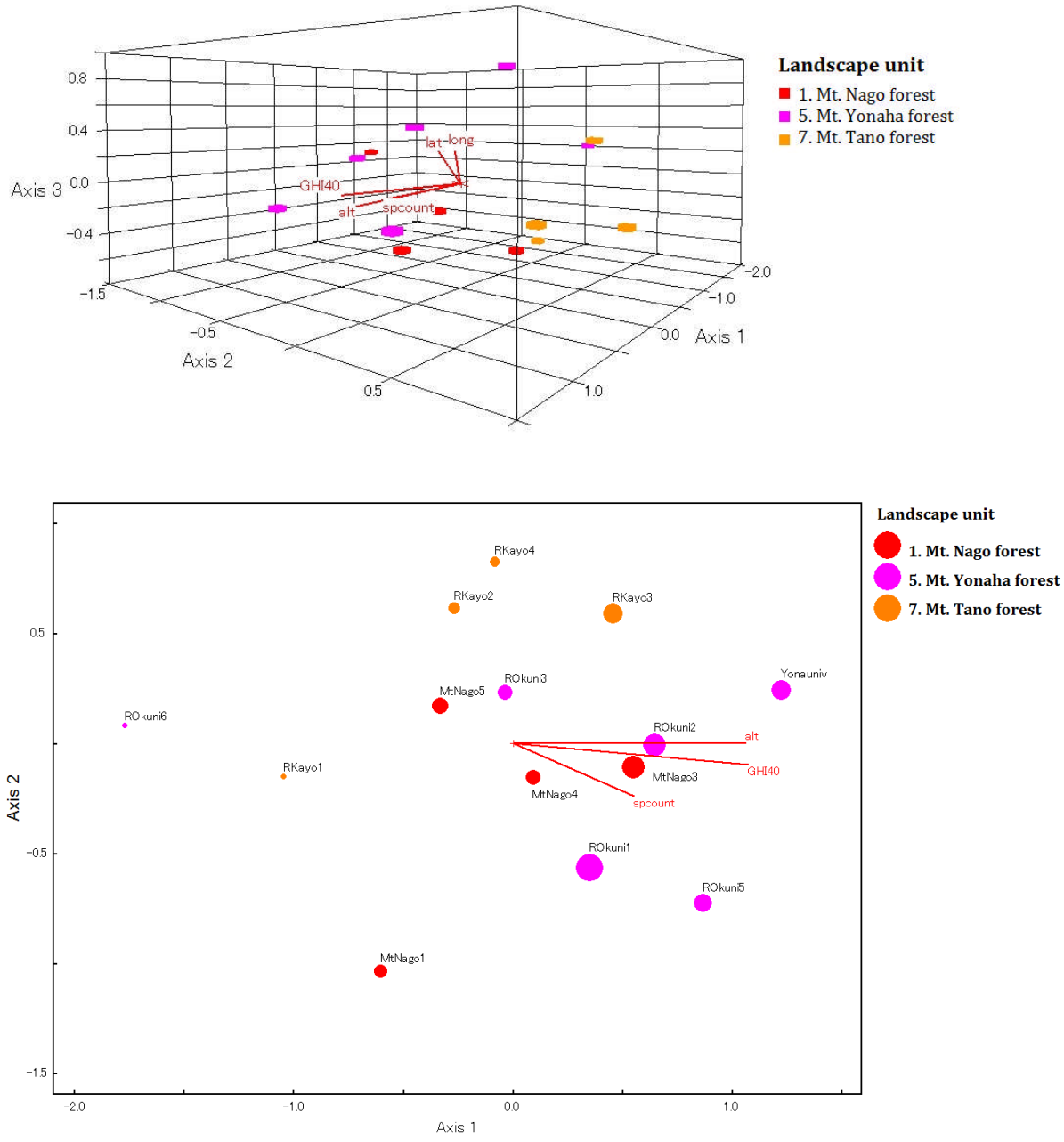


Figure 4.14 NMS result of 14 samples in three selected landscape units: 1. Mt. Nago, 5. Mt. Yonaha, and 7. Mt. Tano forests displayed in 3D (top) and in 2D for axes 1 and 2 (bottom). Abbreviation used: latitude (lat), longitude (long), altitude (alt), the number of species per plot (spcount). GHI40 is GHI for plots with over 40 species (all 14 samples). The size of each RBS sample on the bottom graph is proportional to GHI.

There is a general increase in GHI with altitude in the study area: an increase in altitude was positively associated with GHI for the subset of samples in mountain forests (Figure 4.14). Both GHI and altitude were positively correlated to axis 1 on NMS (Pearson's product-moment correlation coefficient and

Kendall tau rank correlation for axis 1: altitude r^2 = 0.615, τ = 0.626; GHI r^2 = 0.606, τ = 0.560).

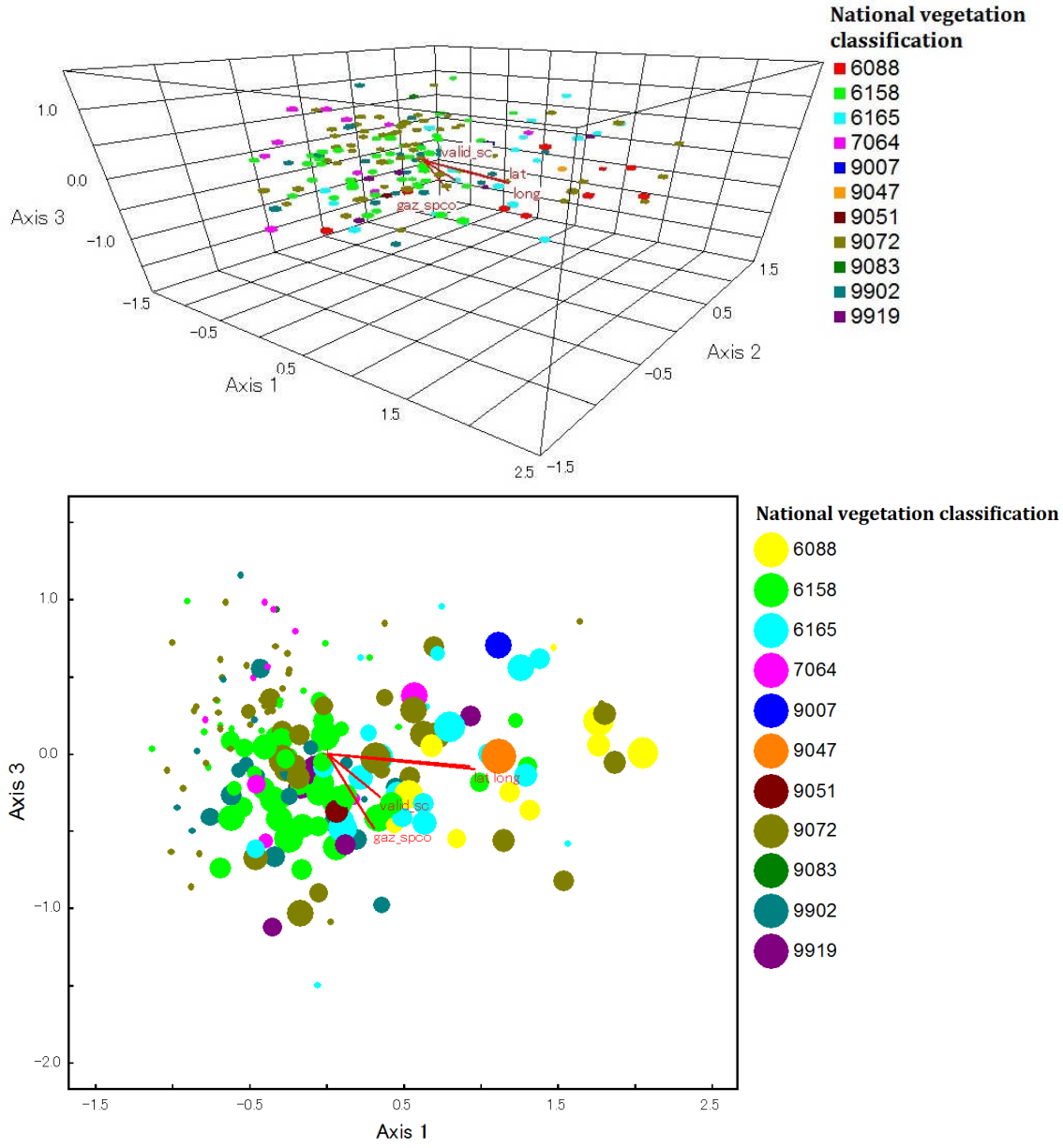


Figure 4.15 NMS result for 191 *Utaki* sacred groves in Okinawa-jima Island shown in 3D (top) and for only axes 1 and 3 (bottom). The size of each point is proportional to GHI. Plant communities or land types are coded as: 6088, *Psychotria rubra–Castanopsis sieboldii* var. *sieboldii*; 6158, *Psychotria manillensis–Acer oblongum* var. *itoanum*; 6165, *Pinus luchuensis*; 7064, *Imperata cylindrica–Miscanthus sinensis*; 9007, *Pinus luchuensis* plantation; 9047, exotic broad-leaf plantation; 9051, Casuarinaceae plantation; 9072, weedy cropland; 9083, cultivated meadow; 9902, urban area; 9919, developed land. Valid_sc; GHI for groves with 40 or more species (0 if less than 40). Gaz_spco; the number of species per grove.

There was small degree of association between the national vegetation classification and GHI for 191 selected *Utaki* sacred groves on Okinawa-jima Island (Figure 4.15). Many of high scoring *Utaki* sacred groves were in forest vegetation such as *Psychotria rubra–Castanopsis sieboldii* var. *sieboldii* community (national vegetation code: 6088), *Psychotria manillensis–Acer oblongum* var. *itoanum*

community (6158), *Pinus luchuensis* community (6165). These forest types are the most widespread and typical vegetation classes in relatively undisturbed area in the island. *Psychotria rubra–Castanopsis sieboldii* var. *sieboldii* community covers the vast majority of mountainous area in north-eastern part of Okinawa-jima Island. *Psychotria manillensis–Acer oblongum* var. *itoanum* community is frequently found along the coast in patches, forming some forest clusters in Motobu peninsula in the northwest. *Pinus luchuensis* community tends to appear in the form of thin stripes along the coast between lowland settlement and hilly areas. Some association observed for latitude, longitude, and GHI on NMS axis 1 suggests that there is an increase in GHI in the north-eastern part of Okinawa, a pattern congruent with RBS samples (Table 4.4). It is plausible that many rare plant species have colonised the *Utaki* sacred groves from the surrounding forests. Protection of the groves from exploitation has probably accommodated habitat specialists of mountain forests. By contrast, patterns of community composition are not associated with altitude, weather, or average, maximum or minimum of plots, which may relate to small range of altitudinal variation from 0 to 260 m a.s.l.

Table 4.4 Pearson's product-moment correlation coefficient (r, r^2) and Kendall tau rank correlation (τ) for NMS axes on 191 selected *Utaki* sacred groves on Okinawa-jima Island. Abbreviation used in Figure 4.15 is shown in brackets.

Axis	1			2			3		
	r	r^2	τ	r	r^2	τ	r	r^2	τ
Latitude (lat)	0.691	0.477	0.489	-0.217	0.047	-0.114	-0.22	0.048	-0.141
Longitude (long)	0.679	0.461	0.426	-0.216	0.046	-0.224	-0.196	0.038	-0.112
No. of species (gaz_spco)	0.391	0.153	0.353	-0.15	0.022	-0.063	-0.495	0.245	-0.411
GHI (valid_sc)	0.413	0.171	0.345	0	0	0.003	-0.373	0.139	-0.279
Average alt.	0.102	0.01	0.045	-0.002	0	-0.063	-0.019	0	-0.049
Maximum alt.	0.102	0.01	0.096	-0.002	0	-0.114	-0.019	0	0.035
Minimum alt.	0.101	0.01	-0.027	-0.002	0	0.073	-0.019	0	0

Migration of rare species from the surroundings is a possible reason for some potential outliers such as *Benoki utaki* in Kunigami-son village in *Pinus luchuensis* plantation and *Ganahana utaki* in Ogimi-son village in exotic broad-leaf plantation that had GHI of over 400 despite the likely disturbance to the vegetation (Figure 4.15). The former *utaki* was recorded as 'a small hill surrounded by *Pinus*

luchuensis dominant community and cropland (Okinawa prefectural board of education, 1978)'. The latter *utaki* was 'on top of a hill covered by *Livistona chinensis* (Palmae) dominant community and *Pinus luchuensis* dominant community, apparently under human disturbance, shrub and herbaceous layers are in poor status (Okinawa prefectural board of education, 1980)'. Both groves were species poor (42 and 47 species for *Benoki utaki* and *Ganahana utaki* respectively) but contained some frequently recorded Black Star species such as *Pinus luchuensis* (Pinaceae), *Cycas revoluta* (Cycadaceae), *Aristolochia liukiuensis* (Aristolochiaceae) and Gold Star species: e.g. *Tarenna gracilipes* (Rubiaceae) and *Viburnum japonicum* (Caprifoliaceae). Given that both *utaki* sites are in northern part of the island, these rare species are likely to originate from less disturbed forested areas in the vicinity. The occurrence of these high ranking rare species in these species poor small forest fragments is probably linked to the unexpected high GHI in disturbed areas.

Many low scoring *Utaki* sites shared similar species composition irrespective of their location in the island and were in disturbed land type such as cultivated meadows, urban area and developed land (Figure 4.15). Vegetation in some high GHI sites along the coast near settlement that are in weedy cropland at present may have changed since the survey was conducted in the 70s and 80s. Therefore, revisiting the sites is necessary in order to further investigate the historical effect of disturbance on habitat conditions of these *Utaki* groves.

4.4.5 Correlation between species life-forms and bioquality

There was some – but only subtle – relationship between Stars and life form. Among five classes of life forms defined for species sampled in the Ryukyu Islands (both RBS and the *Utaki* combined), trees have a slightly higher representation among rare Star categories than other life forms (Figure 4.16). 17 Black, 16 Gold Star species are trees, representing 34.7% and 42.1% respectively for each Star category. 13 Black herb and 10 Gold shrub species, accounting for 26.5% of Black and 26.3% of Gold respectively followed trees in terms of the number of species and proportions. However, when the Star representation was compared within life forms, tree and herb had lower proportion of Black and Gold

species compared to shrub or climber (18.4% of tree, 24.7% of shrub, 20.4% of climber, 8.3% of herb, and 8.0% of fern were assigned Black or Gold status).

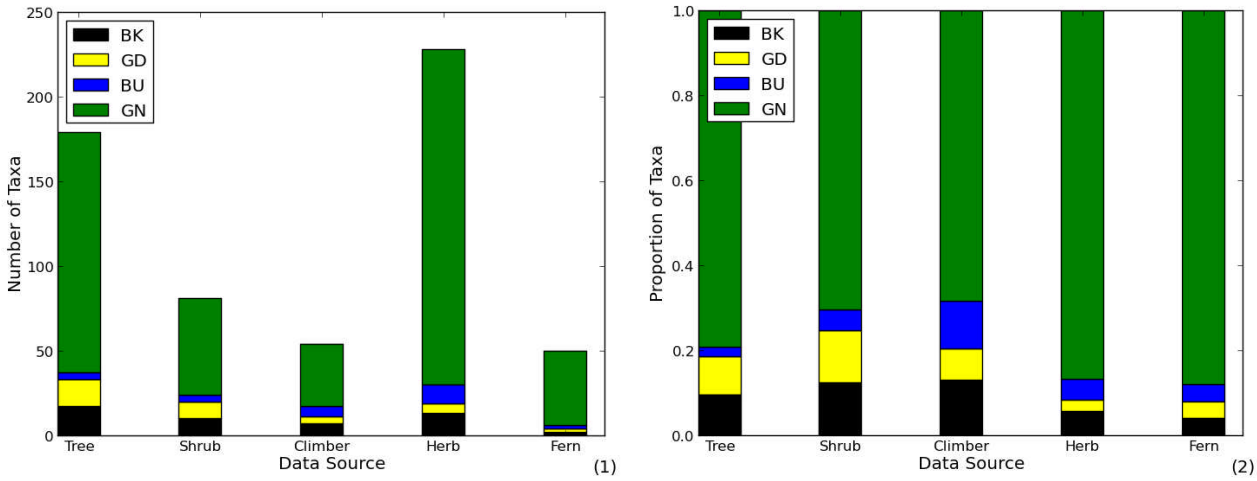


Figure 4.16 The number (1) and proportion (2) of four Star categories in relation to selected life forms. Climbers include lianas and vines. Herb represents herbaceous plants on the land surface.

4.5 DISCUSSION

4.5.1 The Ryukyu Islands bioquality hotspot

The Ryukyu Islands were confirmed to be bioquality hotspots on a local level from two case studies based on field surveys. There was some local variation within the area, but most RBS samples and many of the *Utaki* sacred groves scored a high GHI over 200. This implies that many parts of the Ryukyu Islands have high bioquality, and the island group on the whole should be recognised as an important area for conservation.

The key highlight of this study outcome is that the Ryukyu Islands hotspots were identified by a globally standardised and quantitative measurement based on field survey data. This is a step ahead of descriptive studies on individual species or locally important plant communities reported in the past, most of which were published only within Japan (Aramoto *et al.*, 2005, Hotta, 2003). A checklist-based assessment on similarities in species composition of 26 islands of the Ryukyu Islands (Nakamura *et al.*, 2009) is one of the few examples available in the English-language literature, yet this study did

not explicitly focus on conservation importance of plants. Internationally, the Ryukyu Islands have been identified as a conservation priority area (Olson and Dinerstein, 2002, Rodrigues *et al.*, 2009), but survey-based priority evaluation on a standardised measurement like GHI has rarely been the case for plant community analysis. Hence, hotspot analysis using RBS data on Okinawa-jima Island and survey data of the *Utaki* sacred groves is expected to have a critical contribution to enhance scientific understanding of the area and to re-emphasise its conservation importance globally.

All high scoring areas predicted by Horikawa geoquadrats contained RBS samples or *Utaki* sacred groves with high GHI. This is a significant finding highlighting that coarse resolution maps with only 10% of the Japanese flora sampled were verified to be a good predictor of hotspots. Only one geoquadrat on the south-east of Miyako-jima Island with low GHI was shown to have plant communities with a high GHI in the *Utaki* samples (Figure 4.10). Underestimation of GHI by coarse resolution maps is likely to be unavoidable due to the inclusion of many different land types that may be of low interest (e.g. urban areas) at local level. Some very local hotspots can become obscured at coarse resolution. Local sampling is particularly crucial in enhancing our understanding of which plant communities or which species are globally rare on individual site levels where management practices would be taken. More importantly however, the fine-level bioquality hotspots were in most cases detected at coarser resolution.

4.5.2 Hotspots from a species perspective

At the species level, field surveys indicated that many of the globally rare species are locally common. Some typical species in the Ryukyu Islands such as *Pinus lutchuensis* (Pinaceae), *Cycas revoluta* (Cycadaceae) and *Quercus miyagii* (Fagaceae) are Black Star species, endemic to the islands (Numata, 1974). Many other Black and Gold species were recorded frequently in the *Utaki* sample plots, thus apparently common in the islands. This supports the finding by Williams *et al.* (2009) on vertebrates in the Australian Wet Tropics that globally rare species seemed to avoid extinction by being locally abundant. Species with restricted geographic ranges were habitat specialists with high local abundance,

suggesting that rare species may have evolved with strong adaptation to local climatic fluctuations and can expand their range in suboptimal conditions, compared to generalist widespread species (Williams *et al.*, 2009). Abundance in terms of the number of individuals per plot was not extracted from the *Utaki* sample data; hence there is a limitation in interpretation of the present results. High frequency of some Black Star species in relation to species record totals (Table 4.3) implies potential high abundance in their habitats, though this remains unexamined. *Pinus lutchuensis* (Pinaceae) is a dominant tree in forests, which was the only Black Star species with high abundance score in RBS samples. An interesting question to be addressed for the future work in the Ryukyu Islands would be: do globally rare species that are only restricted to the islands have larger local populations compared to widespread species?

Table 4.5 Comparison of species assessed in the Japanese Red List of Threatened Species and the Star system.

Star infra-selective	The Japanese Red List of threatened species				
Star category	**Critically Endangered**	**Endangered**	**Vulnerable**	**Near Threatened**	**No data**
Black	0	2	8	4	37
Gold	0	2	3	3	26
Blue	1	0	1	0	33
Green	3	2	6	6	495
No Star	1	2	0	2	124

In comparison with other species-based conservation assessments, there was some level of agreement between the Star system and the Japanese Red List of Threatened Species (Table 4.5) and with the global IUCN Red List of Threatened Species. However, there was no overall pattern, which was expected given that these three systems have different criteria for priority setting. Three Critically Endangered species by the Japanese Red List – *Arthropteris palisotii* (Oleandraceae), *Lepistemon obscurum* (Convolvulaceae) and *Polyalthia liukiuensis* (Annonaceae) – are widespread in tropical Asia thus assigned Green Star status. It is probably their limited distribution in the southern Ryukyu Islands that led these species to have high conservation status in the national context. A national focus can be misleading in interpretation of important species for conservation. Clear definition of conservation targets and application of conservation assessment of direct relevance to the targets is crucial to avoid

such potential confusion. Caution is also needed with the (globally focused) IUCN Red List. Two Black Star species – *Pinus lutchuensis* (Pinaceae) and *Cycas revoluta* (Cycadaceae) – were listed in the IUCN Red List as Least Concern. This status may reflect high local abundance. One Black Star species *Satakentia liukiuensis* (Palmaceae) was recorded as Data Deficient in the IUCN Red List but was Near Threatened in the Japanese Red List. This species is known to be only found in two islands of Ishigaki-jima and Iriomote-jima globally, thus it is probable that only the classifiers of the national list would have access to detailed local records of the species, and so were better able to rank this species' conservation status. A further ten and one Green Star species were also treated as Least Concern and Data Deficient respectively in the IUCN Red List. Such low coverage of assessment (15 out of a total 761 species recorded cumulatively for RBS and the *Utaki* samples) severely limits the scope for using the red list information in conservation planning at this time.

4.5.3 Linking hotspots with ecological and geographic characteristics

Landscape units defined by combinations of habitats and geographical features observed on the ground were generally congruent with patterns identified in similarities of species composition of the samples (Figure 4.14). By contrast, the national vegetation classification did not show such a clear pattern with respect to species composition or GHI. RBS samples were mainly conducted in forest areas, which host globally rare forest species such as *Cinnamomum sieboldii* (Lauraceae) and *Camellia lutchuensis* (Theaceae). Admittedly, the outcome from 21 samples across one island that extends 100 km along a north–south axis is more of a quick scan than detailed examination of local variation. Over 450 plots were surveyed for the *Utaki* sacred groves, but about half contained fewer than 40 species records and the survey was conducted during the late 1970s. More sampling on different vegetation types or geographic areas is important to reinforce the generality of these findings. Nevertheless, the two study sites have already shown some interesting insights on bioquality hotspots of the Ryukyu Islands.

Landscape units that combine habitat and geographical characteristics of the area are thus expected to be a good predictor of patterns in species composition on individual sites compared to the national

vegetation classification. One recommendation for future study, as an efficient approach for detecting bioquality hotspots at management level, is to collect field survey data based on landscape classes, such as mountain ranges or calcareous land, rather than selecting study sites using the national vegetation classification.

There was only weak correlation between altitude and GHI in the Ryukyu Islands for RBS samples. This may relate to relatively low elevational gradient from 0 m up to about 500 m a.s.l. across the island group compared to other regions. The highest peak of the Ryukyu Islands is Mt. Omoto-dake (526 m) on Ishigaki-jima Island, followed by Mt. Yonaha (503 m) on Okinawa-jima Island – excluding Mt. Yuwan (694 m) in Amami-oshima Island, which was not surveyed for the *Utaki* sacred groves. In mainland Japan, potential bioquality hotspots predicted by coarse resolution maps were concentrated on high mountains most of which were over 1,000 m in elevation. Some studies have shown an increase in range-restricted species or endemic species richness of plant communities with an increase in altitude – though endemicity declines above the elevational limits of many species (Kessler, 2000, Vetaas and Grytnes, 2002). This is likely to be the case for mainland Japan, but a different scenario can be suggested for the Ryukyu Islands.

It is hypothesised that in the Ryukyu Islands, the land area and geographical distance between islands that affect species' dispersal patterns may have played a more prominent role in the evolutionary history of rare species than elevation. Based on their vegetation survey in the forested northern part of Okinawa-jima Island, Shinzato *et al.* (2007) proposed that the phytogeography of the island is linked to seed dispersal and migration patterns. The dominant species at high altitude and in higher forest strata (e.g. trees) were temperate species with gravity dispersal type; these species may have migrated to the island when it was connected to mainland Japan under a cooler climate and later remained in the area (Shinzato *et al.*, 2007). Low-stratum (shrub and herbaceous) species at lower altitude are often bird-dispersed or wind-dispersed species which may have spread after the land separation from Asia and Japan (Hotta, 2003). This may be linked to the slightly higher proportion of rare tree species than other life forms (Figure 4.16). A possible scenario for this would be that short-distance-dispersal trees may

have become isolated from populations far away from the Ryukyu Islands, and have evolved into distinct species within their narrow range. Further investigation on the relationship between global rarity and species traits would be an interesting research focus as a next step to understand these bioquality hotspots.

4.5.4 Bioquality assessment of the selected *satochi-satoyama* landscape

Case study 1 of the *satochi-satoyama* showed low bioquality scores on survey sites, confirming the broader-scale analyses in Chapter 3 (low values on lowland areas). This outcome suggests that the government's current focus of the landscape as one of the key priority issues in biodiversity conservation should be re-evaluated. One possible direction, which would align with the *satoyama* initiative target, would be to re-direct conservation of the rural agricultural landscape to highlight its cultural significance. Cultural services (e.g. landscape aesthetics, cultural heritage, recreation, and tourism), spiritual and religious significance have increasingly been recognised in biodiversity conservation science particularly from an ecosystem services perspective, although systematic studies are still limited (Daniel *et al.*, 2012). A questionnaire-based survey on the public perception of the *satochi-satoyama* landscape revealed that the word 'biodiversity' is rarely used in publicity by various local NGOs and conservation bodies (Iwata *et al.*, 2011). This term was regarded as a difficult concept to highlight as a conservation target compared to other potential foci, such as iconic species that are familiar to the public (Iwata *et al.*, 2011). Hence promoting conservation from cultural importance is probably more sustainable and would be likely to gain higher public appeal than biodiversity *per se*.

Species that are of local conservation importance, as highlighted in other studies (Inoue, 2001, Katoh *et al.*, 2009), were not explicitly examined in this study, but some individual species may be of interest in local conservation planning. This would be especially important in urban areas where the *satoyama* forests are often the only remaining forest vegetation (Hattori *et al.*, 1995). There were two new sampling records of beetle species in the region in the study plots: *Rosalia bates* (Cerambycidae) in Shimodate Kagesawa (Makihara and Nakamura, 2009b), and *Agrilus viduus subviduus* (Buprestidae) in

Funabashi (Makihara and Nakamura, 2009a). These species are known to be forest species in mountainous regions (Nakane and Nihon Seibutsuchiri Gakkai., 1969), suggesting that these lowland forest patches have provided important habitats for such species sensitive to changes in habitat conditions (Makihara, H. personal communication). Therefore, it is recommended that reform of conservation policy for the *satochi-satoyama* landscape should also distinguish 'local' conservation value from global rarity. More work on a range of species across Japan on individual site basis would be of crucial benefit to re-analyse the significance of locally rare species and habitats as well as to re-define local conservation priority.

4.5.5 Limitation of the case studies

There are limitations in interpreting findings from this case study. Firstly, the sample size of 39 RBS for the *satochi-satoyama* landscape and 21 for the Ryukyu Islands is very small, hence the results should be considered as an initial outcome rather than a generalised conclusion. More field sampling of both sites is critical to further investigate the overall patterns of bioquality as well as to depict local variations to verify the current research outcome. Secondly, it should be noted that only one aspect of conservation prioritisation was examined here. Bioquality assessment focuses on the global rarity of plant species and communities; hence separate evaluation of other attributes that affect conservation decision making should be conducted (Polasky, 2008). Assessment of socio-economic factors and temporal changes in habitat conditions are important in order to enhance the holistic understanding of the conservation status of Japanese landscapes.

4.5.6 Conclusion: future conservation perspectives

Different agendas should be highlighted for the culturally important *satochi-satoyama* landscape and the Ryukyu Islands bioquality hotspot in the national conservation framework. Further field sampling on the Ryukyu Islands is crucial to pinpoint more extensively patterns of global rarity in the plant

communities. Locations where GHI is particularly high should then be utilised in new protected area designation. North-east Okinawa-jima Island, where the surveyed mountain ranges all had high bioquality, is recommended as a primary focus for future work. This agrees with the suggestion made as the result of gap analysis led by the government (Ministry of the Environment of Japan, 2010c). However, this work is limited in scope in a sense that it only revealed spatial patterns with respect to endemic species richness and areas with high number of threatened species. The advantage of the bioquality approach is that it is able to demonstrate variations in plant communities in a quantitative manner. Calculated GHI may also be directly compared to other parts of the world in such a way that global importance of hotspots can be explicitly argued. For instance, the highest-scoring areas in the Ryukyu Islands (over 350) are suggested to be equally as important as mature deciduous forests in Oaxaca, Mexico with GHI of 358 (Gordon *et al.*, 2004). The concentration of hotspots in mountain ranges in the Ryukyu Islands also agrees with the sub-montane forest hotspot identified by a case study in Campo-Ma'an rain forests, Cameroon, with similar variation in GHI (Tchouto *et al.*, 2006). In order to implement conservation actions effectively, the accumulation of research findings such as those from this study is important to build a strong case for the conservation of globally important areas.

The *satochi-satoyama* landscape has scope for promoting conservation from social and cultural aspects, within the national context. Economic values of sustaining traditional management in the *satochi-satoyama* landscape were argued to be very limited, hence the long-term conservation planning is critically important (Takeuchi, 2010). Takeuchi (2010) suggested 'commons' – as a potential approach to promote management of the landscape, although it would require reform of the land property laws which have constrained the local-led conservation activities to date due to complications regarding land ownership (Kotera, 2008). Future policy development for the *satochi-satoyama* landscape should 1) propose a new direction that emphasises the social and cultural importance of the landscape; and 2) consider the long-term financial feasibility of management activities surrounding the area.

The future of sacred groves with high biological conservation value relies on the involvement of local communities and public awareness. Urban development surrounding the sacred groves, which has led

to isolation of forest fragments, was highlighted as the significant constraint in conservation in mainland Japan (Ishii *et al.*, 2010). This was probably related to some low scores of the *Utaki* sacred groves in urban areas of Okinawa-jima and Ishigaki-jima islands. A conservation framework that is built upon local customs with enhanced community engagement is likely to be more efficient than a conventional protected area approach (Bhagwat and Rutte, 2006). For the *Utaki* sacred groves, re-evaluation of the current condition of individual sites and survey on perception of local communities who own the sites is a key to increase the awareness on biological importance of these areas.

This study has highlighted the potential use of a range of existing data: from coarse resolution maps, historical data from literature, to survey plots. This is an important finding in the Japanese context because a vast amount of botanical knowledge and vegetation survey data on many parts of the country already exists. Further tests on the potential use of existing data to detect bioquality hotspots would be an interesting exercise in addition to field surveys that can provide geographic and environmental variables on the ground to investigate ecological correlates of bioquality.

5 Bioquality assessment in comparison to selected measures of biodiversity

5.1 INTRODUCTION

5.1.1 Bioquality as a conservation evaluation tool

The main focus in this chapter is to investigate the strengths and weaknesses of the bioquality approach as a conservation assessment tool against selected measures of biodiversity and in relation to the existing national protected area network. Specifically, I first examine spatial congruence in bioquality hotspots with those identified by selected measures of biodiversity. Using bioquality hotspot maps, I then perform a gap analysis to explore the effectiveness of existing protected areas and to highlight priority areas that are currently under-protected.

Despite considerable research interest in finding support for hotspot analysis as an optimal method of conservation prioritisation (Reid, 1998), many studies have pointed out that there is little congruence among hotspots of species richness, endemism and threatened-species richness (Ceballos and Ehrlich, 2006, Orme *et al.*, 2005, Williams *et al.*, 1996). Identification of hotspots using different biodiversity measures has been attempted from global to local levels on various taxonomic groups (e.g. U.K. for birds Williams *et al.* (1996), vertebrates' global distribution (Grenyer *et al.*, 2006), primates in Asia, Africa and South America (Harcourt, 2000)). Several studies that compared the global distributions of amphibians, reptiles, birds and mammals showed that although spatial patterns of species richness or endemism *per se* were highly correlated between different taxonomic groups, peaks of these two measures tend to be less congruent (Grenyer *et al.*, 2006, Lamoreux *et al.*, 2006, Orme *et al.*, 2005). Grenyer *et al.* (2006) revealed that species richness was highest on the neotropical mainland across all studied taxonomic groups of birds, mammals and reptiles, while patterns of endemic species richness varied, with the highest found in oceanic islands for birds, continental shelf islands for mammals, and the continental land mass for reptiles. Similarly, for birds' global breeding range, only 2.5% of the hotspot area overlapped for species richness, threatened-species richness, and endemism, in which a hotspot was defined as the top 2.5% of each index (Orme *et al.*, 2005). These findings imply that one

should expect spatial patterns of hotspots to be different depending on the index of biodiversity adopted.

Spatial patterns of hotspots were found to be scale-dependent, in terms of both the spatial resolution of the hotspot map and the definition of rarity (Grenyer *et al.*, 2006, Leroux and Schmiegelow, 2007, Reid, 1998). Spatial variation in habitats becomes more prominent on finer-resolution maps, reducing the overlap in the distribution of widespread and rare species with different habitat requirements (Reid, 1998). Given that species-rich areas are not necessarily rich in rare species, spatial congruence between the two measures declines at finer resolutions (Ceballos and Ehrlich, 2006, Orme *et al.*, 2005). Arbitrary cut-off points to define rarity hotspots are often employed, such as the rarest 2.5% of avian geographic range sizes globally (Orme *et al.*, 2005) or rarest 5% or 25% of bird ranges within the U.K. (Williams *et al.*, 1996). A more stringent definition of rarity lowers the spatial congruence of rarity hotspots in a similar way to changing the spatial resolution (Ceballos and Ehrlich, 2006, Grenyer *et al.*, 2006). Hotspot concordance analyses should therefore be examined cautiously with regard to the resolution and definition applied in each analysis.

Here the important issues are: what differences are there in hotspots suggested by bioquality assessment compared to other biodiversity measures in Japan? What fine-resolution hotspot patterns can or should be depicted on national maps? Given that few hotspot analyses have been done in Japan (Kato and Ebihara, 2011), this study is the first to compare different biodiversity hotspot measurements.

Availability of fine-resolution species distribution maps at 10′ latitude by 15′ longitude (approximately 20×20 km^2 grid square) enables examination of spatial concordance of hotspots in much more detail than previous studies at global level, e.g. 1° latitude/longitude grid for vertebrates (Ceballos and Ehrlich, 2006, Orme *et al.*, 2005). Such fine-resolution analysis is of direct relevance to national conservation management.

5.1.2 Biodiversity measures chosen for comparative analyses

A main goal of many biodiversity-conservation-related measures is to recommend protected areas (or sustainable use) that maximise protected diversity regionally or globally. Several measures of biodiversity were selected for comparative analysis in this study: the number of species (species richness); the number of Japanese endemic species (endemic species richness); and range size rarity, called corrected weighted endemism (CWE). It is self-evident that all these measures have different criteria for priority ranking, and thus are expected to generate different conservation targets (Orme *et al.*, 2005, Williams *et al.*, 1996). There are pros and cons in adopting any of these measurements that need to be understood to provide a balanced set of priorities.

Species richness and endemic species richness indices have gained a popular claim in conservation science based on the notion that they would maximise the total number of species conserved for a limited area under protection (Magurran, 2004). However, both have severe weaknesses as a conservation prioritisation index. The problem with species richness is that it masks other potentially important prioritisation factors such as species rarity, range size, abundance, or habitat speciality, however defined (Gaston, 1994). Maximisation of species richness for certain priority areas does not in any way guarantee maximisation of species richness in the network of protected areas across the whole study region (Curnutt *et al.*, 1994, Pearman and Weber, 2007), and is even more deficient in prioritising protected areas that might maximise the protection of species numbers globally. For that, either the complementarity of different areas has to contribute to their prioritisation, or alternatively analysis of individuality or endemism within priority areas can be considered (Funk and Fa, 2010).

Endemism and therefore endemic richness scores are often defined at national or regional level, e.g. Japanese endemics or endemic to Mediterranean region. This may be useful within national contexts, but comparisons between different regions are not possible because the total area to which species are endemic is not standardised (Brooks *et al.*, 2002). Range size rarity or CWE is a species assemblage measure that has been applied across various regions (e.g. Africa (Linder, 2001), Australia (Crisp *et al.*, 2001), and the U.K Williams *et al.* (1996)). In the CWE method, a species is ‘down-weighted by dividing each grid-square occurrence by the total number of grid squares occupied’ (Crisp *et al.*, 2001,

Linder, 2001), then the index is calculated by taking 'the sum of this range-down-weighted species values for each grid, controlled for the total number of species in the grid' (Crisp *et al.*, 2001, Linder, 2001).

The general principle behind calculation of this community rarity score is the same as the Genetic Heat Index (GHI) (Hawthorne, 2012), but there are two major differences. Firstly, calculation of "species' rarity weights" directly from their grid square occurrences across the study area in the CWE method is a more precise measurement compared to the four-level categorical division of Stars by the GHI. However, it means that grid occurrences – at whatever resolution used - of all species examined must be known in order to calculate an index. For a globally standardised score like GHI, this would be practically impossible with the currently available data. Given that the Star is assigned based on descriptive information of species' global geographic range size, following the Keys developed (Hawthorne, 2012), GHI can be calculated for a wide range of species assemblages even when accurate distribution information for individual species may not be available. The application of descriptive information to calculate coarse-resolution GHI such as administrative boundaries (e.g. prefectures) was found to be practical for global distribution of Japanese species in Chapter 3: an equivalent global analysis would not be possible in the CWE approach.

Furthermore, weight measurement in the CWE is dependent on the grid resolution and the total spatial extent of examined area (Kier and Barthlott, 2001). For instance, Crisp *et al.* (2001) used a 1° latitude/longitude grid on Australia (over 7.6 million km^2) while Linder (2001) adopted a 2.5° grid on sub-Saharan Africa (over 13 million km^2). Species' rarity weights can vary between regions even for the same species in different CWEs, hence an index is only meaningful inside the study area and is not globally standardised. GHI and the Star system, for which mean geographic range size of each of four Stars is intended to be globally standardised (Hawthorne, 2012), can be compared quantitatively between different study sites and regions. The Star system also differs from CWE by allowing users to adjust species' weights according to taxonomic and other factors.

Given the differences in what each biodiversity index measures and variation in their definitions, the first main challenge in this chapter is to analyse how these underlying differences of indices affect spatial patterns of hotspots. Because Japan is a large region with so many endemic species, there may be less difference in patterns shown in a national CWE and a global score like the GHI than those apparent in smaller study areas. Thus, the comparison below is in no way a foregone conclusion. This analysis should be crucial to help steer conservation policy development in Japan by laying out the options for what to optimise and by ranking areas accordingly.

5.1.3 Establishing Protected Area Network in Japan

Japan's network of protected areas is the cornerstone of the strategy to conserve biodiversity locally and globally in addition to species or habitat specific protection schemes (Biodiversity Centre of Japan, 2012). Areas currently under-represented in terms of bioquality hotspots need to be identified; new protected areas and priorities can then be proposed. The Convention of Biological Diversity (CBD) 2020 targets states that by 2050, global protected area coverage is expected to increase to 17% for terrestrial and inland-water ecosystems (Aichi 2020 Biodiversity Target 11 (Secretariat of the Convention on Biological Diversity, 2010)). The Japanese Biodiversity Strategy does not clearly state its national target of protected area coverage in response to the 2020 target. Nevertheless, it is recognised that the key challenge in the national context is to enhance the network of protected areas (Ministry of the Environment of Japan, 2010a).

An important question addressed here is: how does the current condition of conservation areas reflect this target of 17% protected area coverage and to what extent do or can priority areas cover bioquality hotspots?

Two major constraints in the existing protected area network in Japan are: lack of understanding of the effectiveness of these protected areas as an ecological network; and complication with different schemes for protected areas designation. Just under 15% of terrestrial ecosystem in Japan is under legal protection chosen by various criteria with some spatial overlap between the categories (Ministry of the

Environment of Japan, 2012a). Nature reserves in Japan are mainly divided into two categories: strict conservation areas and natural parks (Ministry of the Environment of Japan, 2012b).

The primary focus of strict conservation areas is protection of natural environment especially for those ecosystems that have had minimal human intervention over a long time (Biodiversity Centre of Japan, 2012). Restriction on access and land use is at the highest level in these areas. In addition to three types of conservation area (Table 5.1), there are some species or habitat specific sites, such as Wildlife Protection Areas, Habitat Conservation Areas, Natural Monuments, and Ramsar Convention sites (Biodiversity Centre of Japan, 2012).

Natural Parks have been selected to serve as recreational places to encourage public awareness for nature conservation in addition to biodiversity conservation (Ministry of the Environment of Japan, 2010a). Natural parks are categorised into National, Quasi-National, and Prefecture levels (Table 5.1) in decreasing level of ecological significance (Ministry of the Environment of Japan, 2012b).

Table 5.1 Summary statistics of area coverage of existing protected areas in Japan as of 2012 (Ministry of the Environment of Japan, 2012a)

	No. of Sites/Parks	Total Area (ha)	Japanese Land Surface (%)
Conservation Areas			
Wilderness Area	5	5,631	0.015
Nature Conservation Area	10	21,593	0.057
Special Conservation Site	541	77,342	0.204
Conservation Areas total	**556**	**104,566**	**0.276**
Natural Parks			
National Park	30	2,093,363	5.539
Quasi-National Park	56	1,362,613	3.605
Prefecture Park	315	1,977,528	5.232
Natural Parks total	**401**	**5,433,504**	**14.376**

The effectiveness of protected areas is largely untested across Japan (Kamei and Nakagoshi, 2006). It was only in 2010 that the government commissioned a systematic review of natural parks across the country (Ministry of the Environment of Japan, 2010c). Designation criteria for both strict conservation areas (Ministry of the Environment of Japan, 2012d) and natural parks (Ministry of the Environment of Japan, 2012b) are frequently filled with ambiguous phrases. The five Wilderness Areas and ten Nature Conservation Areas together account for less than 0.1% of land area in Japan (Table 5.1). Special

Conservation Sites at the prefectural level only add 0.2% of land area. This sum is very small, and it is recognised that habitat conditions of even these designated areas have not been evaluated thoroughly (Ministry of the Environment of Japan, 2010a). This is especially a problem at lower administrative levels, such as prefectural conservation sites. The National Biodiversity Strategy admits that 'investigation of current conditions of these ecosystems and improved management planning in response to review outcome' is a priority issue (Ministry of the Environment of Japan, 2010a).

Enforcement of different roles in various protected areas is also weak. The main functions of natural parks are defined as 'to protect distinct natural landscapes, to increase the public awareness through enhanced accessibility, and to contribute to secure biodiversity conservation' (Ministry of the Environment of Japan, 2010c). The parks cover 14.3% of the Japanese land surface and play a significant role in securing large-scale protection of ecosystems across Japan and as recreational sites. A total of 600 million people visits per annum is recorded cumulatively for 86 National and Quasi-National Parks (Ministry of the Environment of Japan, 2010a). This emphasises the important role of natural parks in raising public awareness about biodiversity conservation. Beyond this public information value, the development of ecological networks between existing national parks and other protected areas is critical in enhancing their core functions. This issue has been addressed (Ministry of the Environment of Japan, 2010a), yet little work has been conducted explicitly to improve the functionality of different parks.

Gap analysis (Scott *et al.*, 1993) can be used to assess the efficiency of protected area networks. By overlaying bioquality scores on the protected areas, hotspot areas that are outside or have little spatial overlap with protected areas can be identified as priority areas with respect to the global rarity of plant species and communities. Gap analysis has been increasingly applied in the evaluation of efficiency in existing protected areas at national levels (e.g. England (Oldfield *et al.*, 2004), Canada (Wiersma and Nudds, 2009)) and at a regional level (e.g. European wetland species in Natura2000 (Jantke *et al.*, 2011)). Globally, Rodrigues *et al.* (2009) have conducted a large-scale gap analysis by overlaying the existing protected area coverage on distribution maps in terms of the extent of occurrence for terrestrial mammals, birds, freshwater turtles and tortoises, and amphibians. Their work identified the tropics –

particularly tropical and subtropical moist forests – as urgent priorities for the expansion of the network of protected areas.

The other frequently applied systematic way to design protected area network is complementarity, a term formalised by Vane-Wright *et al.* (1991) that aims 'to provide minimum sets of sites that can maintain biodiversity at its maximum' (Kati *et al.*, 2004). Reserve selection algorithms compare shared and non-shared species between sites each time a reserve is selected to measure 'the number of unrepresented species (or other biodiversity features) that a new area adds' (Margules and Pressey, 2000). This approach is analogous in principle to the similarity index but has a great disadvantage in that complementarity fails to recognise the ecological importance of individual component species. As in the species richness method, complementarity treats all species as having an equal contribution to biodiversity, and hence disregard species that have disproportionately high value for conservation such as rarity or threat status. An alternative, more scientifically plausible approach would be to combine a species assemblage measure such as GHI (or local weighted endemism) with ordination analyses. This could also pinpoint centres of different and complimentary ecological types, although it would be better than complementarity by virtue of placing absolute global hotspots as priorities (rather than some randomly chosen first protected areas). Due to the lack of data on measurable ecological variables to compare with GHI on Horikawa geoquadrat maps, such analysis is an angle for future study. In any case, complementarity on a global perspective would be impossible, and my study is mostly focussed on global priorities within Japan's borders.

Given that the total area of protected area in Japan is relatively high in relation to the CBD target, the critical questions are: is the present spatial coverage of protected area adequate in securing protection of bioquality hotspots, and where are the new priority areas identified to achieve 17% target as a nation?

5.2 RESEARCH QUESTIONS

1) To what extent are spatial patterns of bioquality hotspots, using Horikawa dot maps, congruent with other existing measures of biodiversity, notably endemism, species richness and range size rarity?

2) Is the current protected area coverage in Japan likely to be adequate for conserving bioquality?

3) Where are additional the priority areas that could be added to the existing protected area network to achieve the 17% target of the CBD at a national level and to improve Japanese contribution in response to global priorities?

5.3 METHODS

5.3.1 Plant species assemblages data

Presence records of 821 taxa on Horikawa geoquadrat maps (1,418 cells of 10′ latitude by 15′ longitude 'geoquadrat' grid) were used to examine the relationship between GHI and selected biodiversity measures (see Methods in Chapters 2 for data preparation and in Chapter 3 for GHI calculation). Horikawa geoquadrat maps represent approximately 10% of all accepted taxa compiled in the Flora of Japan database (8,262 taxa) and 9.9% of accepted endemic species (219 Japanese endemics in Horikawa maps out of 2,205 endemics with accepted names in the database).

For gap analysis, the Horikawa geoquadrat hotspots map was used as a baseline priority map. Additional bioquality maps obtained from different data sources were used as supplementary fine-resolution information in order to enhance the accuracy of GHI in those geoquadrats where additional data were available:

- Rapid Botanical Survey (RBS) plots: A total of 60 survey plots in two selected landscapes: the *satochi-satoyama* and Okinawa-jima islands (See Chapter 4).

- The *Utaki* sacred grove survey data: Vegetation survey data for a total of 474 *utaki* sacred groves of the Ryukyu Islands commissioned by Okinawa prefectural government (See Chapter 4).

- Checklists of selected islands: Available checklists for several islands were compiled from literature into BRAHMS. Islands where Horikawa geoquadrat maps were particularly data deficient were prioritised: Taketomi-jima island (Shinzato, 1985); Kuchierabu-jima island (Sako, 1978); Suwanose-jima island (Sako and Kirino, 1980); Takara-jima and Kodakara-jima Islands (Sako and Ueno, 1981); Taira-jima island (Sako and Fukushima, 1985); Akuseki-jima island (Sako, 1984); Kuroshima island (Sako and Maruno, 1983);Uji Islands (Ie-jima, Mukai-jima) (Sako *et al.*, 1988); Mage-shima island (Sasaki *et al.*, 1960); Tanegashima island (Sasaki and Ouchiyama, 1953); selected islands in the Ogasawara Islands (Chichi-jima island (Tanimoto *et al.*, 1995); Haha-jima islands (Shimizu, 1994); Muko-jima islands (Shimizu, 1993)).

- Ministry of the Environment's vegetation survey data (**MOE survey plots**). For MOE survey plots, GHI were calculated for 2,017 grid cells at 0.1° latitude by 0.1° longitude grid across Japan using species occurrence records of 3,322 taxa with Stars.

5.3.2 MOE survey plots

The Ministry of the Environment has conducted plot-based vegetation surveys in selected areas across Japan between 2000 and 2008. 29,144 locations of unique latitude–longitude coordinates have been surveyed using the proposed guideline (Japan Integrated Biodiversity Information System, 2008, Ministry of the Environment of Japan, 2012c). Species occurrence records and plot location data were obtained from Ito group at University of Tokyo, Japan in ACCESS database format. Taxa were identified by Japanese local names in the field, hence transferred to scientific names using the Flora of Japan database compiled in this study. Taxon occurrence records with plot locations were transferred to BRAHMS.

Given that some survey plots were repeatedly visited over years and that many plots had fewer than 40 species records, plot records were merged to 2,345 grid cells of 0.1° latitude by 0.1° longitude (**0.1-degree grid**), which was treated as a new sample unit (Figure 5.1). Of these samples, 2,017 grid cells contained species with Stars, but this was further reduced to 1,577 grid cells with 40 or more species, suitable for GHI calculation. A total of 386,588 taxon-occurrence records were compiled to the database, 98% of which were given scientific names in the Flora of Japan database. For the remaining 8,596 (2.2% of total) records, most species were identified only to higher taxonomic levels, and were omitted from analyses. 3,634 unique taxa were found in the entire data set, 3,322 species of which were assigned Stars (189 Black, 269 Gold, 500 Blue, and 2,364 Green Star species).

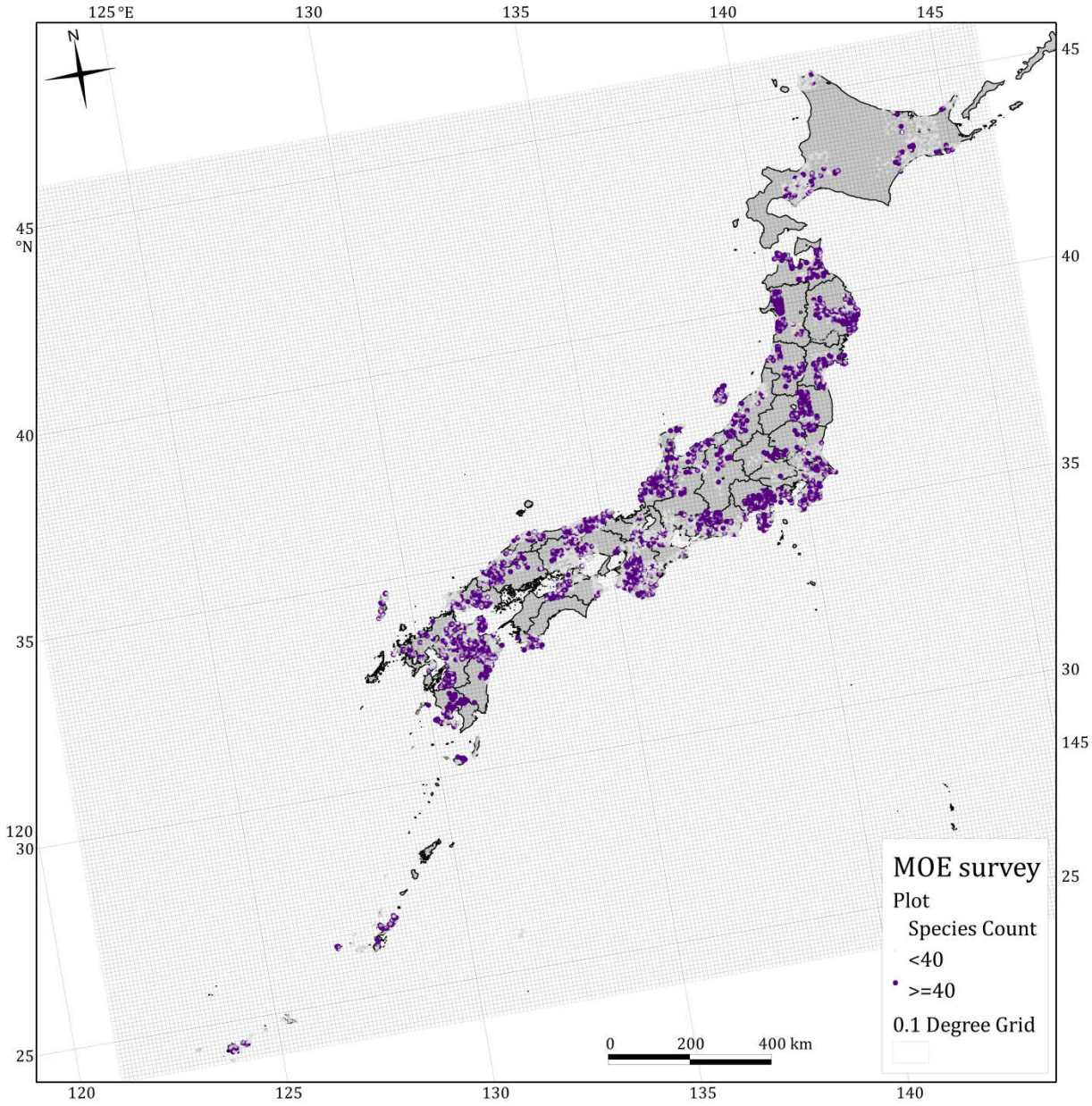


Figure 5.1 Ministry of the Environment's survey plot location and 0.1° latitude by 0.1° longitude grid cell (0.1-degree grid). Survey plots with 40 or more species (species count) are shown in dark blue.

5.3.3 Selected measures of biodiversity analysed

Three measures of biodiversity were compared with bioquality scores: the number of species; the number of endemic species; and CWE for each of 1,169 geoquadrats with more than 40 species' occurrence records. CWE was estimated following the methodologies applied in Crisp *et al.* (2001). Congruence between biodiversity measures was calculated by Pearson's *r* and Spearman's rho correlations using Spatial Analysis in Macroecology (SAM) software version 4.0 (Rangel *et al.*, 2010a).

All biodiversity measures were spatially autocorrelated (Moran's *I* using Gabriel connectivity with 199 permutations: GHI = 0.74, species richness = 0.556, endemic species richness = 0.685, CWE = 0.512; all $P < 0.005$), thus the statistical significance of correlations was tested by estimated degrees of freedom following Dutilleul (1993) method (Rangel *et al.*, 2010b).

5.3.4 The flow of gap analysis

The baseline GHI map using Horikawa geoquadrats were supplemented by MOE survey plots resampled on a 0.1-degree grid and other survey based data; these maps were then overlaid on protected area maps. Protected area maps showed Natural Parks at national, quasi-national, and prefectural levels (Geospatial Information Authority of Japan (GSI), 2010), and three types of Nature Conservation Areas (Geospatial Information Authority of Japan (GSI), 2011b) (Figure 5.2). Areas high in GHI but not covered by the existing protected area network were identified as priority areas for re-evaluation. Topography maps obtained from Hijmans *et al.* (2005) and resampled as 400-m contour lines in Quantum GIS (The Quantum GIS project, 2012) were also used as a guide for geographic features.

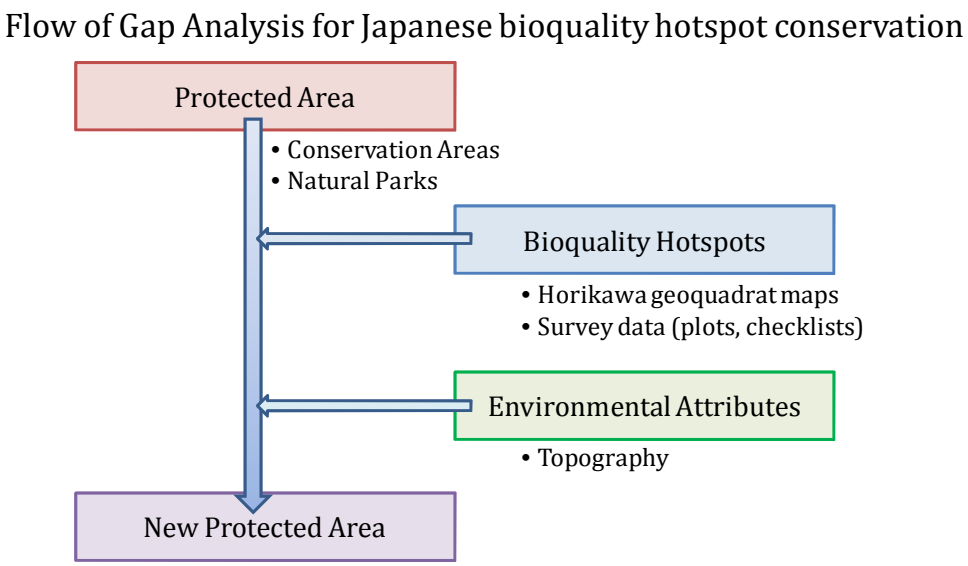


Figure 5.2 Summary of data layers used and steps for gap analysis. Horikawa geoquadrat maps and survey data were used to produce GHI layers, which were then compared for protected area coverage.

5.4 RESULTS

5.4.1 Comparison of GHI with selected biodiversity measures

Japanese endemic species richness and CWE showed some correlation with GHI (Table 5.2; Figure 5.3), but there was no clear, universally concordant spatial pattern between bioquality and any selected measure of biodiversity.

Species richness in the geoquadrat samples tends to increase with decreasing latitude, but the scattering of the species-rich geoquadrats across mainland Japan suggest a possible sampling bias. Horikawa, the author of geoquadrat maps was based in the University of Hiroshima in the vicinity of the area highlighted as the fourth highest geoquadrat in terms of species richness, for instance. It may be the case that collection intensity was lower in some regions than others. Hokkaido and Ogasawara islands which are geographically far from central Japan were expected to be more difficult to access and survey in the 1970s than mainland Japan. It has been established that such a bias shows no obvious effect on GHI or Star proportions (Chapter 2), and other ratio-derived indices, like CWE, are also likely to be less affected than absolute measures like species or endemic richness.

Endemic species richness hotspots were concentrated in high mountain ranges of central Honshu. High-altitude areas such as the Japanese Alps region also had higher GHI than lowlands, a general trend in mainland Japan (Chapter 3). In contrast, the subtropical islands of the Ryukyu Islands, one of the key bioquality hotspots, contained a low endemic richness, with fewer than 30 endemic species. Two possible explanations are likely to contribute to this difference: 1) the subtropical islands have many globally range-restricted species that are also found in Taiwan, and which are therefore not national endemics; and 2) high mountain ranges contain a higher proportion of widespread species (including some endemics) than subtropical islands. Endemism hotspot analysis that merely differentiates species in two categories of endemic or non-endemic gives no weight to non-endemic but globally rare species, while widespread national endemics are highly valued, resulting in different priority areas compared to bioquality hotspots.

CWE was generally low across Japan with high scoring areas towards the northern or southern tips of Japan. This reflects the high proportion of species in these areas whose within-Japan distribution is limited, though the species as a whole are not necessary globally rare. Species such as *Artemisia arctica* subsp. *sachalinensis* (Asteraceae), *Picea jezoensis* (Pinaceae), and *Salix nummularia* (Salicaceae) have their southernmost range in northern Japan; and tropical species, e.g. *Rhynchotechum discolour* (Gesneriaceae) or *Wendlandia formosana* (Rubiaceae), have their northernmost range in the Ryukyu Islands. These species are assigned Green Stars, while CWE implicitly highlights areas rich in these species as priority ones. The Ryukyu Islands as a whole scored higher than mainland Japan using CWE, but the small variation of less than 6 points across Japan highlights few hotspots compared to the other methods.

Table 5.2 Correlation analyses of different biodiversity measures.

Measurement type	Species richness	Endemic species richness	Corrected Weighted Endemism
Genetic Heat Index	Pearson's r = 0.327 Spearman's rho = 0.473 Corrected P = 0.003	Pearson's r = 0.344 Spearman's rho = 0.632 Corrected P <0.001	Pearson's r = 0.723 Spearman's rho = 0.594 Corrected P < 0.0001
Species richness		Pearson's r = 0.723 Spearman's rho = 0.768 Corrected P <0.001	Pearson's r = 0.146 Spearman's rho = 0.266 Corrected P = 0.309
Endemic species richness			Pearson's r = 0.034 Spearman's rho = 0.135 Corrected P = 0.723

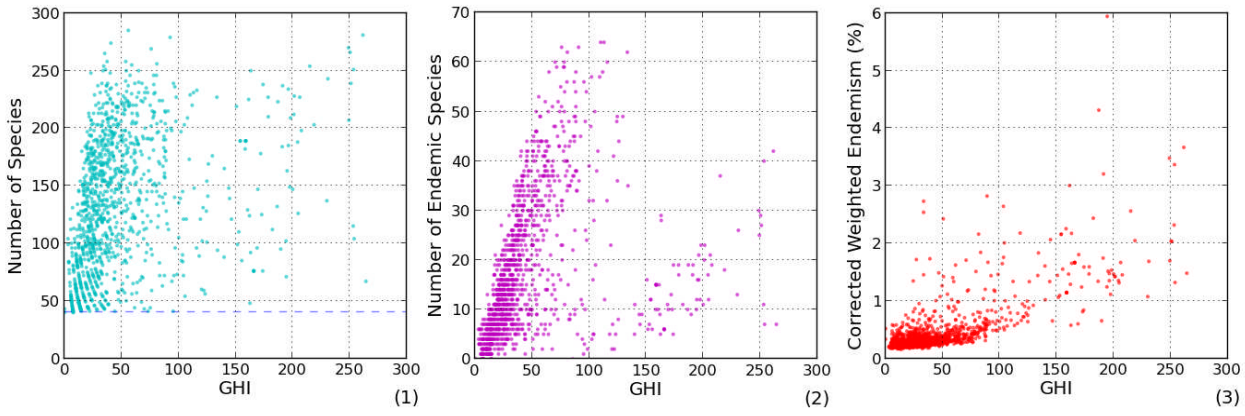


Figure 5.3 Scatter plot of Horikawa geoquadrat GHI against selected measures of biodiversity for 1,169 geoquadrats with 40 or more species: (1) the number of species; (2) the number of endemic species, and (3) corrected weighted endemism. Blue dotted line indicates 40 species in panel (1).

There were two levels of correspondence between high GHI and low endemic species richness (Figure 5.3 (2)). In the Ryukyu Islands, many rare (Black or Gold) species are non-endemic, for instance *Cirsium brevicaule* (Asteraceae) and *Vaccinium wrightii* (Ericaceae) only occur in Taiwan and the Ryukyu Islands. These species would be disregarded in endemism based analysis while they contribute to high GHI in global rarity assessment. Widespread endemics such as *Castanea crenata* (Fagaceae) and *Tsuga sieboldii* (Pinaceae) are Green Stars but are considered important merely because of their endemic statuses. Such disparity in the recognition of conservation significance at species level between two assessment methods is the likely cause for the apparent disagreement between GHI and endemic species richness.

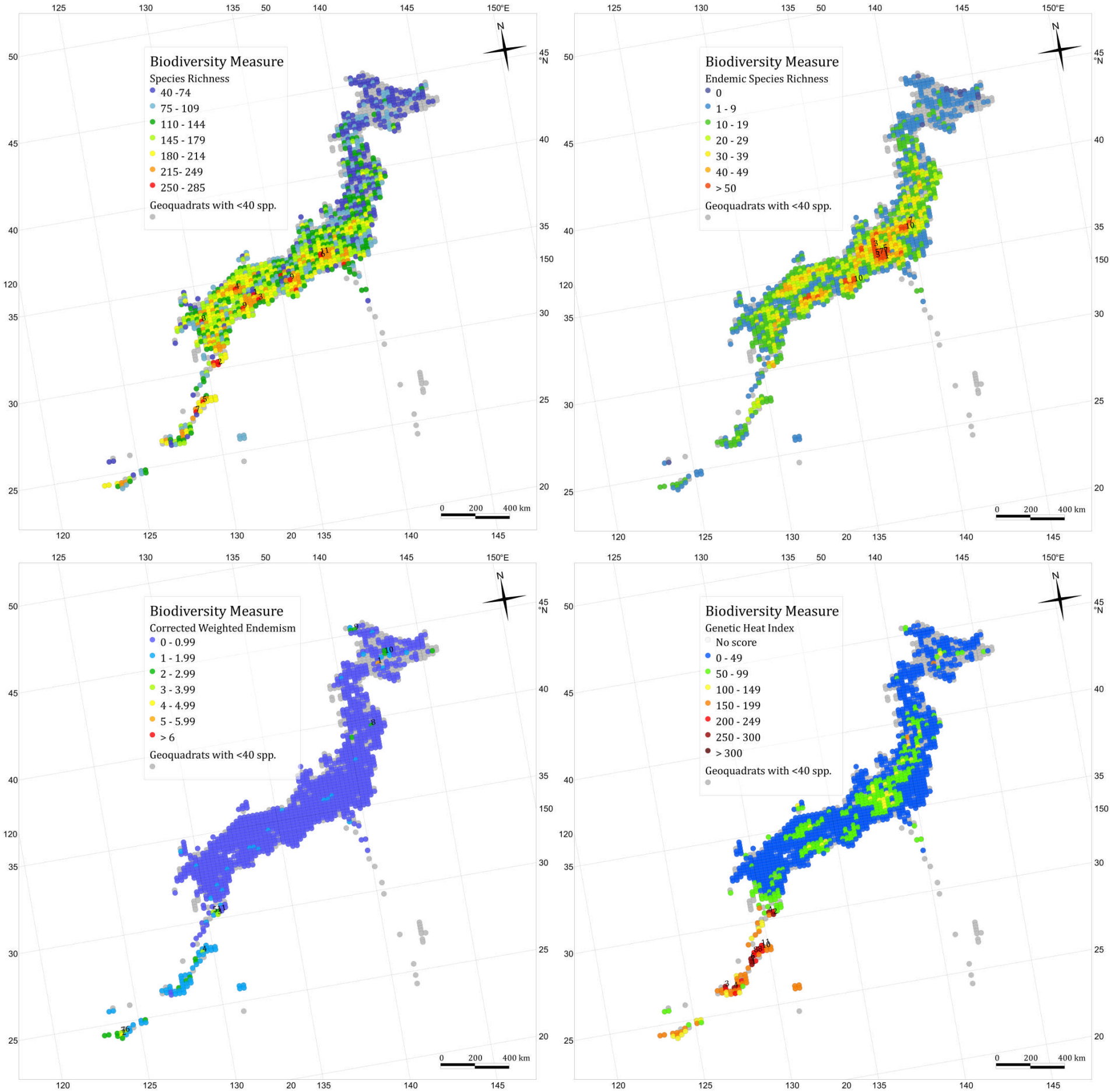


Figure 5.4 Spatial patterns of species richness, endemism, Corrected Weighted Endemism (CWE) and the Genetic Heat Index (GHI). Top 10 hotspots for each measure are numbered. The colour scale is standardised for the variation from minimum to maximum values across biodiversity measures.

5.4.2 Protected area and bioquality hotspots

The spatial overlap of existing protected areas and bioquality hotspots is very limited (Figure 5.5; Figure 5.6). Only 13 natural parks (3 national, 4 quasi-national and 6 prefecture) intersect partially with 81 geoquadrats with GHI over 150. Three national parks of Yakushima island, Iriomote–Ishigaki islands, and Ogasawara islands are however significant bioquality hotspots. Three of four quasi-national parks in Mt. Chokai, Amami-oshima island, and Okinawa-jima island coastline and six prefecture parks: Tokara islands, Kume-jima island, Irabu-jima island, Tonaki-jima island of the Ryukyu Islands, and Mt. Kabu in Yamagata, Furano-Ashibetu area of Yubari mountain range in Hokkaido would merit upgrade of their conservation status, particularly if they can be corroborated with on-site bioquality assessments. For three types of nature conservation areas, only six sites (four on the east side of Mt. Chokai, Dewa mountain range in Akita, Yamagata and two on Yonaguni-jima island of the Ryukyu Islands) were within geoquadrats of over 150 GHI. No geoquadrat with GHI > 200 are currently designated as nature conservation area and only limited areas are covered as natural parks at various administrative levels.

There was frequent overlap of protected areas and areas with moderate GHI (100–150) across mainland Japan. Some National Parks such as Yakushima island, Chubu mountain ranges, the Japanese Alps, and the Yoshino–Kumano area, cover areas that scored high GHI at finer resolution than geoquadrats, indicating bioquality hotspots within these areas (Figure 5.6). Many Prefecture Parks were in relatively moderate GHI areas including mountain ranges on Japan sea side of central Japan (e.g. Mt. Chokai), and Shikoku mountain ranges. Both Horikawa geoquadrats and MOE survey data are at coarser resolutions than many actual protected areas, so the exact extent of spatial overlap with these protected areas cannot be accurately observed. Nevertheless, moderate-priority bioquality areas measured at roughly 100 km^2 (MOE survey data) or 400 km^2 (geoquadrat) were shown to be under at least some legal protection in most cases.

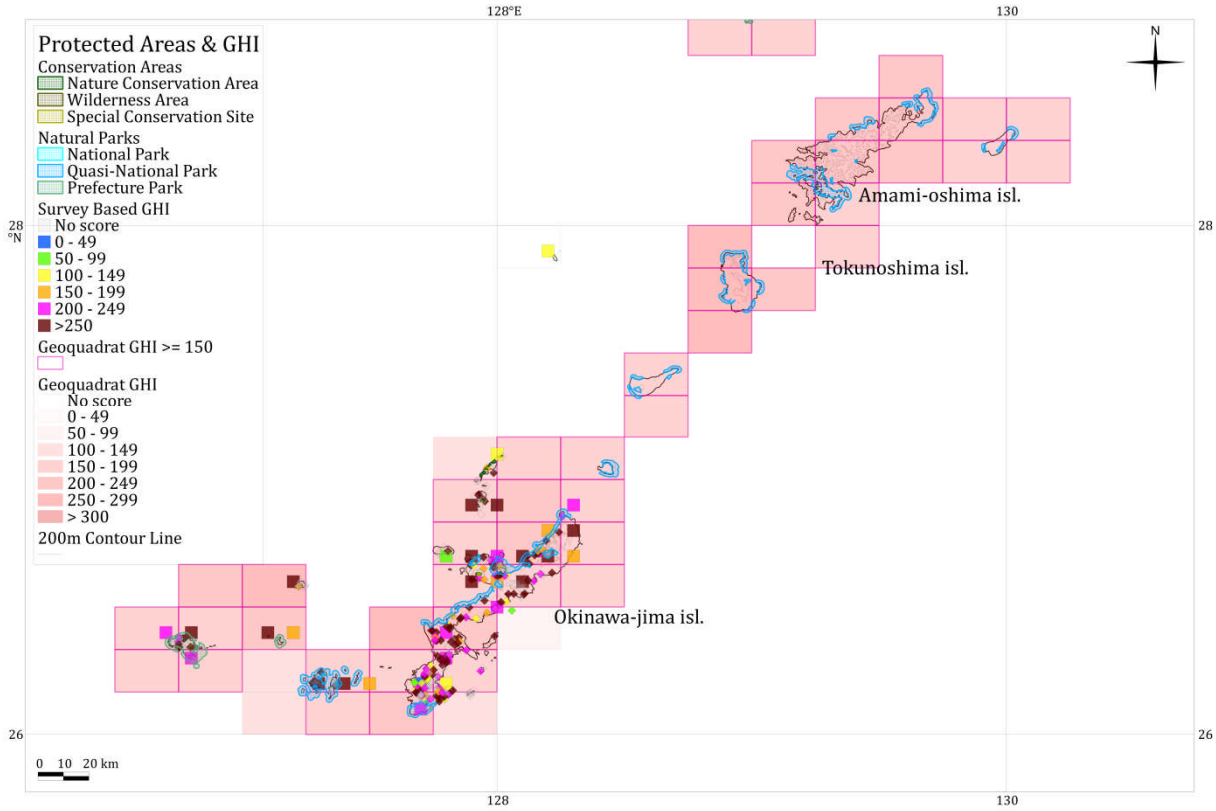


Figure 5.5 Northern and central parts of the Ryukyu Islands, compared for existing protected area network and bioquality assessment. The majority of mountainous areas of Amami-oshima island, Tokuno-shima island, and Okinawa-jima island (northeast area) are currently under-protected. Bioquality maps were supplemented by survey based GHI, colour scheme of scores is the same and sample types were identified by shapes: MOE survey areas (■), RBS plots (●), Utaki sacred groves (♦).

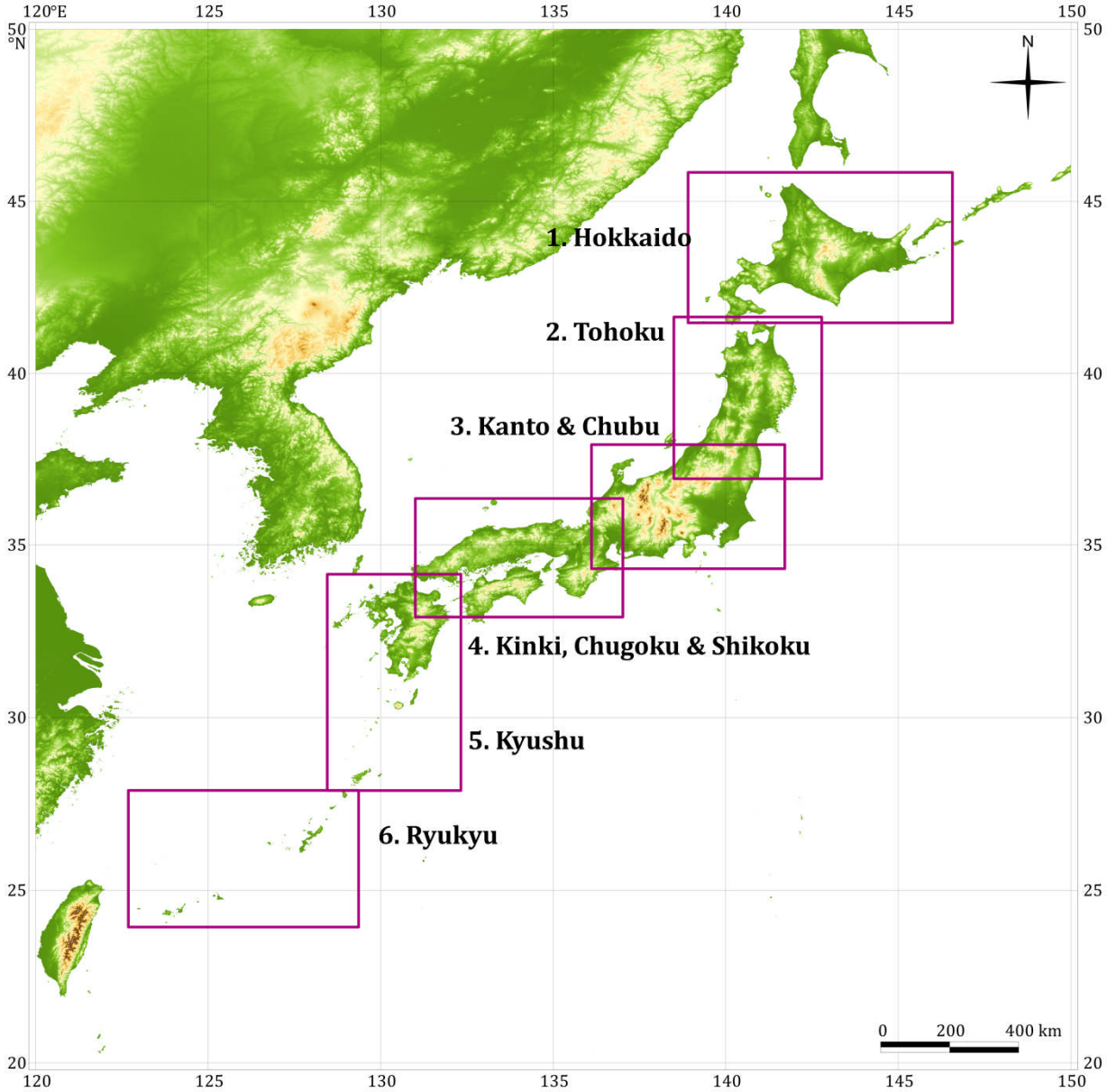
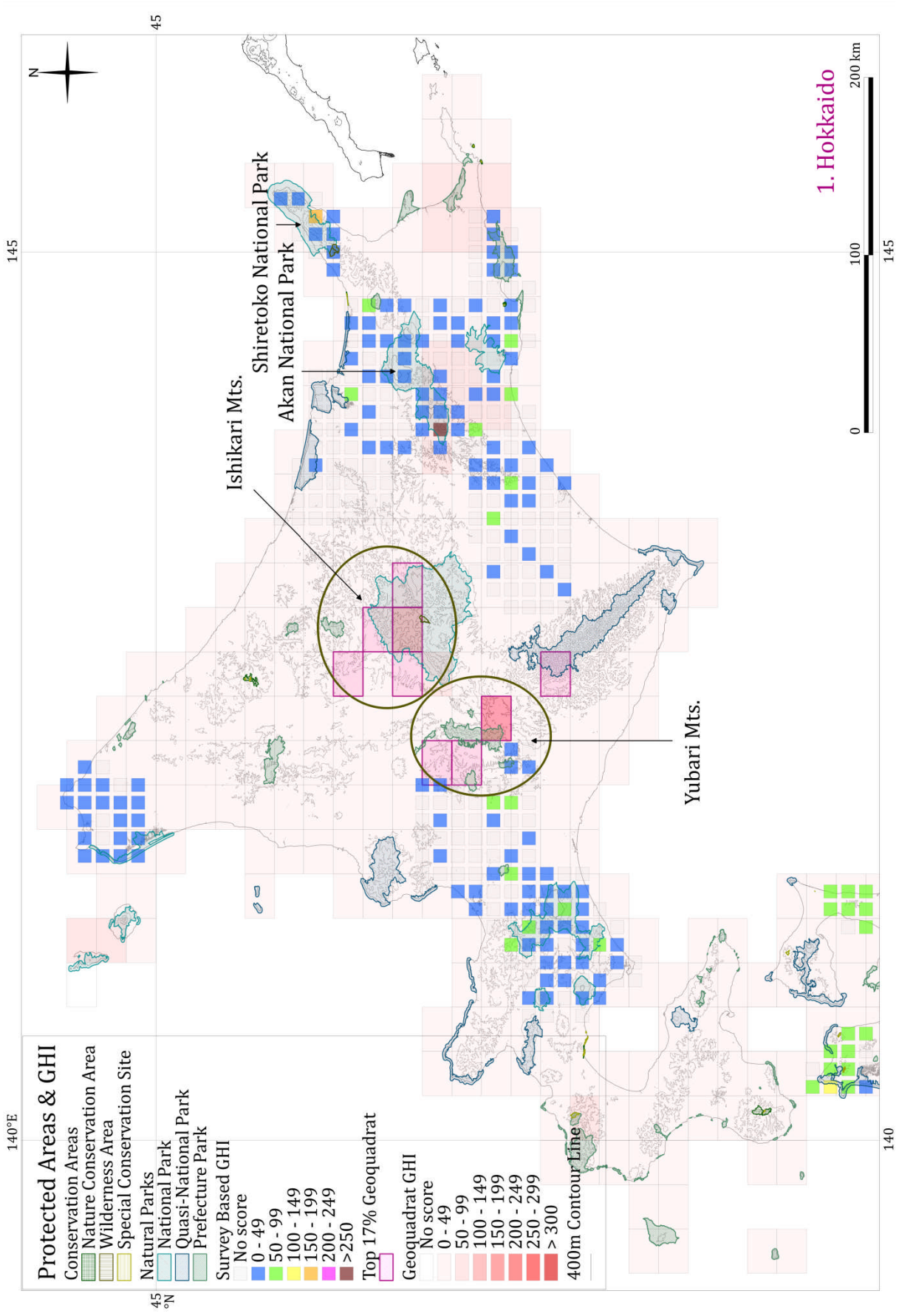
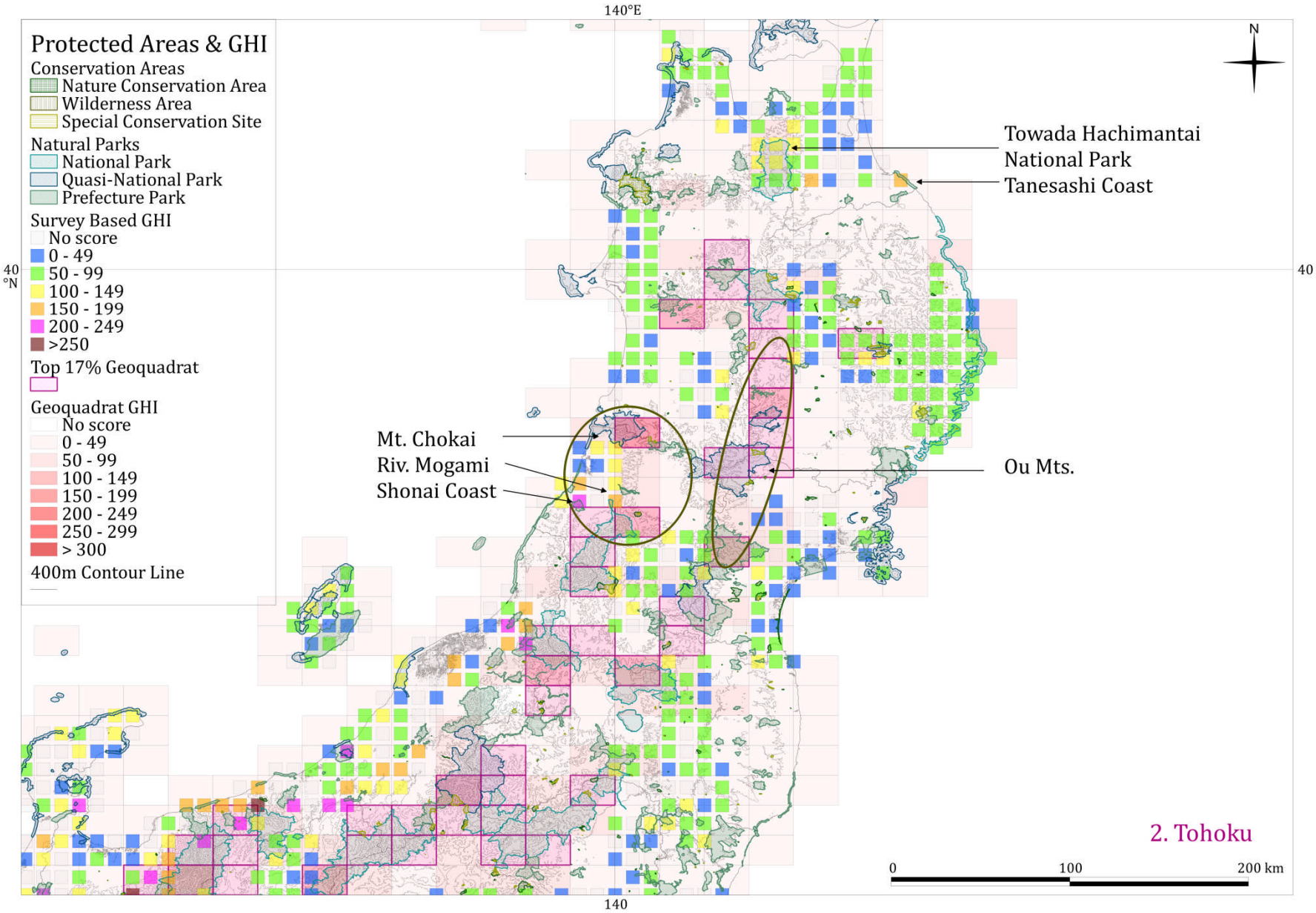
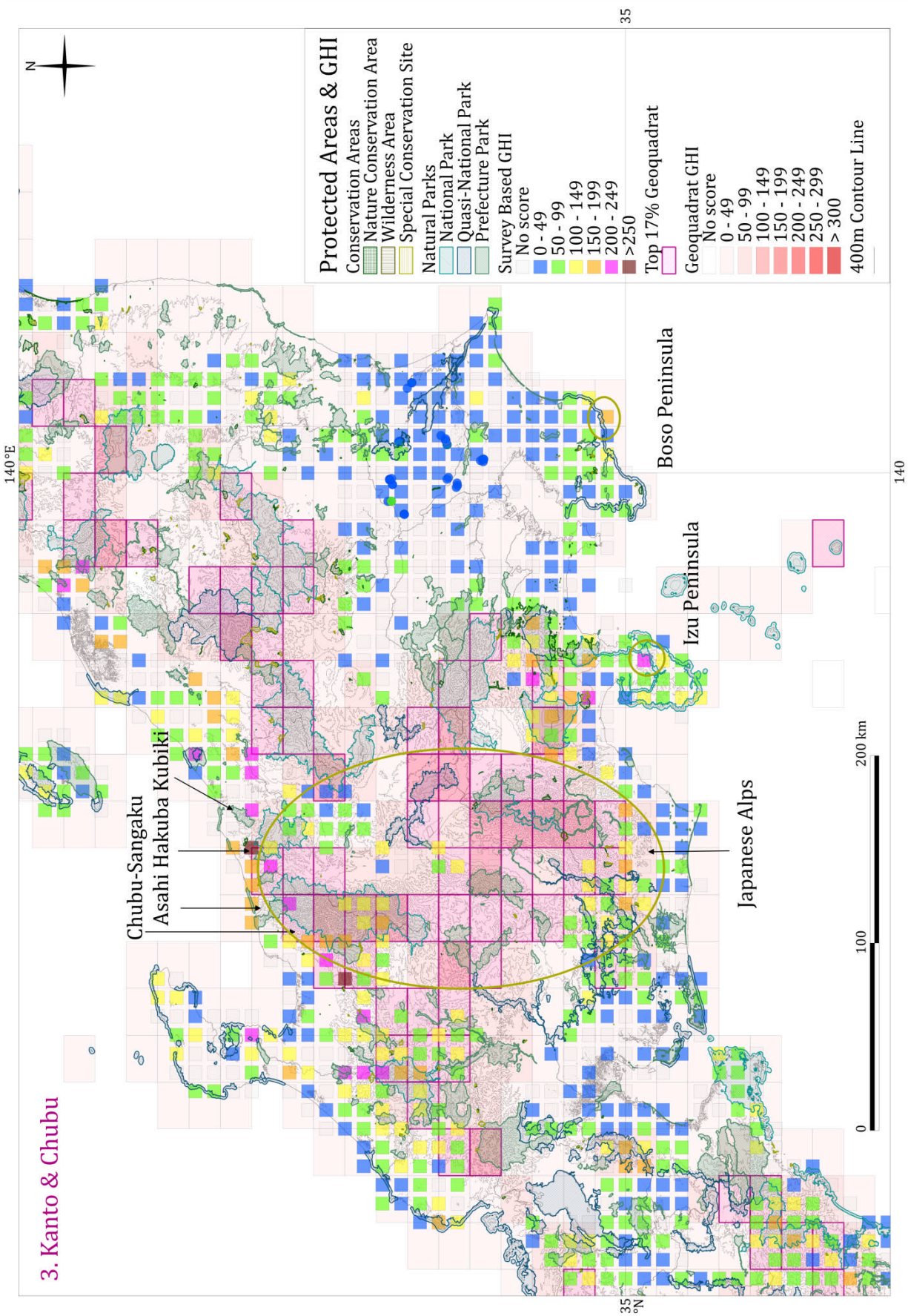
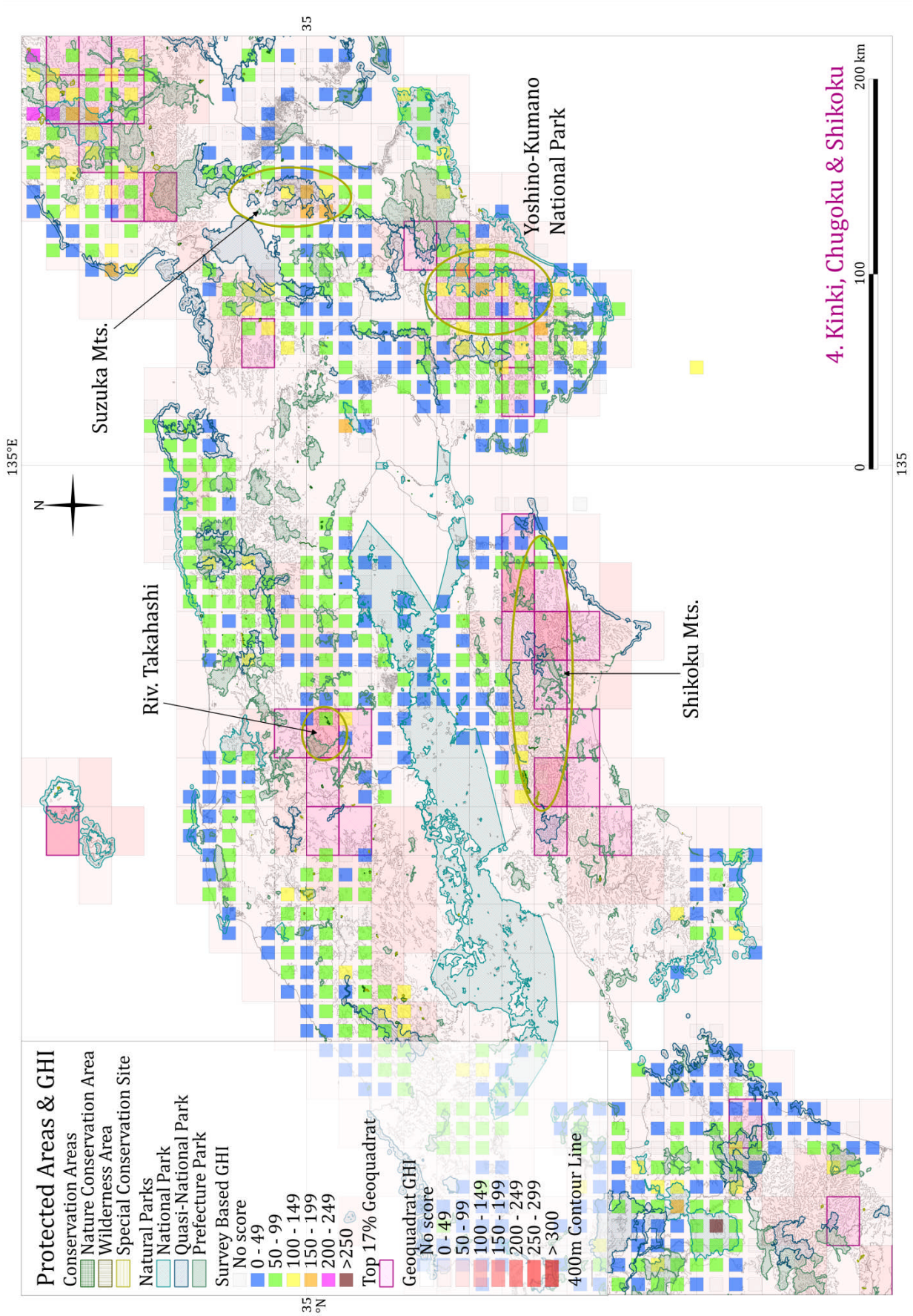


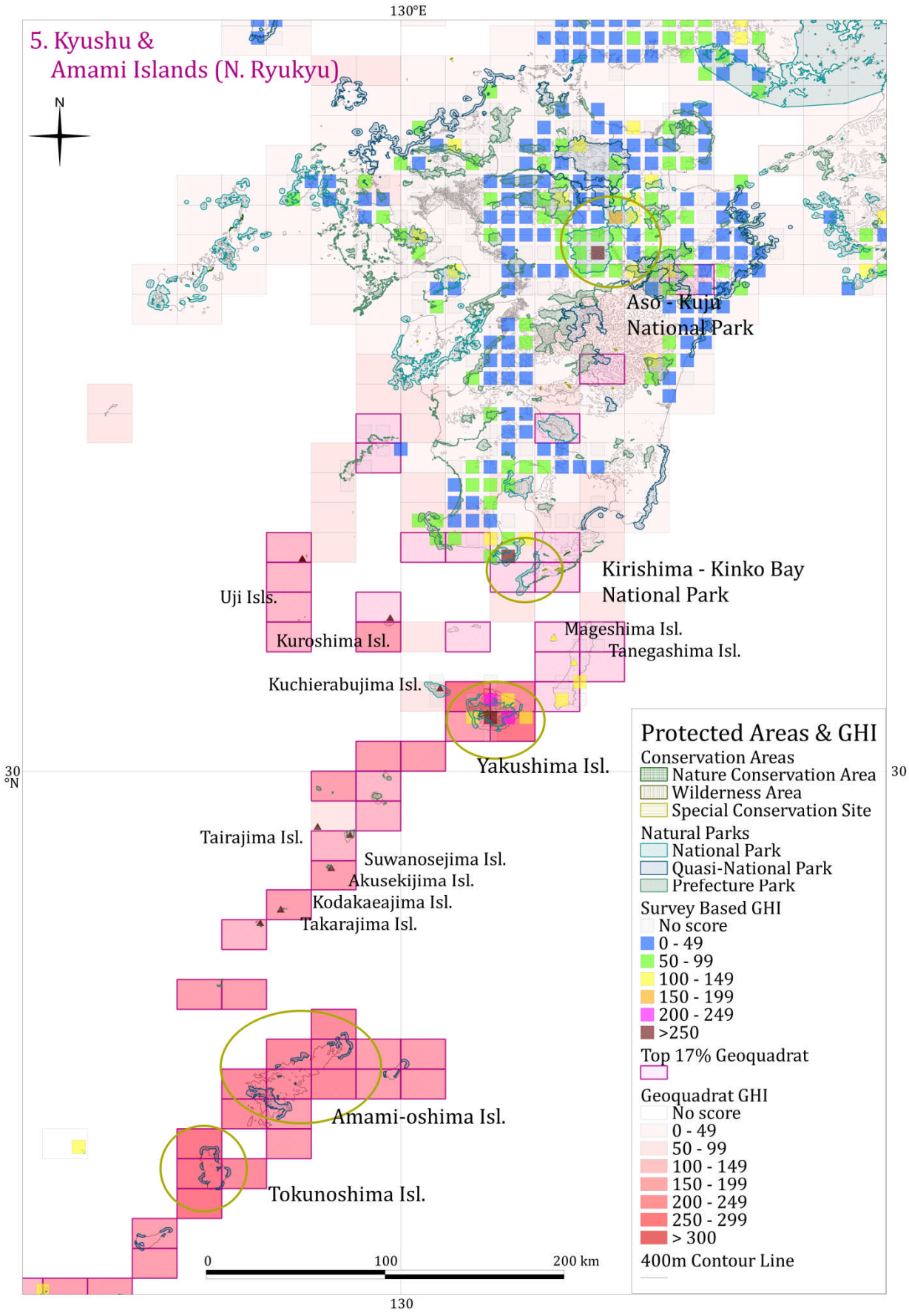
Figure 5.6 Comparison of existing protected area network and bioquality assessment. Maps were divided into six parts in the following pages (pp. 188-193): 1. Hokkaido, 2. Tohoku, 3. Kanto and Chubu, 4. Kinki, Chugoku, and Shikoku, 5. Kyushu and Norther Ryukyus, and 6. Central and Southern Ryukyus. Where bioquality maps were supplemented by survey based GHI, colour scheme of scores is the same and sample types were identified by shapes: MOE survey areas (■), RBS plots (●), *Utaki* sacred groves (♦), checklists (▲).

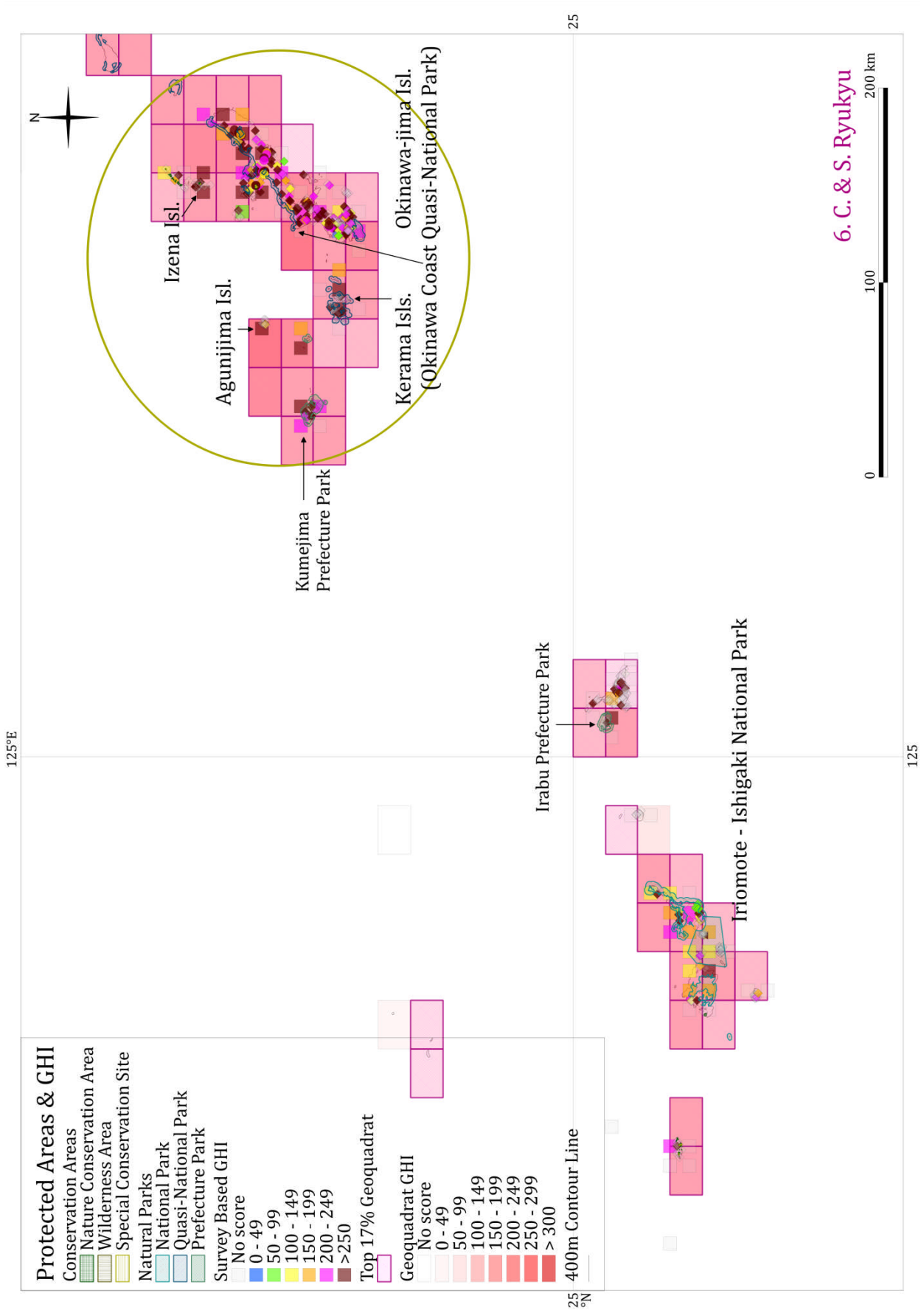

1. Hokkaido
Ishikari Mts.
Shiretoko National Park
Akan National Park
Yubari Mts.
N
0
100
200 km
140°E
145
45
45 °N
Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line


Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line
140°E
140
40 °N
40
N
Towada Hachimantai
National Park
Tanesashi Coast
Mt. Chokai
Riv. Mogami
Shonai Coast
Ou Mts.
2. Tohoku
0
100
200 km


Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line
N
140°E
140
35
35°N
Boso Peninsula
Izu Peninsula
Japanese Alps
Chubu-Sangaku
Asahi Hakuba Kubiki
0
100
200 km
3. Kanto & Chubu


4. Kinki, Chugoku & Shikoku
Suzuka Mts.
Yoshino-Kumano
National Park
Riv. Takahashi
Shikoku Mts.
135°E
35
35 °N
N
0
100
200 km
135
Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line


130°E
5. Kyushu &
Amami Islands (N. Ryukyu)
N
Aso - Kuju
National Park
Kirishima - Kinko Bay
National Park
Uji Isls.
Kuroshima Isl.
Mageshima Isl.
Tanegashima Isl.
Kuchierabujima Isl.
Yakushima Isl.
30
°N
Tairajima Isl.
Suwanosejima Isl.
Akusekijima Isl.
Kodakaeajima Isl.
Takarajima Isl.
Amami-oshima Isl.
Tokunoshima Isl.
0
100
200 km
130
30
Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line


Protected Areas & GHI
Conservation Areas
Nature Conservation Area
Wilderness Area
Special Conservation Site
Natural Parks
National Park
Quasi-National Park
Prefecture Park
Survey Based GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
>250
Top 17% Geoquadrat
Geoquadrat GHI
No score
0 - 49
50 - 99
100 - 149
150 - 199
200 - 249
250 - 299
> 300
400m Contour Line
Izena Isl.
Okinawa-jima Isl.
Agunijima Isl.
Kerama Isls.
(Okinawa Coast Quasi-National Park)
Kumejima
Prefecture Park
Irabu Prefecture Park
Iriomote - Ishigaki National Park
6. C. & S. Ryukyu
N
125°E
125
25
25 °N
0
100
200 km

5.5 DISCUSSION

5.5.1 Role of bioquality approach as a conservation assessment tool

Comparison of bioquality hotspots with selected measures of biodiversity generally supports the findings of previous studies, highlighting the very different nature of individual indices as priority-setting tools. When designing conservation areas using such tools, is essential to have clear conservation targets. Species richness was considered a poor indicator for conserving rare species in an Australian case study by Curnutt *et al.* (1994). The main constraint in using species richness is the hidden identity of species properties (Brooks *et al.*, 2006), and it is clear that species-rich areas depicted by the subset of the Japanese flora failed to capture critical areas with respect to global rarity (Figure 5.4). The latter areas added together will soon protect a larger and more locally specialised species pool than an equal area prioritised on their individual richness of often widespread species.

Endemic species richness and CWE approaches both have their own roles in identifying nationally important areas. Mismatch between endemism-derived measures and bioquality raises an important point that clear distinction between different levels of rarity should be made when prioritising rare species (Crain *et al.*, 2011). Endemism is widely recognised as a key prioritisation factor (Lamoreux *et al.*, 2006), but national or sub-national endemism on its own lacks subtlety for quantifying variation in geographic range size between endemic species. It is also highly affected by the total area they were identified to be endemic to (Brooks *et al.*, 2002). In the Japanese case, the endemic species are not necessarily range-restricted within Japan. Conversely, some globally widespread species are locally rare in Japan, and some globally very rare species are not endemic to Japan. Bioquality assessment clearly differentiated them and can better highlight global rarity hotspots. This approach does, however, mean that widespread endemic species would be de-valued relative to non-endemic globally rare species.

Selecting criteria for setting priority areas needs a balance between global interest, national interest and local-level interests and should also cover a range of non-biological factors such as anthropogenic factors affecting the conditions of habitats, although these are beyond the scope of this study. The

bioquality approach is suited to specify globally important areas, although it should be considered as just one of several possible assessment tools. Nevertheless, the various layers of priority should be additive, rather than, for instance, averaged. This means that priority bioquality areas would ideally be represented in the protected area network and what other 'layers' of priority indicate can be considered in parallel. In these other layers, national-only interest points to areas that deserve different attention due to the preponderance of species at the limit of their range being in higher concentrations at the perimeter of the country (e.g. CWE analysis). Bioquality assessment is currently limited to plants; hence important areas for other taxonomic groups that may be derived from different approaches (Table 1.2) could also be added in designing protected area. However, I shall here focus on the global interest implicit in the bioquality hotspots.

5.5.2 Issues with existing protected area coverage

In general, protected area coverage seemed adequate in most parts of mainland Japan where bioquality scores are low to moderately high, i.e. GHI of 150 or lower. However, except for Ogasawara islands and Yakushima Island, the majority of high-priority bioquality hotpots with GHI above 200 were found to be outside the existing protected area coverage (Table 5.3). Most of the Ryukyu Islands were identified as severely under-protected, with only part of the area designated as Quasi-National Parks. Several subtropical islands were identified as priority areas for the allocation of new conservation areas (Figure 5.5). The most urgently needed are: central part of Amami-oshima Island; Tokuno-shima Island; northern part of Okinawa-jima Island; Aguni-jima Island and Kerama islands. These islands scored exceptionally high GHI with some over 300 in MOE data or in the *Utaki* sacred groves and over 200 in Horikawa geoquadrats. This supports the finding of a global gap analysis of fauna by Rodrigues *et al.* (2009) that identified the Ryukyu Islands as a globally urgent priority area for expanding protected areas.

Table 5.3 Summary of priority conservation areas that are identified in this study as not adequately protected at present. Some areas that require further investigation on the existing protected area are also highlighted. Abbreviation used: Mountain(s) (Mt(s)); island(s) (isl(s)); Prefecture Natural Park (PNP); Quasi-National Park (QNP); National Park (NP) .

Priority area (District)	Existing protected areas	Findings and recommendations
Yubari Mts. (Hokkaido)	Furano-Ashibetsu PNP	▪ Mt. Yubari scored the highest GHI (202) for mainland Japan by Horikawa maps ▪ Field survey to verify high bioquality locations should be conducted ▪ Expansion or potential upgrade of the park is recommended
Boso peninsula (Kanto)	Minami Boso QNP	▪ Area with 168 GHI was found by MOE survey ▪ Vegetation or areas within the park that are particularly high in GHI should be given special protection
Izu peninsula (Kanto)	Fuji-Hakone-Izu NP	▪ 2 MOE survey grid scored over 200 GHI (Mt. Ashitaka 230, Mt. Amagi 201) ▪ Field survey on the mountain ranges is recommended to fine-tune or upgrade conservation areas inside the park
Japanese Alps (Chubu)	Chubu-Sangaku NP, Southern Japanese Alps NP, and many PNPs	▪ Mountain ranges were highlighted as potential hotspots by Horikawa maps ▪ Evaluation of conservation status using survey data on site is recommended
Shikoku Mts. (Shikoku)	Tsurugi-yama QNP, 18 Kochi PNPs on individual mountains	▪ Mountain range was predicted to be potential hotspots by Horikawa maps ▪ Habitat conditions of many mountains that are already designated as prefecture parks should be assessed ▪ Priority protection may be allocated for specific localities where GHI is high and/or are under threats
Mt. Aso and Mt. Kuju (Kyushu)	Aso-Kuju NP	▪ 2 MOE survey grid on the mountains showed moderate to high GHI (Mt. Aso 261, Mt. Kuju 160) ▪ Monitoring the conservation status particularly around these mountains is suggested
Amami-oshima Isl. and Tokuno-shima Isl. (Northern Ryukyu)	Amami islands QNP	▪ Island hotspots of global importance (Amami-oshima island 255 GHI, Tokuno-shima island 268) was revealed by Horikawa maps ▪ The current conservation area is only restricted to coastal vegetation, thus urgent designation of protected area is necessary ▪ Extensive field survey on island vegetation should be lead
Okinawa-jima Isl., Aguni-jima Isl., Kume-jima Isl., and Kerama Isls. (Central Ryukyu)	Okinawa coastal QNP, Kume-jima PNP	▪ Bioquality hotspots were confirmed by RBS survey and Utaki sacred grove analysis, supporting the findings from coarse resolution evaluation using FOJ and Horikawa maps ▪ No conservation area is assigned to forest vegetation which was highlighted as global priority areas at present ▪ New high-priority large-scale protected area, particularly of northern Okinawa-jima island, is of crucial importance to safeguard conservation of globally rare plant community on the island group ▪ Island-wide detail field survey is urgently needed to develop conservation action plan that reflect the current condition of priority species and their habitats

The spatial extent of Quasi-National Parks is limited compared to bioquality hotspots identified across large areas (Table 5.3). Such low coverage of protected area in the Ryukyu Islands may be due to the fact that globally rare species were locally abundant, as observed in RBS samples in Okinawa-jima Island (see Chapter 4). Nevertheless, high local abundance does not imply that these areas are 'safe' and these island groups should be regarded as an essential part of Japan's contribution to global plant hotspots. Expansion of new protected areas and upgrade of conservation status of the existing parks in the Ryukyu Islands would thus be recommended. This finding supports the recent study commissioned by the government (Kato and Ebihara, 2011), re-emphasising the importance of these areas.

The other under-protected area was Yubari mountain range in Hokkaido, which was also highlighted as priority areas for re-evaluation in the recent study (Ministry of the Environment of Japan, 2010c). Given that only one Horikawa geoquadrat showed high GHI and no other data were readily available for this region, further analysis to verify the bioquality is called for.

In fact, a general limitation in this study is that bioquality hotspot maps used in the gap analysis were sometimes too coarse to identify details of where important bioquality hotspots lie on the ground in relation to the spatial arrangement of existing protected areas. Evaluation of these existing protected areas from a bioquality perspective by conducting Rapid Botanical Surveys (RBS) on the ground is recommended to refine their conservation status for practical management purposes. Field observation in the Ryukyu Islands which were hotspots as an island group revealed variation in the bioquality inside the island (Chapter 4, and dotted points in Figure 5.6). Such fine-resolution investigation is particularly important for areas such as the Yubari mountain range where data were insufficient to identify specific locations within the area that should be prioritised.

Data availability of fine-resolution maps also affects the definition of priority in relation to hotspot prioritisation using the bioquality approach. If only the Horikawa geoquadrat bioquality map is used for identifying priority areas, covering a total of 17% of land area in Japan, areas scoring as low as 68 had to be chosen to attain the required 241 hottest geoquadrats. When priority areas were selected on the basis of having a GHI of over 150, priority areas were reduced to a third (81 geoquadrats). Two

important points should be highlighted in applying bioquality hotspots as an index to increase the protected area coverage *per se*: (1) bioquality hotspots are highly localised and/or (2) data are in some geoquadrats insufficient to identify high scoring areas on the coarse grid.

A study by Kier *et al.* (2009) comparing species richness and endemic species richness standardised for area on vascular plants and vertebrates found that globally, islands contribute to half of top 20 hotspots of endemism though the total area of these islands is small (Kier *et al.*, 2009). In Japan, two major bioquality hotspots in the Ryukyu Islands (1,074 km^2) and Ogasawara islands (98.83 km^2 including Kazan Islands) together only account for 0.31% of Japanese land surface (approximately 377,950 km^2) (Geospatial Information Authority of Japan (GSI), 2011c). Therefore, if priority areas were assessed on the basis of high GHI alone, small areas of Japan would need to be selected.

The lack of data on local variation within the geoquadrat will probably have led this study to miss out some localised hotspots. Supplementary data, such as MOE data, showed some higher-scoring locations on mainland Japan outside the 17% highest bioquality geoquadrats (Figure 5.6). Two main recommendations for future work regarding priority-setting for hotspots would be: (1) given that the highest-scoring areas are small, maximum effort should be taken to enhance the conservation status of these hotspots and to expand the protected area on these localities as a top priority. (2) Coarse-resolution maps are useful as a first approximation to guide where to focus examination, but detailed on-site surveys should follow, and are essential in planning priority areas at management level.

5.5.3 'Network' of conservation areas

In addition to the designation of new priority areas, the other main recommendation from this study for future conservation planning in Japan is to investigate how to improve the 'network' of conservation areas, including upgrading some existing designated areas to higher levels of protection. 'Developing [the] ecological network' is one of four focal targets in National Biodiversity Strategy (Ministry of the Environment of Japan, 2010a). Two priorities in future conservation planning in Japan are: (1)

designation of new protected areas based on bioquality hotspots, and (2) upgrading conservation status of existing protected areas or expanding the protected cover to moderately important areas from bioquality perspectives.

Increasing the area covered by protected areas is a considerable challenge (Walpole *et al.*, 2009). An analysis by Jenkins and Joppa (2009) on global protected area coverage using IUCN's protected area categories revealed that progress in increasing the protected area cover was 0.4% per annum since 1997, with Brazil accounting for the majority (74%) of the increase. Findings from gap analysis in this chapter highlighted that the current 14% protected area cover in Japan may sound effective if one merely takes the area coverage *per se* but urgent priority areas are, in fact, missing from the existing system.

In order to improve the effectiveness of existing protected areas, ecological linkage between protected areas of various sizes and status should be evaluated and enhanced. The bioquality approach can contribute to this, alongside other social and ecological studies. Coarse-resolution bioquality maps produced in this study can be used to identify target areas for detailed examination. Evaluation of local variation in bioquality by field surveys in conjunction with other assessments should then feed into a design with the goal of establishing 'networks' of protected areas.

6 General conclusions: Future biodiversity conservation in Japan

The main goal of this study was to investigate how biodiversity hotspots in Japan could be revealed and mapped to encapsulate conservation elements of biodiversity in practical ways and at various scales. Limitations of existing methods were outlined in Chapter 1 and have been mentioned subsequently.

The spatial patterns of hotspots revealed for the first time in Japan by the bioquality approach suggest that this is a promising and effective conservation evaluation method to improve our understanding on where globally rare species are clustered at a fine scale. Incorporating this approach as one indicator for setting priorities is expected to broaden the Japanese government's conservation framework beyond its national interest, to strengthen scientific support for the process of designating protected areas, and to enhance motivation for conservation by highlighting the global significance of the Japanese flora.

In comparison to existing global conservation approaches, there are several advantages that give the bioquality approach a distinct role as a conservation prioritisation system. The species-based assessment – the Star system developed for Japan in Chapter 2 – is suitable for ranking many taxa in a short time, using objective and justifiable criteria that readily feed into the weighting of Stars in community-level assessments. Fast evaluation is made possible because of a relatively simple set of criteria: species' geographic range and taxonomy, as opposed to, for example, the IUCN system where the criteria are more data-demanding (Mace *et al.*, 2008, Newton and Oldfield, 2008), and lead to categories related to risk of extinction. The Star system makes use of available taxonomic and ecological knowledge of plant species and focuses on conservation significance of plant species based on their global rarity.

For plant communities, the application of the Genetic Heat Index (GHI) for various data sets at different spatial resolutions across Japan demonstrated the high scalability of the bioquality approach. Zooming from a coarse-resolution national analysis to field sample plots, the bioquality hotspots were identified as the Ryukyu and Ogasawara Island groups. Various mountain ranges in mainland Japan

were also predicted to be the potential hotspots. Clusters of hotspots within these coarse-resolution hotspots became apparent at finer resolution in the Ryukyu Islands, by examination of field survey data including my own RBS samples (Chapter 4). In other words, there was general spatial congruence in the locations of hotspots across these different resolutions in the Ryukyu Islands at least, and no surprise hotspots were uncovered at finer resolution in the cold-spot region of the *satochi-satoyama* landscape. This finding has a significant implication in terms of applying global priorities to local management practices. Bioquality assessments at coarse resolution, which can be derived from herbaria or similarly derived samples or checklists are useful in providing an overview of areas across large regions. Further investigation on the ground within these rather crudely defined, low-resolution hotspots can: a) strengthen the evidence to support the general findings, and b) reveal insights into detail on which more precise areas merit conservation action. This is a great strength of bioquality assessment against WWF's ecoregions or CI's hotspots which are too coarse to pinpoint important localities within their priority areas (Mace *et al.*, 2010, Rodríguez *et al.*, 2007), and whose criteria do not readily lend themselves to scaling.

Spatial resolution and extent of assessments are important (Willis and Whittaker, 2002), the smaller the sample area the higher the maximum GHI as shown in Chapters 3 and 4, and expected from statistical considerations (Hurlbert and Jetz, 2007). This higher variability of smaller samples would apply even if globally rare species were distributed randomly, but given that they are evidently clustered into hotspots at all scales this effect is critical when considering protected area design (Hartley and Kunin, 2003). Plant communities in small isolated areas may not be sustainable, especially if recently fragmented from a previously more widespread ecosystem. Small plant communities that have assembled and evolved as such, isolated on mountain tops or islands, are expected to be more vulnerable to habitat destruction such as land use change than mainland ecosystems (Kier *et al.*, 2009). Therefore the small, hottest spots in many cases should not be considered in isolation of the landscape in which they are found, and the coarser-resolution bioquality patterns are meaningful for conservation planning as well as the finer, much more localised hotspots.

There is certainly scope for developing the bioquality approach. Firstly, the bioquality approach is currently a plant-specific assessment tool. It is reasonable to specialise in one taxonomic group rather than fitting a uniform set of evaluation measurements to many organisms with different life histories, biomasses and demography (Lughadha *et al.*, 2005). Nevertheless, the development of such a global-rarity-based assessment tool for other taxonomic groups would be important for future work. Secondly, bioquality only assesses the biological importance of plant species and communities, and other factors that affect the conservation status of study areas are not incorporated. A national, or even more parochial perspective on which species are rare, and where these priority species are clustered, was investigated in Chapter 5 and clearly reveals different priorities, with different hotspots to the bioquality hotspots. Also, expansions of invasive species such as *Bischofia javanica* (Euphorbiaceae) or *Pinus luchuensis* (Pinaceae) in the Ogasawara islands are known to have altered vegetation (Sugiura *et al.*, 2008, Tanaka *et al.*, 2010). These plant-related and other non-biological threats should be considered when examining conservation prioritisation. Mostly, however, such issues were not specifically investigated in this study. While a focus on a few aspects of biodiversity conservation problems is practical in avoiding confusion by combining many contrasting factors that determine conservation priority from different dimensions (Mace *et al.*, 2000), it is important to analyse each issue separately. In GIS terms, these other factors should be considered different layers, to be overlain on a bioquality layer by conservation planners. The bioquality assessment should be made in parallel with other considerations, even given that bioquality is an important aspect in its own right. Analysis on the effect of anthropogenic disturbance, land use history on the area of conservation concern would also provide additional information useful for management planning. Integrated assessment is particularly important for hotspot conservation. Small hotpots are more vulnerable to loss, and in the final analysis, vulnerability should be considered alongside the intrinsic value when determining priorities for protection.

In terms of evaluating the effectiveness of the current protected area in Japan, three key messages have emerged from this study:

- High priority areas, particularly of the Ryukyu Islands, are currently severely under-protected while medium-priority or low-priority areas of mountains in mainland Japan seemed adequately designated as conservation areas.
- The current focus on the *satochi-satoyama* landscape in national biodiversity conservation policy framework needs re-evaluation. For this landscape, conservation activities should be redirected to highlight the cultural and social importance. Instead, the Ryukyu Islands should be designated as a key priority biodiversity conservation area.
- Enhancement of a network of protected areas is an important aspect for further consideration to improve ecological function of individual sites under the existing conservation framework.

A simple measurement of area coverage or protected area status is insufficient to examine the 'effectiveness' of protected areas (Chape *et al.*, 2005). Analysis of spatial overlaps between protected areas and bioquality hotspots using available data is merely a first step to investigate under-represented areas where urgent actions are required. More field sampling is necessary to enhance the resolution and spatial coverage of areas assessed by the bioquality approach across Japan.

The Flora of Japan database has become available globally for almost all vascular plant families found in Japan for the first time. Using newly acquired field data as well as using existing literature-based resources that were only available in Japan, the extensive national analysis of bioquality hotspots identified global priority areas that are directly relevant to conservation policy on the ground. This study also opened doors to address new questions and hypotheses for testing in the future. Further examination of factors such as climate, topography, and geological features that have led to hotspots is an interesting biogeographic research question to be addressed. Within hotspots, the ecological and evolutionary characteristics of rare species are yet to be explored. It is hoped that the Star system, the Flora of Japan database, distribution maps, and field sampling data as well as bioquality hotspots maps that were compiled as a result of this study will be used as new evidence to support Japanese biodiversity conservation activities and to enhance understanding of the ecological importance of the Japanese flora to the world.

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Appendix A: Phytogeography of Japan

The Japanese archipelago (Figure A1) is comprised of the four major islands of Hokkaido, Honshu, Shikoku and Kyushu; the small island groups of Ryukyu, Ogasawara, Kazan and Izu; and over 3,000 small islands (the total number of islands larger than 0.1 km^2 along the coast line is 6,852) (Statistical Research and Training Institute, 2012). Izu islands extend southwards from central Japan and the Ogasawara Islands and Kazan Islands are two volcanic island groups in the Pacific. The Ryukyu Islands stretch from the southern tip of Kyushu to east of Taiwan, and have formed mainly by the sea level change over geological time (Numata, 1974). It is a long, narrow chain of islands covering an extensive latitudinal range from 22 °N to 45 °N with total land area of approximately 377,950 km^2 (Statistical Research and Training Institute, 2012).

Climatic patterns across the latitudinal and altitudinal range of the country are important environmental factors affecting the vegetation of Japan. The high mountain ranges which form the backbone of mainland Japan divide the major islands into two sides with distinct climatic patterns: the Japan Sea side (west) and the Pacific side (east) (Nakanishi *et al.*, 1993, Numata, 1974). Much of the precipitation on the Japan Sea side is winter snowfall caused by the Siberian air mass. Precipitation in winter ranges between 150 to 400 mm per month while it is as low as 100 to 200 mm per month in summer. The Pacific side receives high summer precipitation of 150 to 400 mm per month and low winter precipitation of less than 100 mm per month (Yahara, 1989). The warm Kuroshio Current and monsoon wind from tropical Southeast Asia bring summer rain on the southwest Pacific side of Japan. The northeast Pacific side of Japan has similar climatic patterns to the Japan Sea side, with much precipitation occurring in winter due to the effect of the cold Oyashio Current from the north in winter (Nakanishi *et al.*, 1993, Numata, 1974, Yahara, 1989). Abundant rainfall across the archipelago and its topography – the terrain is too steep for agriculture or forestry commercially - have contributed to a high forest cover of 67%, one of the highest among the developed countries.

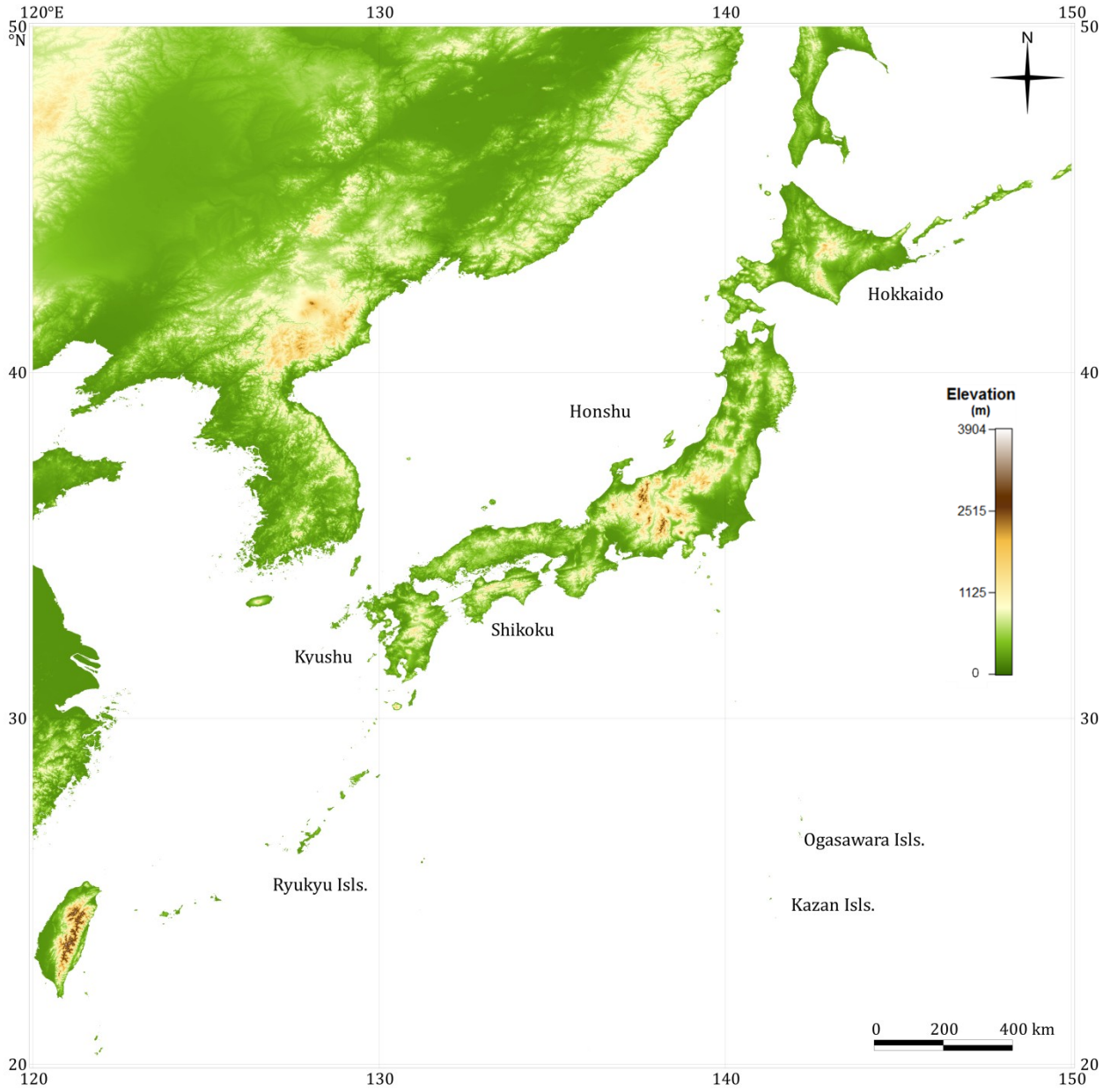


Figure A1. Elevation map of Japan. (Data source: 90m DEM version 4 from The CGIAR-CSI GeoPortal (2008))

The widely accepted natural vegetation classification in Japan divides vegetation types into four forest classes, proposed based on Miyawaki's extensive vegetation surveys on sacred groves across Japan (Figure A2) (Nakanishi *et al.*, 1993). Because many sacred groves have been protected from human exploitation and intervention, Miyawaki suggested potential primary forest types based on the assumption that these groves represent unmanaged vegetation in the area. The predicted four primary forest types have been adopted in WWF's ecoregion approach as well as by the Japanese government and researchers as reference conditions of primary habitats (Japan Integrated Biodiversity Information System (J-IBIS), 2011, Olson *et al.*, 2001). This zonation of forest types matches climatic patterns along the latitudinal and altitudinal gradients of the country (Murata, 1977, Nakanishi *et al.*, 1993, Numata, 1974). Climatically, these forest classes roughly correspond to five major zones: alpine, sub-

boreal, cool temperate and warm temperate with sub-tropical added for small island groups. Features of the vegetation and characteristic species in these zones are briefly summarised here.

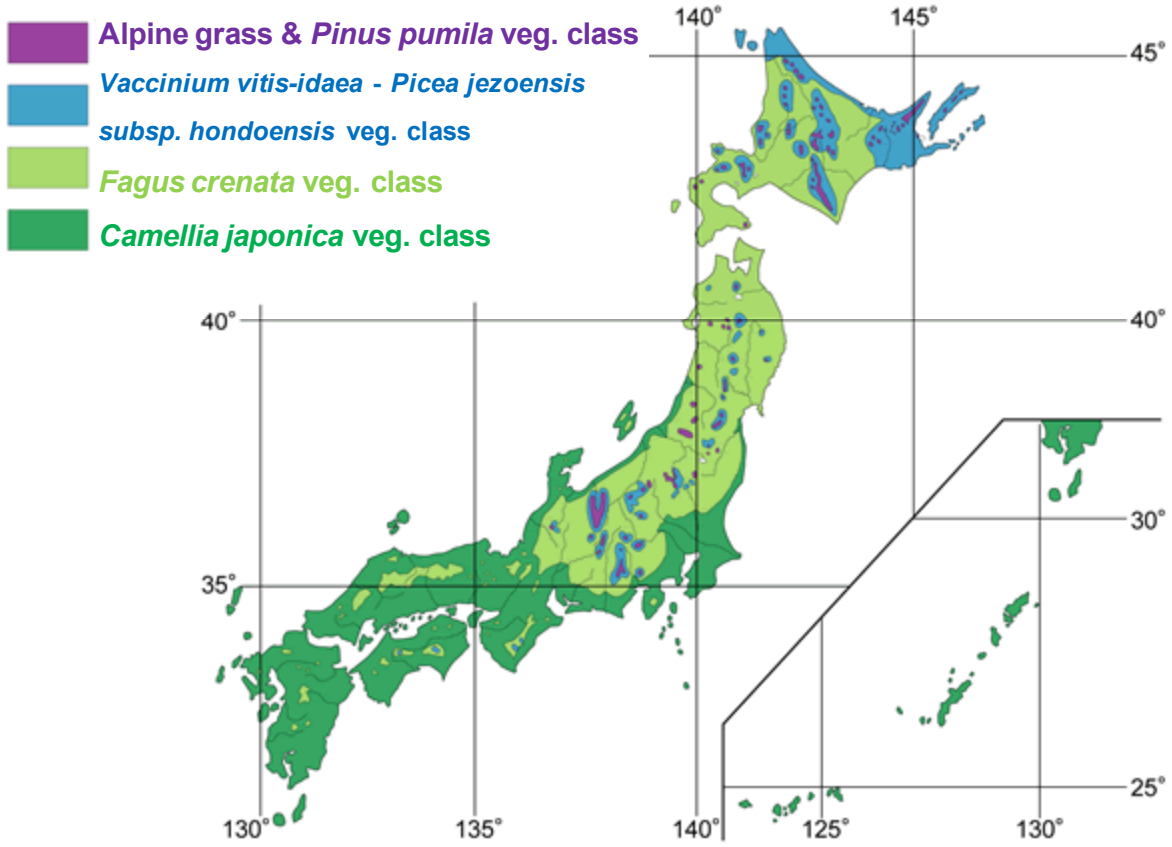


Figure A2. Four vegetation classes identified as primary forest types by Miyawaki (Map adopted from (Japan Integrated Biodiversity Information System (J-IBIS), 2011))

Sub-boreal and alpine

The sub-boreal coniferous zone occurs in Hokkaido, in the mountains of north central Japan over 1400 m in elevation and some other small areas of high mountain in the southwest (Numata, 1974). The dominant conifers are *Abies sachalinensis var. mayriana* (Pinaceae) in Hokkaido and *Abies veitchii* and *Abies mariesii* (Pinaceae) in Honshu. The high mountains and northern part of Hokkaido, the coldest part of Japan which belongs to boreal and alpine vegetation type, is characterised by alpine scrub species such as *Pinus pumila* (Pinaceae), *Vacciniumvitis-idaea* (Ericaceae) and *Picea jezoensis subsp. hondoensis* (Pinaceae).

Cool temperate

Natural vegetation in northern Japan and the Japan Sea side is dominated by *Fagus crenata* (Fagaceae), often mixed with *Fagus japonica* (Fagaceae) particularly in the southern part (Numata, 1974). Forest

species in this vegetation type are known to show adaptation to heavy snowfall, with their distribution matching the area with patterns of snow cover (Numata, 1974, Yahara, 1989).

Warm temperate

The dominant trees of the warm temperate forests on the Pacific side in southwest Japan are *Castanopsis sieboldii* (Fagaceae) and *Machilus thunbergii* (Lauraceae). In the southern part, *Cinnamomum camphora* (Lauraceae), *Quercus gilva* (Fagaceae) and *Quercus acuta* (Fagaceae) are other major co-occurring species (Numata, 1974, Yahara, 1989). Some species of the genera found in this zone, such as *Aucuba* (Cornaceae), *Cardiocrinum* (Liliaceae), and *Helwingia* (Cornaceae) have distributions extending from 30° N in the Himalayas and southwest China eastwards to Japan (Murata, 1977, Numata, 1974, Yahara, 1989). *Camellia japonica* (Cruciferae /Braccicaceae) is also a characteristic species associated with natural forests across the southern part of Japan in this climatic zone (Numata, 1974).

Sub-tropical

The small island groups of Ogasawara, Kazan and Ryukyu fall into the sub-tropical climate group. Many species in the Ogasawara Islands are of Asian subtropical origin such as *Machilus* (Lauraceae), *Neolitsea* (Lauraceae), *Euonymus* (Celastraceae), *Vaccinium* (Ericaceae) and *Gardenia* (Rubiaceae) (Fujita *et al.*, 2008, Numata, 1974, Shimizu, 2003). The flora of the Ryukyu Islands contains elements of the Sino-Himalayan region in the mountainous areas and tropical elements from the south in lowland areas (Aramoto *et al.*, 2006, Itô, 1997, Numata, 1974, Shinzato *et al.*, 2007). Forest zones above 300 m a.s.l share many common tree species with southern warm temperate forests of the mainland. The Coral zone and estuarine mangrove forests are found in the Iriomote islands and are characteristic vegetation types in lowland areas of the south Ryukyu Islands (Aramoto, 1978, Aramoto *et al.*, 1984, Aramoto and Sunakawa, 1975). Representative species of the coral zone are *Limonium wrightii* (Plumbaginaceae), *Crossostephium chinensis* (Asteraceae) and *Osteomeles anthyllidifolia* (Rosaceae).

Appendix B: Scripts written for analyses in this study

Scripts for R (version 2.14.1) and Ipython (version 0.13) used in data handling and analyses are listed. All scripts and some data are available online via https://github.com/Nodoka/Bioquality

Table B1: Summary of R scripts used in analysis. For script, see 'bin' node on https://github.com/Nodoka/Bioquality

Code ID	Code title	Description
B1	tabulate_fam_stars.R	Examine Star presentation at family level
B1	tabulate_origin_stars.R	Examine Star presentation between data sources
B2	examine_star_scenarios_for_sensitivity.R	Compare Star representation between Star classification protocols
B2	examine_GHI_by_prefecture_for_star_sensitivity.R	Calculate prefecture level GHI for sensitivity analysis
B3	generate_species_grid.R	Merge Horikawa geoquadrats to one degree grid
B3	generate_species_kmgrid.R	Merge Horikawa geoquadrats to 100km grid
B4	calculate_weight_horim.R	Calculate star weights from Horikawa data
B4	calculate_weight_tdwg.R	Calculate star weights from TDWG data
B5	tdwg_generate_sp_grid.R	Convert TDWG level 3 codes to one degree grids
B5	tdwgsp_area.R	Calculate species geographic range based on TDWG level 3 area
B6	investigate_conifer_degreegrid.R	Measure geographic range on conifer data at degree grid
B6	investigate_conifer_kmgrid.R	Measure geographic range on conifer data at 100 km grid
B6	investigate_conifer_tdwgcount.R	Measure geographic range on conifer data at TDWG L3 count
B6	investigate_conifer_countstats.R	Compare geographic range on conifer data by different measurements
B7	manipulate_cell_pref.R	Agglomeration step 1: Border treatment
B7	generate_species_pref.R	List species per prefecture using selected border treatment
B7	tabulate_excl_cellsp.R	Examine omitted species in border exclude
B8	manipulate_GHI_by_prefecture.R	Agglomeration step 2: GHI calculation
B9	compare_GHI_by_prefecture.R	Comparison of GHI at prefectures between FOJ and Horikawa data
B9	compare_species_proportions_by_prefecture.R	Comparison of secies richness at prefectures between FOJ and Horikawa data
B9	compare_prefscores_agglomeration.R	Merge prefecture GHI calculated by various agglomeration methods
B9	analyse_prefscores_agglomeration.R	Run statistical tests comparing prefecture GHI by agglomeration methods
B10	agglomerate_Hokkaido_cellgrid.R	Generate quartergrid GHI for Hokkaido
B11	blend_cellpref_score.R	Adopt prefecture GHI for geoquadrats with less than 40 species
B12	utaki_gazcode_GHI.R	Calculate GHI for utaki sacred groves
B13	produce_cell_score.R	Comparison of GHI with selected biodiversity measures
B13	contrast_cellGHI_with_biodiversity_measures.R	Run statistical tests comparing biodiversity measures
B14	produce_MOE_score.R	Generate 0.1° latitude by 0.1° longitude grid and calculate GHI for MOE data

Table B2: Summary of scripts for IPython and graphs generated. For scripts, see 'graphing' node on https://github.com/Nodoka/Bioquality

Code title	Graphs generated
bar_stacked_origin_starsinfs.py	Bar chart of stars for FOJ and Kew WCSP
bar_stacked_sensitivity.py	Bar chart of stars for sensitivity analysis
classification_method_score_boxplots.py	Box plot of star classification methods
classification_method_score_meandiffbar.py	Bar chart of star classification methods
classification_method_score_scatters.py	Scatter plot of star classification methods
range_size_histograms.py	Box plot and histogram of Horikawa data
horigrid_countarea_scatters.py	Scatter plot of grid count of Horikawa data
horigrid_x1adds_scatters.py	Scatter plot of grid count of Horikawa data with additional data
tdwg_boxhist.py	Box plot and histogram of TDWG data
tdwg_scatter.py	Scatter plot of TDWG data
tdwgx1_scatter.py	Scatter plot of TDWG data at degree grid
conifer_counts_scatters.py	Scatter plot of conifer specimen data
conifer_histogram.py	Histogram of conifer data
bar_stacked_fojhori.py	Bar chart of stars for FOJ and Horikawa
hori_foj_score_scatter.py	Scatter plot of prefecture FOJ vs. Horikawa GHI with outliers
pref_method_fojhoriscore_onescatter.py	Scatter plot of FOJ vs. Horikawa prefectures
pref_method_borders_scatter.py	Scatter plot of Horikawa prefectures for border treatment
pref_method_horiscore_scatter.py	Scatter plot of Horikawa prefectures for GHI calculation
bar_stacked_studysites.py	Bar chart of stars for 3 case study sites
bar_stacked_Ryu_starhabit.py	Bar chart of stars grouped by lifeform for Ryukyu samples
rbs0910_hori_scatter.py	Scatter plot of RBS sample GHI vs. Horikawa GHI
utaki_hori_scatter.py	Scatter plot of Utaki GHI vs Horikawa GHI
biodiversity_measures_hori_scattersv2.py	Scatter plot comparing biodiversity measures
central_limit_theorem.py	Histogram of GHI for randomly generated samples

Appendix C: The Flora of Japan database

C1. List of families and their star representation

Table C1. Summary of families listed in the Flora of Japan database. Major groups; †= fern and fern allies, ‡= gymnosperm; *=monocots extracted from Kew WCSP; # = moss mapped in Horikawa geoquadrat maps. Stars are abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN; X, taxa without stars. Stars and acc = the total number of taxa assigned Stars (stars) or accepted (acc) per family. APG order and families were taken from APG III system.

family	BK	GD	BU	GN	X	stars	acc.	APG order	APG family
Aspleniaceae†	1	3	1	37	5	42	47		
Azollaceae†	0	0	1	1	0	2	2		
Blechnaceae†	0	1	2	8	1	11	12		
Cheiropleuriaceae†	0	0	0	1	0	1	1		
Cyatheaceae†	3	0	0	5	0	8	8		
Davalliaceae†	0	0	0	3	0	3	3		
Dennstaedtiaceae†	0	2	0	17	1	19	20		
Dicksoniaceae†	0	0	0	1	0	1	1		
Dipteridaceae†	0	0	0	1	0	1	1		
Dryopteridaceae†	22	11	15	101	41	149	190		
Equisetaceae†	0	0	0	9	0	9	9		
Gleicheniaceae†	0	0	0	3	0	3	3		
Grammitidaceae†	2	1	1	2	0	6	6		
Hymenophyllaceae†	3	0	0	29	0	32	32		
Isoetaceae†	0	0	1	2	0	3	3		
Lindsaeaceae†	4	0	0	14	0	18	18		
Lomariopsidaceae†	0	0	1	6	1	7	8		
Lycopodiaceae†	0	1	2	21	2	24	26		
Marattiaceae†	1	0	1	2	0	4	4		
Marsileaceae†	0	0	0	2	1	2	3		
Oleandraceae†	0	0	0	4	0	4	4		
Ophioglossaceae†	5	3	1	18	2	27	29		
Osmundaceae†	0	0	1	4	1	5	6		
Parkeriaceae†	3	1	0	17	1	21	22		
Plagiogyriaceae†	0	3	0	5	2	8	10		
Polypodiaceae†	4	3	1	43	2	51	53		
Psilotaceae†	0	0	0	1	0	1	1		
Pteridaceae†	4	3	0	21	3	28	31		
Salviniaceae†	0	0	0	1	0	1	1		
Schizaeaceae†	0	0	0	4	0	4	4		
Selaginellaceae†	1	1	0	16	0	18	18		
Thelypteridaceae†	3	3	0	37	2	43	45		
Vittariaceae†	0	0	0	7	0	7	7		
Woodsiaceae†	11	12	20	83	45	126	171		
Araucariaceae‡	0	0	0	2	0	2	2		
Capparaceae‡	0	0	0	0	1	0	1		
Cephalotaxaceae‡	0	1	2	3	0	6	6		
Cryptomeriaceae‡	0	1	1	0	0	2	2		
Cupressaceae‡	2	5	3	6	1	16	17		
Cycadaceae‡	1	0	0	0	0	1	1		
Ginkgoaceae‡	0	0	0	1	0	1	1		
Pinaceae‡	8	6	14	8	4	36	40		
Podocarpaceae‡	0	1	0	5	0	6	6		
Sciadopityaceae‡	0	1	0	0	0	1	1		
Taxaceae‡	0	0	2	2	0	4	4		
Acanthaceae	0	4	1	13	0	18	18	Lamiales	Acanthaceae
Aceraceae	3	6	18	8	1	35	36	Sapindales	Sapindaceae
Actinidiaceae	0	0	1	6	1	7	8	Ericales	Actinidiaceae
Adoxaceae	0	0	0	1	0	1	1	Dipsacales	Adoxaceae
Agavaceae	0	0	0	1	0	1	1	Asparagales	Agavaceae
Aizoaceae	0	0	0	1	0	1	1	Caryophyllales	Aizoaceae
Alangiaceae	0	0	0	3	0	3	3	Cornales	Cornaceae
Amaranthaceae	0	0	0	23	1	23	24	Caryophyllales	Amaranthaceae
Anacardiaceae	0	0	0	7	0	7	7	Sapindales	Anacardiaceae

Annonaceae	0	0	0	1	0	1	1	Magnoliales	Annonaceae
Apocynaceae	3	0	2	10	1	15	16	Gentianales	Apocynaceae
Aquifoliaceae	4	2	2	17	4	25	29	Aquifoliales	Aquifoliaceae
Araliaceae	5	2	7	22	1	36	37	Apiales	Araliaceae
Aristolochiaceae	39	16	5	8	13	68	81	Piperales	Aristolochiaceae
Asclepiadaceae	10	7	4	17	7	38	45	Gentianales	Apocynaceae
Asparagaceae	1	0	4	8	0	13	13	Asparagales	Asparagaceae/Agavaceae/Ruscaceae
Asteraceae	122	120	72	255	38	569	607	Asterales	Asteraceae
Balanophoraceae	1	1	2	1	1	5	6	UnplacedEudicot	Balanophoraceae
Balsaminaceae	0	0	1	2	1	3	4	Ericales	Balsaminaceae
Basellaceae	0	0	0	2	0	2	2	Caryophyllales	Basellaceae
Begoniaceae	0	1	0	2	0	3	3	Cucurbitales	Begoniaceae
Berberidaceae	1	7	4	6	6	18	24	Ranunculales	Berberidaceae
Betulaceae	5	4	6	32	17	47	64	Fagales	Betulaceae
Bignoniaceae	0	0	0	2	0	2	2	Lamiales	Bignoniaceae
Boraginaceae	3	6	6	21	1	36	37	Unplaced EuasteridI	Boraginaceae
Buddlejaceae	0	0	1	2	1	3	4	Lamiales	Scrophulariaceae
Buxaceae	0	3	1	3	0	7	7	Buxales	Buxaceae
Cabombaceae	0	0	0	2	0	2	2	Nymphaeales	Cabombaceae
Cactaceae	0	0	0	0	1	0	1	Caryophyllales	Cactaceae
Callitrichaceae	0	0	0	3	0	3	3	Lamiales	Plantaginaceae
Calycanthaceae	0	0	0	1	0	1	1	Laurales	Calycanthaceae
Campanulaceae	10	2	2	35	2	49	51	Asterales	Campanulaceae
Capparidaceae	0	0	0	1	0	1	1	Brassicales	Brassicaceae
Caprifoliaceae	9	12	24	28	9	73	82	Dipsacales	Caprifoliaceae
Caricaceae	0	0	0	0	1	0	1	Brassicales	Caricaceae
Caryophyllaceae	12	11	5	82	24	110	134	Caryophyllales	Caryophyllaceae
Casuarinaceae	0	0	0	2	0	2	2	Fagales	Casuarinaceae
Celastraceae	4	3	3	21	2	31	33	Celastrales	Celastraceae
Ceratophyllaceae	0	0	0	6	0	6	6	Ceratophyllales	Ceratophyllaceae
Cercidiphyllaceae	0	1	0	1	0	2	2	Saxifragales	Cercidiphyllaceae
Chenopodiaceae	2	0	0	26	1	28	29	Caryophyllales	Amaranthaceae
Chloranthaceae	0	0	0	4	1	4	5	Chloranthales	Chloranthaceae
Clethraceae	0	0	0	2	0	2	2	Ericales	Clethraceae
Combretaceae	0	0	0	3	1	3	4	Myrtales	Combretaceae
Commelinaceae	0	0	0	26	0	26	26	Commelinales	Commelinaceae
Convallariaceae	3	3	4	20	5	30	35	Asparagales	Ruscaceae
Convolvulaceae	1	1	1	25	0	28	28	Solanales	Convolvulaceae
Coriariaceae	0	0	1	1	0	2	2	Cucurbitales	Coriariaceae
Cornaceae	0	1	4	15	0	20	20	Cornales	Cornaceae/Helwingiaceae/Garryaceae
Crassulaceae	10	7	5	33	11	55	66	Saxifragales	Crassulaceae
Cruciferae	6	1	3	104	16	114	130	Brassicales	Brassicaceae
Cucurbitaceae	4	1	1	25	6	31	37	Cucurbitales	Cucurbitaceae
Cymodoceaceae	0	0	0	5	0	5	5	Alismatales	Cymodoceaceae
Cyperaceae	22	21	80	464	29	587	616	Poales	Cyperaceae
Daphniphyllaceae	0	0	2	2	0	4	4	Saxifragales	Daphniphyllaceae
Diapensiaceae	4	4	2	2	0	12	12	Ericales	Diapensiaceae
Dipsacaceae	0	0	2	2	1	4	5	Dipsacales	Dipsacaceae
Dracaenaceae	0	0	0	2	0	2	2	Asparagales	Ruscaceae
Droseraceae	0	1	0	10	5	11	16	Caryophyllales	Droseraceae
Ebenaceae	0	2	0	8	0	10	10	Ericales	Ebenaceae
Elaeagnaceae	5	6	1	5	8	17	25	Rosales	Elaeagnaceae
Elaeocarpaceae	0	1	0	3	0	4	4	Oxalidales	Elaeocarpaceae
Elatinaceae	0	0	0	0	1	0	1	Malpighiales	Elatinaceae
Empetraceae	0	0	0	1	0	1	1	Ericales	Ericaceae
Ericaceae	37	41	34	39	20	151	171	Ericales	Ericaceae
Euphorbiaceae	13	8	1	77	3	99	102	Malpighiales	Euphorbiaceae
Eupteleaceae	0	0	1	0	0	1	1	Ranunculales	Eupteleaceae
Fagaceae	1	3	6	30	12	40	52	Fagales	Fagaceae
Flacourtiaceae	0	0	0	4	0	4	4	Malpighiales	Salicaceae
Gentianaceae	10	6	4	23	9	43	52	Gentianales	Gentianaceae
Geraniaceae	0	5	5	16	5	26	31	Geraniales	Geraniaceae

Gesneriaceae	0	3	2	5	0	10	10	Lamiales	Gesneriaceae
Glaucidiaceae	0	1	0	0	0	1	1	Ranunculales	Ranunculaceae
Globulariaceae	2	0	0	1	0	3	3	Lamiales	Scrophulariaceae
Goodeniaceae	0	0	0	1	1	1	2	Asterales	Goodeniaceae
Guttiferae	20	12	5	12	17	49	66	Malpighiales	Clusiaceae
Haloragaceae	1	0	1	5	0	7	7	Saxifragales	Haloragaceae
Hamamelidaceae	2	1	4	6	4	13	17	Saxifragales	Hamamelidaceae
Hedwigiaceae	0	0	0	1	0	1	1	Sapindales	Burseraceae
Hemerocallidaceae	0	2	0	9	1	11	12	Asparagales	Hemerocallidaceae
Hernandiaceae	0	0	0	2	0	2	2	Laurales	Hernandiaceae
Hippocastanaceae	0	0	0	1	1	1	2	Sapindales	Sapindaceae
Hippuridaceae	0	0	0	1	0	1	1	Lamiales	Plantaginaceae
Hostaceae	7	9	7	5	0	28	28	Asparagales	Agavaceae
Hydrocharitaceae	1	0	1	33	0	35	35	Alismatales	Hydrocharitaceae
Hypoxidaceae	0	0	0	2	0	2	2	Asparagales	Hypoxidaceae
Icacinaceae	0	0	1	1	0	2	2	NearGarryales	Icacinaceae
Illiciaceae	1	0	1	0	0	2	2	Austrobaileyales	Illiciaceae
Iridaceae	0	0	0	13	1	13	14	Asparagales	Iridaceae
Juglandaceae	0	0	0	4	1	4	5	Fagales	Juglandaceae
Juncaceae	0	0	3	48	0	51	51	Poales	Juncaceae
Labiatae	23	26	26	110	20	185	205	Lamiales	Lamiaceae
Lardizabalaceae	0	0	0	3	3	3	6	Ranunculales	Lardizabalaceae
Lauraceae	8	3	7	25	5	43	48	Laurales	Lauraceae
Lecythidaceae	0	0	0	2	0	2	2	Ericales	Lecythidaceae
Leeaceae	0	0	0	1	0	1	1	Vitales	Vitaceae
Leguminosae-c.	1	0	1	11	0	13	13	Fabales	Fabaceae
Leguminosae-m.	0	0	0	8	0	8	8	Fabales	Fabaceae
Leguminosae-p.	8	8	13	183	17	212	229	Fabales	Fabaceae
Lentibulariaceae	0	1	1	11	0	13	13	Lamiales	Lentibulariaceae
Liliaceae	5	10	15	42	2	72	74	Liliales	Liliaceae/Ruscaceae
Linaceae	0	0	0	5	0	5	5	Malpighiales	Linaceae
Loganiaceae	1	0	1	3	0	5	5	Gentianales	Loganiaceae
Loranthaceae	0	1	0	5	0	6	6	Santalales	Loranthaceae/Santalaceae
Lythraceae	0	0	2	13	2	15	17	Myrtales	Lythraceae
Magnoliaceae	2	0	1	5	0	8	8	Magnoliales	Magnoliaceae
Malpighiaceae	0	0	0	3	0	3	3	Malpighiales	Malpighiaceae
Malvaceae	3	0	1	23	4	27	31	Malvales	Malvaceae
Melastomataceae	4	1	0	4	0	9	9	Myrtales	Melastomataceae
Meliaceae	0	0	0	3	1	3	4	Sapindales	Meliaceae
Menispermaceae	0	0	0	12	0	12	12	Ranunculales	Menispermaceae
Menyanthaceae	0	0	1	4	0	5	5	Asterales	Menyanthaceae
Mitrastemonaceae	0	0	0	1	0	1	1	UnplacedEudicot	Rafflesiaceae
Molluginaceae	0	0	0	3	0	3	3	Caryophyllales	Molluginaceae/Aizoaceae
Moraceae	5	0	0	26	5	31	36	Rosales	Moraceae/Cannabaceae
Myoporaceae	1	0	0	1	0	2	2	Lamiales	Myoporaceae
Myricaceae	0	0	0	5	1	5	6	Fagales	Myricaceae/Juglandaceae
Myrsinaceae	2	1	1	9	1	13	14	Ericales	Myrsinaceae
Myrtaceae	1	1	0	6	0	8	8	Myrtales	Myrtaceae
Nartheciaceae	0	0	1	6	0	7	7	Liliales	Melanthiaceae
Nelumbonaceae	0	0	0	1	0	1	1	Proteales	Nelumbonaceae
Nyctaginaceae	0	0	0	7	0	7	7	Caryophyllales	Nyctaginaceae
Nymphaeaceae	0	1	3	4	5	8	13	Nymphaeales	Nymphaeaceae
Olacaceae	0	0	0	1	0	1	1	Santalales	Olacaceae
Oleaceae	9	5	8	24	7	46	53	Lamiales	Oleaceae
Onagraceae	0	0	1	41	6	42	48	Myrtales	Onagraceae
Orchidaceae	44	4	48	209	6	305	311	Asparagales	Orchidaceae
Orobanchaceae	1	0	0	5	0	6	6	Lamiales	Scrophulariaceae
Oxalidaceae	1	2	0	8	1	11	12	Oxalidales	Oxalidaceae
Paeoniaceae	0	0	0	2	0	2	2	Saxifragales	Paeoniaceae
Palmaceae	4	0	0	8	1	12	13	Arecales	Arecaceae
Pandanaceae	4	0	1	2	0	7	7	Pandanales	Pandanaceae
Papaveraceae	2	3	2	18	7	25	32	Ranunculales	Papaveraceae
Philydraceae	0	0	0	1	0	1	1	Commelinales	Philydraceae

Phormiaceae	0	0	0	1	0	1	1	Asparagales	Hemerocallidaceae
Phrymaceae	0	0	0	1	0	1	1	Lamiales	Phrymaceae
Phytolaccaceae	0	0	0	4	0	4	4	Caryophyllales	Phytolaccaceae
Piperaceae	2	1	0	2	0	5	5	Piperales	Piperaceae
Pittosporaceae	0	5	0	3	2	8	10	Apiales	Pittosporaceae
Plantaginaceae	0	2	0	5	0	7	7	Lamiales	Plantaginaceae
Plumbaginaceae	1	1	0	2	0	4	4	Caryophyllales	Plumbaginaceae
Podostemaceae	7	0	0	2	0	9	9	Malpighiales	Podostemaceae
Polemoniaceae	0	1	1	3	0	5	5	Ericales	Polemoniaceae
Polygalaceae	0	1	0	6	1	7	8	Fabales	Polygalaceae
Polygonaceae	3	1	7	95	47	106	153	Caryophyllales	Polygonaceae
Pontederiaceae	0	0	0	3	0	3	3	Commelinales	Pontederiaceae
Portulacaceae	1	0	0	4	1	5	6	Caryophyllales	Portulacaceae
Potamogetonaceae	1	0	0	26	8	27	35	Alismatales	Potamogetonaceae
Primulaceae	9	15	4	23	2	51	53	Ericales	Primulaceae
Proteaceae	0	0	0	1	0	1	1	Proteales	Proteaceae
Pyrolaceae	0	0	0	15	0	15	15	Ericales	Ericaceae
Ranunculaceae	38	41	32	79	69	190	259	Ranunculales	Ranunculaceae
Rhamnaceae	3	1	8	13	0	25	25	Rosales	Rhamnaceae
Rhizophoraceae	0	0	0	6	0	6	6	Malpighiales	Rhizophoraceae
Rosaceae	21	28	24	148	117	221	338	Rosales	Rosaceae
Rubiaceae	12	14	6	123	6	155	161	Gentianales	Rubiaceae
Ruppiaceae	0	0	0	1	0	1	1	Alismatales	Potamogetonaceae
Rutaceae	7	4	2	21	4	34	38	Sapindales	Rutaceae
Sabiaceae	0	1	0	6	0	7	7	BasalEudicot	Sabiaceae
Salicaceae	2	1	6	33	40	42	82	Malpighiales	Salicaceae
Santalaceae	1	0	0	3	0	4	4	Santalales	Santalaceae
Sapindaceae	0	0	0	4	0	4	4	Sapindales	Sapindaceae
Sapotaceae	1	0	0	2	0	3	3	Malpighiales	Ochnaceae
Saururaceae	0	0	0	2	0	2	2	Piperales	Saururaceae
Saxifragaceae	23	49	40	47	39	159	198	Saxifragales	Saxifragaceae/Grossulariaceae/ Penthoraceae/Parnassiaceae/ Hydrangeaceae/Escalloniaceae
Scheuchzeriaceae	0	0	0	1	0	1	1	Alismatales	Scheuchzeriaceae
Schisandraceae	0	0	1	2	0	3	3	Austrobaileyales	Schisandraceae
Scrophulariaceae	26	23	20	77	8	146	154	Lamiales	Scrophulariaceae
Simaroubaceae	0	0	0	2	0	2	2	Sapindales	Simaroubaceae
Smilacaceae	2	1	0	10	2	13	15	Liliales	Smilacaceae
Solanaceae	3	4	3	21	1	31	32	Solanales	Solanaceae
Sonneratiaceae	0	0	0	1	0	1	1	Myrtales	Lythraceae
Stachyuraceae	0	1	2	1	0	4	4	Crossosomatales	Stachyuraceae
Staphyleaceae	0	0	0	3	1	3	4	Crossosomatales	Staphyleaceae
Sterculiaceae	0	0	0	7	0	7	7	Malvales	Malvaceae
Styracaceae	0	0	2	4	0	6	6	Ericales	Styracaceae
Symplocaceae	9	5	2	10	0	26	26	Ericales	Symplocaceae
Theaceae	12	0	3	8	3	23	26	Ericales	Theaceae
Theligonaceae	0	0	1	0	0	1	1	Gentianales	Rubiaceae
Thymelaeaceae	5	2	2	9	1	18	19	Malvales	Thymelaeaceae/Euphorbiaceae
Tiliaceae	0	1	3	10	1	14	15	Malvales	Malvaceae
Trapaceae	0	0	0	3	0	3	3	Myrtales	Lythraceae
Trapellaceae	0	0	0	1	0	1	1	Lamiales	Pedaliaceae
Triuridaceae	2	1	2	0	0	5	5	Pandanales	Triuridaceae
Trochodendraceae	0	0	0	1	0	1	1	Trochodendrales	Trochodendraceae
Tyohaceae	0	0	0	1	0	1	1	Poales	Typhaceae
Typhaceae	0	0	0	16	2	16	18	Poales	Typhaceae
Ulmaceae	0	1	0	11	0	12	12	Rosales	Ulmaceae
Umbelliferae	14	23	18	52	6	107	113	Apiales	Apiaceae
Urticaceae	10	2	4	52	14	68	82	Rosales	Urticaceae
Valerianaceae	0	4	1	5	3	10	13	Dipsacales	Valerianaceae
Verbenaceae	9	0	1	37	4	47	51	Lamiales	Verbenaceae/Acanthaceae
Violaceae	7	6	14	43	8	70	78	Malpighiales	Violaceae
Vitaceae	2	1	5	13	1	21	22	Vitales	Vitaceae
Zingiberaceae	2	1	1	7	2	11	13	Zingiberales	Zingiberaceae

Zosteraceae	0	0	0	9	0	9	9	Alismatales	Zosteraceae
Zygophyllaceae	0	0	0	1	0	1	1	Zygophyllales	Zygophyllaceae
Acoraceae*	0	0	0	3	0	3	3	Acorales	Acoraceae
Alismataceae*	0	0	0	9	0	9	9	Alismatales	Alismataceae
Amaryllidaceae*	6	0	5	30	0	41	41	Asparagales	Amaryllidaceae/Alliaceae
Araceae*	20	15	24	33	1	92	93	Alismatales	Araceae
Burmanniaceae*	4	0	0	6	0	10	10	Dioscoreales	Burmanniaceae
Cannaceae*	0	0	0	1	0	1	1	Zingiberales	Cannaceae
Dioscoreaceae*	1	1	0	16	0	18	18	Dioscoreales	Dioscoreaceae
Eriocaulaceae*	12	6	11	22	0	51	51	Poales	Eriocaulaceae
Flagellariaceae*	0	0	0	1	0	1	1	Poales	Flagellariaceae
Gramineae*	11	8	7	204	211	230	441	Poales	Poaceae
Juncaginaceae*	0	0	0	2	0	2	2	Alismatales	Juncaginaceae
Marantaceae*	0	0	0	1	0	1	1	Zingiberales	Marantaceae
Melanthiaceae*	2	6	9	16	4	33	37	Liliales	Melanthiaceae
Musaceae*	0	1	0	2	0	3	3	Zingiberales	Musaceae
Palmae*	0	0	0	1	0	1	1	Arecales	Arecaceae
Petrosaviaceae*	0	0	1	1	0	2	2	Liliales	Melanthiaceae
Stemonaceae*	2	0	1	2	0	5	5	Pandanales	Stemonaceae
Tofieldiaceae*	0	0	2	3	0	5	5	Liliales	Melanthiaceae
Brachytheciaceae#	0	0	0	1	0	1	1		
Conocephalaceae#	0	0	0	1	1	1	2		
Hylocomiaceae#	0	0	0	3	0	3	3		
Hypnaceae#	0	0	0	1	0	1	1		
Makinoaceae#	0	0	0	1	0	1	1		
Mniaceae#	0	0	0	2	1	2	3		
Neckeraceae#	0	0	0	1	0	1	1		
Pleuroziopsaceae#	0	0	0	1	0	1	1		
Polytrichaceae#	0	0	0	2	0	2	2		
Porellaceae#	0	0	0	2	0	2	2		
Rhizogoniaceae#	0	0	0	0	1	0	1		
Schistostegaceae#	0	0	0	1	0	1	1		
Thuidiaceae#	0	0	0	0	1	0	1		
Wiesnerellaceae#	0	0	0	1	0	1	1		

C2. Taxa with stars on the Flora of Japan database

Checklist flora of Japan

Online database of the Flora of Japan is provided via http://herbaria.plants.ox.ac.uk/bol/florajapan

For each taxon, the following information is provided;

- **Star**: status assigned using the proposed guidelines.
- **Plot**: taxa recorded in plot samples are identified by: **s**, the *satochi-satoyama* landscape RBS samples; **o**, Okinawa-jima island RBS samples; **u**, the *Utaki* sacred groves; **c**, checklists of selected islands; **p**, botanical prefecture FOJ data; **h**, Horikawa geoquadrat data.
- Reference on distribution information used to assign Star is identified. Data providers are: the Flora of Japan (Iwatsuki *et al.*, 1999, 2001, 2005, Iwatsuki *et al.*, 1993, Iwatsuki *et al.*, 1995a, Iwatsuki *et al.*, 1995b), Kew's world checklist of selected families (W.C.S.P., 2012). Additional data were sourced from Missouri Botanic Garden's Tropicos available at http://www.tropicos.org, Global Compositae Checklist available at http://compositae.landcareresearch.co.nz/Default.aspx, the International Legume Database & Information Service (hereafter **ILDIS**) available at http://www.ildis.org/, and the Old Flora of Japan (Ohwi *et al.*, 1965).

Appendix D: Botanical survey plot data

D1. Rapid Botanical Survey 2009

Table D1: Summary of 2009 RBS sample plots. sampname = plot ID, the number represents the plot number in a forest patch; Date = survey date; Pref. = prefecture; gazetteer = Name of *satoyama* forest patch; lat = latitude (°N); long = longitude (°E); alt = altitude (m); H = habitat type (wd = forest, gr = grassland); Mgt = forest management (y = Yes, n = No); rec. = total number of recorded species; sp. = total number of unique species; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN.

ID	sampname	date	Pref.	gazetteer	lat	long	alt	H	Mgt	rec.	sp.	GHI	BK	GD	BU	GN
1	USHIKH1	18-Jun-09	Ibaraki	Ushiku Kakogahara	35.95561	140.15078	8	wd	y	85	81	46	0	1	9	67
2	USHIKH2	18-Jun-09	Ibaraki	Ushiku Kakogahara	35.95504	140.15046	0	gr	y	66	64	75	1	1	3	55
3	USHIKH3	18-Jun-09	Ibaraki	Ushiku Kakogahara	35.95592	140.15094	0	wd	n	67	61	32	0	1	3	51
4	SDKAGE1	19-Jun-09	Ibaraki	Shimodate kagesawa	36.26189	139.96475	27	wd	y	75	70	45	0	1	7	58
5	SDKAGE2	19-Jun-09	Ibaraki	Shimodate kagesawa	36.26194	139.96533	42	wd	y	67	64	30	0	0	6	54
6	SDKAGE3	19-Jun-09	Ibaraki	Shimodate kagesawa	36.26158	139.96431	0	rp	y	42	40	30	0	0	4	35
7	SDKAGE4	19-Jun-09	Ibaraki	Shimodate kagesawa	36.26214	139.96281	47	wd	n	72	67	18	0	0	4	61
8	SDKAGE5	19-Jun-09	Ibaraki	Shimodate kagesawa	36.26275	139.96631	0	wd	y	46	46	34	0	1	2	40
9	KOGASW1	14-Jul-09	Ibaraki	Koga Sanwa	36.18397	139.78000	21	wd	y	61	59	48	0	0	9	47
10	KOGASW2	14-Jul-09	Ibaraki	Koga Sanwa	36.18398	139.77934	0	wd	y	59	55	39	0	0	7	46
11	KOGASW3	14-Jul-09	Ibaraki	Koga Sanwa	36.18319	139.77833	31	wd	n	101	89	35	0	1	7	76
12	FUNAAP1	20-Jul-09	Chiba	Funabashi Andersen Park	35.76317	140.06056	44	wd	y	101	98	35	0	0	11	82
13	FUNASK1	20-Jul-09	Chiba	Funabashi Seiso Kojo	35.77758	140.06672	51	wd	y	98	92	47	0	1	11	77
14	FUNATM1	21-Jul-09	Chiba	Funabashi Toyotomi	35.76194	140.07486	50	wd	y	122	116	29	0	0	11	102
15	FUNATM2	21-Jul-09	Chiba	Funabashi Toyotomi	35.76055	140.07386	0	wd	n	75	72	34	0	0	8	61
16	KASHIK1	24-Jul-09	Chiba	Kashiwa Kobukuro	35.90261	139.94588	42	wd	y	95	91	37	0	0	11	76
17	KASHIK2	24-Jul-09	Chiba	Kashiwa Kobukuro	35.90000	139.93333	0	wd	y	92	85	25	0	0	7	74
18	KASHIO3	24-Jul-09	Chiba	Kashiwa Oaoda	35.90672	139.92325	29	wd	n	65	63	24	0	0	5	56
19	HOKONP1	29-Jul-09	Ibaraki	Hokota Nodono	36.14444	140.48133	38	wd	y	96	92	67	1	1	8	79
20	HOKONP2	29-Jul-09	Ibaraki	Hokota Nodono	36.14408	140.48247	21	wd	y	92	89	17	0	0	5	81
21	HOKONP3	29-Jul-09	Ibaraki	Hokota Nodono	36.14378	140.48136	42	wd	n	79	76	22	0	0	5	63
22	HOKOFB4	29-Jul-09	Ibaraki	Hokota Fudaba	36.16758	140.4515	37	wd	y	89	79	36	0	0	9	65
23	MORICC1	31-Jul-09	Ibaraki	Moriya City Council	35.94886	139.97633	47	wd	y	94	90	27	0	0	8	79
24	MORITZ2	31-Jul-09	Ibaraki	Moriya Tatsuzawa	35.95619	139.96667	73	wd	n	106	101	24	0	0	8	89
25	YUKIKM1	05-Aug-09	Ibaraki	Yuki Kenko no mori	36.27044	139.84858	16	wd	y	99	90	31	0	1	6	78
26	YUKIKM2	05-Aug-09	Ibaraki	Yuki Kenko no mori	36.25281	139.84897	10	wd	y	92	77	16	0	0	4	69
27	YUKIKM3	05-Aug-09	Ibaraki	Yuki Kenko no mori	36.25281	139.84897	16	wd	n	91	87	70	1	0	10	70
28	SJGORO1	07-Aug-09	Ibaraki	Sekijo Gorosuke	36.24619	139.93781	36	wd	y	171	122	33	0	0	13	102
29	SJGORO2	07-Aug-09	Ibaraki	Sekijo Gorosuke	36.24678	139.93844	37	wd	n	61	60	41	0	0	8	50
30	SJMARU1	07-Aug-09	Ibaraki	Sekijo Maruyama	36.25153	139.97028	43	wd	y	113	104	39	0	0	13	87

31	USHINS1	13-Aug-09	Ibaraki	Ushiku Nature Sanctuary	35.96256	140.17322	29	wd	y	126	118	41	0	1	12	96
32	USHINS2	13-Aug-09	Ibaraki	Ushiku Nature Sanctuary	35.96231	140.17272	35	wd	y	84	78	28	0	0	7	66
33	USHINS3	13-Aug-09	Ibaraki	Ushiku Nature Sanctuary	35.96222	140.1725	0	wd	n	15	15	NA	0	0	3	12
34	USHIMS1	13-Aug-09	Ibaraki	Ushiku Muzina no sato	35.96383	140.18222	0	wd	y	81	76	36	0	0	9	65
35	AMIKOP1	13-Aug-09	Ibaraki	Ami Koike Park	35.98840	140.19992	0	wd	y	101	90	36	0	0	10	73
36	YASAAO1	19-Aug-09	Ibaraki	Yasato Shimoaoyanagi	36.20500	140.17000	38	wd	y	147	128	25	0	0	10	110
37	YASAKE2	19-Aug-09	Ibaraki	Yasato Kenmin no mori	36.20889	140.16917	0	wd	y	103	92	41	0	0	12	74
38	YASAYA3	19-Aug-09	Ibaraki	Yasato Yagyu	36.21019	140.15741	0	wd	n	93	77	56	0	0	14	61
39	YASAFP4	19-Aug-09	Ibaraki	Yasato Flower Park	36.21472	140.16667	0	wd	y	109	95	37	0	1	8	79

D2. Rapid Botanicaly survey 2010

Table D2: Summary of 2010 RBS sample plots. Sample = plot ID, the number represents the plot number in a forest patch; Date = survey date; lat = latitude (°N); long = longitude (°E); alt = altitude (m); L = landscape unit (1. Mt. Nago forest, 2. Mt. Nago river, 3. Nt. Nago utaki, 4. Cape Hedo coastal grassland, 5. Mt. Yonaha forest, 6. Mt. Yonaha river, 7. Mt. Tano forest, 8. Urasoe utaki, 9. Mt. Katsuu rocky summit, 10. Mt. Katsuu forest); V = national vegetation classification (6088, *Psychotria rubra-Castanopsis sieboldii* var. *sieboldii*; 6152, *Cycas revolute*; 6158, *Psychotria manillensis-Acer oblongum* var. *itoanum*; 6165, *Pinus luchuensis*; 7064, *Imperata cylindrica-Miscanthus sinensis* communities); rec. = total number of species sampled; sp. = total number of unique species; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN.

ID	Sample	date	island	gazetteer	lat	long	alt	L	V	rec.	sp.	GHI	BK	GD	BU	GN
4001	MtNago1	14-Jun-10	Okinawa	Mt. Nago	26.596	128.00569	206	1	6152	96	65	248	3	5	1	43
4002	CapeHedo	14-Jun-10	Okinawa	Cape Hedo	26.87204	128.26462	45	4	6158	28	23	NA	1	0	1	19
4003	MtNago2	15-Jun-10	Okinawa	Mt. Nago	26.58872	128.01057	219	2	7064	60	47	200	2	3	1	36
4004	YonaunivF	16-Jun-10	Okinawa	Univ. forest, Mt. Yonaha	26.74128	128.22073	308	5	6165	109	88	296	6	7	2	63
4005	ROkuni1	19-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.71838	128.20425	272	5	6088	101	83	377	9	4	4	60
4006	ROkuni2	19-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.71813	128.20041	274	5	6088	93	72	330	7	3	3	55
4007	ROkuni3	19-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.70893	128.19717	194	5	6088	98	69	262	5	3	2	54
4008	ROkuni4	19-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.70866	128.19665	155	6	6165	42	40	105	1	1	1	34
4009	ROkuni5	20-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.70499	128.19229	305	5	6088	112	97	290	7	7	5	73
4010	ROkuni6	20-Jun-10	Okinawa	Okuni FR., Mt. Yonaha	26.7079	128.19569	180	5	6088	92	72	171	2	5	3	53
4011	MtNago3	26-Jun-10	Okinawa	Mt. Nago	26.58451	128.00754	293	1	6088	109	95	325	7	8	3	65
4012	MtNago4	26-Jun-10	Okinawa	Mt. Nago	26.58596	128.00484	262	1	6088	106	93	250	6	4	5	70
4013	MtNago5	26-Jun-10	Okinawa	Mt. Nago	26.59103	128.00417	219	1	6088	81	76	278	6	3	1	59
4014	MtNago6	26-Jun-10	Okinawa	Mt. Nago utaki	26.58858	127.99271	94	3	6088	70	58	141	2	2	1	48
4015	RKayo1	27-Jun-10	Okinawa	Kayo forest road, Mt. Tano	26.57537	128.10298	166	7	6088	68	60	166	2	3	4	47
4016	RKayo2	27-Jun-10	Okinawa	Kayo forest road, Mt. Tano	26.57594	128.09377	176	7	6088	57	50	231	3	3	1	41
4017	RKayo3	27-Jun-10	Okinawa	Kayo forest road, Mt. Tano	26.58842	128.07541	256	7	6088	79	69	300	6	3	1	54
4018	RKayo4	27-Jun-10	Okinawa	Kayo forest road, Mt. Tano	26.58813	128.06439	326	7	6088	76	69	214	3	5	3	52
4019	Urasoe	01-Jul-10	Okinawa	Urasoe park, Urasoe city	26.25199	127.73048	75	8	6088	80	70	266	4	6	1	51
4020	MtKatsu1	08-Jul-10	Okinawa	Mt. Katsuu	26.63102	127.93506	462	9	6158	65	59	398	6	4	3	39
4021	MtKatsu2	08-Jul-10	Okinawa	Mt. Katsuu	26.63146	127.93475	436	10	6088	88	78	282	4	9	2	54

D3. The *Utaki* sacred groves

Table D3: Summary of the *Utaki* sacred grove survey data. Sample = ID for a plot. Island (isl) (see list below); Municipal = city (c), town (t), village (v); utaki = Name of utaki in the reference; lat = latitude (°N); long = longitude (°E); alt = average altitude (m); slope = slope angle (°); V= national vegetation classification (see list below); sp. = total number of unique species recorded per *utaki*; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN.

ID	sample	isl.	municipal	utaki	lat	long	alt	slope	V	sp.	GHI	BK	GD	BU	GN
31	Kunig31	7	Kunigami v.	Hama 'Nishimui'	26.72028	128.16000	-	-	9072	60	195	3	3	3	51
32	Kunig32	7	Kunigami v.	Hama 'Shadongu'	26.71639	128.15972	28	11.7	6165	30	NA	1	2	1	26
33	Kunig33	7	Kunigami v.	Hiji 'Asagi'	26.72778	128.17833	87	27.5	6088	76	162	2	6	5	63
34	Kunig34	7	Kunigami v.	Hiji 'Nakamui'	26.71949	128.17944	66	27.5	6165	38	NA	1	3	3	31
35	Kunig35	7	Kunigami v.	Hentona Uwashima 'Asagi'	26.74131	128.17940	47	21.3	6165	32	NA	1	4	2	25
36	Kunig36	7	Kunigami v.	Iji 'Youkeisho'	26.76059	128.19219	-	-	7064	40	360	5	0	3	32
37	Kunig37	7	Kunigami v.	Sate 'Yankushi'	26.78780	128.22112	-	-	6129	23	NA	2	1	1	19
38	Kunig38	7	Kunigami v.	Benoki keisho	26.79377	128.24297	146	25.5	9007	41	359	4	3	4	30
39	Kunig39	7	Kunigami v.	Uka 'Nishimuinishidake'	26.81167	128.23611	-	-	9098	31	NA	0	3	1	27
40	Kunig40	7	Kunigami v.	Hedo 'Tahanna'	26.85631	128.25686	116	19.5	6158	50	216	3	2	3	42
41	Ginoz41	7	Ginoza v.	Matsuda 'Go no taki'	26.49556	127.99333	33	5.9	9072	85	247	5	6	7	67
42	Ginoz42	7	Ginoza v.	Matsuda 'Minami no taki'	26.49278	127.99167	33	5.9	9902	59	249	3	6	4	46
43	Ginoz43	7	Ginoza v.	Matsuda Ubu gawa	26.49417	127.99333	33	5.9	9072	39	NA	3	2	1	33
44	Ginoz44	7	Ginoza v.	Ginoza Ubu gawa	26.48639	128.05833	-	-	9072	59	81	0	4	4	51
45	Ginoz45	7	Ginoza v.	Sokei 'Maryougama'	26.47889	127.97417	38	5.5	9072	37	NA	3	0	5	29
46	Ginoz46	7	Ginoza v.	Kanna 'Yoriage'	26.47722	127.95958	21	11.3	9902	73	193	2	8	5	58
47	Higas47	7	Higashi v.	Takae 'Aza no kamisama'	26.66194	128.25333	114	22.4	9902	19	NA	3	0	1	15
48	Higas48	7	Higashi v.	Udomari keisho	26.63431	128.21583	111	18.7	9072	49	288	4	3	2	40
49	Higas49	7	Higashi v.	Miyagi keisho	26.62583	128.18139	49	9.8	9072	39	NA	3	1	2	33
50	Higas50	7	Higashi v.	Kawata keisho	26.62944	128.17083	26	13.6	6088	47	204	3	1	2	41
51	Higas51	7	Higashi v.	Kawata 'Masaru no miya'	26.62972	128.16528	26	13.6	9902	35	NA	0	0	3	32
52	Higas52	7	Higashi v.	Kesaji keisho	26.60236	128.14403	25	10.1	6088	87	241	4	9	7	67
53	Higas53	7	Higashi v.	Kominato keisho	26.60639	128.12861	52	13.2	6088	31	NA	3	2	2	24
54	Higas54	7	Higashi v.	Arume keisho	26.60444	128.12222	49	21.3	6088	76	261	4	8	6	58
55	Nakij55	7	Nakijin v.	Waku gawa utaki	26.65444	127.98639	40	11.8	9072	55	267	4	4	1	46
56	Nakij56	7	Nakijin v.	Waku gawa kigansho	26.65806	127.98889	18	12.5	6158	18	NA	0	0	0	18
57	Nakij57	7	Nakijin v.	Amesoko kigansho	26.67056	127.98056	38	21.2	9072	48	294	4	3	2	39
58	Nakij58	7	Nakijin v.	Kamiunten kigansho	26.68444	127.99833	21	6.4	9072	45	233	2	5	2	36
59	Nakij59	7	Nakijin v.	Jana utaki	26.68472	127.97417	15	3.7	6165	41	234	2	4	2	33
60	Nakij60	7	Nakijin v.	Jana shikawa kigansho	26.68222	127.96639	23	13.1	6158	30	NA	2	3	3	22
61	Nakij61	7	Nakijin v.	Heshiki kigan	26.69250	127.95833	10	4.5	9072	37	NA	2	3	2	30
62	Nakij62	7	Nakijin v.	Shoshi utaki	26.69528	127.94681	5	7.4	6158	74	284	5	7	4	58
63	Kin63	7	Kin t.	Namisato 'Keisho ookawa'	26.45056	127.92694	41	8.2	9072	39	NA	1	4	0	34
64	Kin64	7	Kin t.	Kin keisho 'Busuzu'	26.45472	127.91750	51	7.4	9902	47	147	1	4	2	40
65	Kin65	7	Kin t.	Igei 'Mae no utaki'	26.45972	127.87833	60	13.1	9072	44	239	3	2	2	37

66	Kin66	7	Kin t.	Yaka 'Iri'	26.45389	127.85389	22	11.1	9919	56	257	4	3	3	46
67	Kin67	7	Kin t.	Yaka 'Agari'	26.45806	127.85806	22	11.1	6165	46	365	5	3	2	36
68	Motob68	7	Motobu t.	Gushiken 'Gushiken no taki'	26.69500	127.91250	11	9.1	6165	38	NA	3	3	1	31
69	Motob69	7	Motobu t.	Urasaki 'Urazaki no taki'	26.67667	127.89417	31	5.5	9072	45	347	4	4	4	33
70	Motob70	7	Motobu t.	Hamamoto 'Toteikun'	26.66944	127.89083	24	7.3	6158	35	NA	2	4	1	28
71	Motob71	7	Motobu t.	Toguchi 'Gushikawa Gushiku'	26.66361	127.89778	39	5.9	6158	59	356	5	7	4	43
72	Motob72	7	Motobu t.	Inoha 'Inoha jinja'	26.66278	127.90917	71	12.2	7064	42	100	0	4	2	36
73	Motob73	7	Motobu t.	Izumi 'Izumi jinja'	26.65111	127.94667	121	16.9	9902	56	188	1	8	2	45
74	Motob74	7	Motobu t.	Kenken 'Uzamo jinja'	26.64722	127.88306	15	99.9	9072	32	NA	2	4	2	24
75	Motob75	7	Motobu t.	Kenken 'Ninufa'	26.64778	127.88222	15	99.9	9072	16	NA	0	1	1	14
76	Yonas76	10	Yonashiro v.	Ikei-jima Ikei joshi	26.38639	127.99000	18	2.8	6158	40	368	4	4	1	31
77	Yonas77	12	Yonashiro v.	Miyagi-jima 'Kamihara no guchi'	26.37111	127.98528	46	14.6	9902	36	NA	1	3	2	30
78	Yonas78	13	Yonashiro v.	Henza-jima Higashijo	26.34111	127.95806	28	14.6	9072	24	NA	0	2	2	20
79	Katsu79	7	Katsuren v.	katsuren joshi	26.33056	127.87889	31	8.1	6158	45	240	3	3	0	39
80	Katsu80	14	Katsuren v.	Tsuken-jima 'Kubougushiku'	26.24917	127.93556	-	-	9902	42	243	3	2	1	36
81	Katsu81	14	Katsuren v.	Tsuken-jima higasen keisho	26.25958	127.94125	-	-	9072	23	NA	1	1	0	21
82	Ishik82	7	Ishikawa c.	Iha joshi	26.42167	127.81750	26	15.7	9072	42	336	4	3	2	33
83	Ishik83	7	Ishikawa c.	Kagekaru kigan	26.42444	127.80222	69	9.1	6165	46	326	4	3	5	34
84	Ishik84	7	Ishikawa c.	Yamashiro Ushiage	26.41389	127.81333	60	6.6	9919	46	378	5	4	1	36
85	Ishik85	7	Ishikawa c.	Iha-aji grave	26.41722	127.81750	26	15.7	9072	41	322	4	2	2	33
86	Ishik86	7	Ishikawa c.	Higashionna utaki	26.41056	127.82944	30	6.4	9902	29	NA	1	3	0	25
87	Kaden87	7	Kadena t.	Kadena kigan	26.36722	127.75778	23	4	9902	57	247	3	6	2	46
88	Kaden88	7	Kadena t.	Yara joshi	26.36778	127.76278	34	5	6165	87	286	6	8	5	68
89	Kaden89	7	Kadena t.	Yara muruchi	26.36972	127.77917	45	7.4	6165	62	266	4	5	4	49
90	Yomit90	7	Yomitani v.	Zakimi joshi	26.40833	127.74194	83	10.9	6165	52	410	6	5	2	39
91	Yomit91	7	Yomitani v.	Zakimi utaki 'Kushinumachuguwa'	26.40667	127.74667	83	10.9	6165	51	365	5	5	2	39
92	Yomit92	7	Yomitani v.	Kina utaki	26.40167	127.76167	69	7.4	9072	53	436	6	7	2	38
93	Yomit93	7	Yomitani v.	Sho-hashiou grave	26.38722	127.75722	57	3.9	6165	50	228	2	6	2	40
94	Yomit94	7	Yomitani v.	Iramina utaki	26.38028	127.75722	36	5	9072	50	198	2	4	3	41
95	Yomit95	7	Yomitani v.	Owan gushiwa	26.37056	127.75667	23	4	7064	45	213	2	4	2	37
96	Chata96	7	Chatan v.	Sunabe utaki	26.33278	127.74750	-	-	9902	33	NA	0	3	1	29
97	Chata97	7	Chatan v.	Chatan jo	26.30917	127.76639	17	8.4	6158	71	296	5	7	4	55
98	Ginow98	7	Ginowan c.	Morikawa keisho	26.27028	127.74139	27	8.2	7064	51	135	1	4	2	44
99	Ginow99	7	Ginowan c.	Ganekojo	26.25389	127.75111	87	9.8	6158	41	351	5	1	0	35
100	Ginow100	7	Ginowan c.	Futenmangu	26.29306	127.77694	53	7.4	9902	49	263	3	4	4	38
101	Ginow101	7	Ginowan c.	Oyama utaki	26.28361	127.75222	5	5.3	9902	36	NA	1	1	2	32
102	Kitan102	7	Kitanakagusuku v.	Chunjun kigansho	26.30361	127.80028	39	10.9	9902	29	NA	0	5	1	23
103	Kitan103	7	Kitanakagusuku v.	Chunjun Nasunotaki	26.30528	127.79750	82	11.8	6158	45	380	5	3	3	34
104	Kitan104	7	Kitanakagusuku v.	Kishaba utaki	26.30611	127.79083	82	11.8	6158	34	NA	4	3	1	26
105	Kitan105	7	Kitanakagusuku v.	Oshiro no taki	26.29222	127.80028	36	11.6	6158	60	405	6	8	3	43

106	Kitan106	7	Kitanakagusuku v.	Adaniyajo taki	26.29750	127.78972	67	9.8	6158	50	216	2	5	3	40
107	Kitan107	7	Kitanakagusuku v.	Nakashiro-wakamatu grave	26.29694	127.78472	53	7.4	9902	44	300	3	5	2	34
108	Nakag108	7	Nakagusuku v.	Nakagusukujo	26.28444	127.80292	79	14.6	6158	72	263	4	8	3	57
109	Nakag109	7	Nakagusuku v.	Arakaki keisho	26.27250	127.78583	91	12.6	6158	73	263	4	8	4	57
110	Nakag110	7	Nakagusuku v.	Asato no tera	26.25750	127.78861	3	13.1	9072	22	NA	0	0	1	21
112	Nishi112	7	Nishihara t.	Okuma goten	26.22750	127.76778	29	10.3	9902	44	205	2	4	0	38
113	Nishi113	7	Nishihara t.	Kadena Uchima utaki	26.22917	127.76722	29	10.3	9902	18	NA	0	0	0	18
114	Nishi114	7	Nishihara t.	Goya kigansho	26.22778	127.75778	46	10.9	9072	31	NA	0	2	1	28
116	Nishi116	7	Nishihara t.	Gaja Eboshigawa utaki	26.21333	127.75556	32	19.1	9083	26	NA	2	2	1	21
117	Nishi117	7	Nishihara t.	Kohatsu kigansho	26.22556	127.75139	46	10.9	9072	34	NA	0	3	1	30
118	Nishi118	7	Nishihara t.	Onaga R. Teranokoshiro	26.23528	127.74639	79	14.6	6158	48	256	3	4	2	39
119	Nishi119	7	Nishihara t.	Tanabaru keisho	26.24583	127.75500	97	14.6	9072	36	NA	2	3	0	31
120	Tomig120	7	Tomigusuku v.	Nesabu utaki	26.18833	127.69278	16	9.4	6158	44	273	3	4	1	36
121	Tomig121	7	Tomigusuku v.	Noha utaki	26.18444	127.69167	16	9.4	9072	40	233	2	4	1	33
122	Tomig122	7	Tomigusuku v.	Gibo utaki	26.17750	127.68042	24	6.9	9902	54	133	1	4	3	46
123	Tomig123	7	Tomigusuku v.	Takashiki utaki	26.16583	127.68111	28	10.6	9072	44	361	4	5	2	33
124	Tomig124	7	Tomigusuku v.	Tomigusuku joshi	26.18972	127.68417	9	5.2	6158	70	201	3	5	5	57
125	Tomig125	7	Tomigusuku v.	Taira jo	26.17139	127.69833	29	12.2	9072	60	270	4	5	3	48
126	Tomig126	7	Tomigusuku v.	Bin joshi	26.16361	127.68417	28	10.6	6158	44	300	3	5	2	34
127	Naha127	7	Naha c.	Bennotaki	26.21889	127.73167	107	7.4	6158	53	142	1	5	1	46
128	Naha128	7	Naha c.	Sakiyama utaki	26.21389	127.72444	72	12.2	9902	41	102	1	1	2	37
129	Naha129	7	Naha c.	Sueyoshikyu	26.23111	127.71324	72	9.5	9902	79	220	4	6	4	65
130	Naha130	7	Naha c.	Nishimuiibe	26.22722	127.71667	72	9.5	6158	53	306	5	2	3	43
131	Naha131	7	Naha c.	Ashimine utaki	26.20111	127.70389	31	7.3	9902	45	127	1	3	1	40
132	Naha132	7	Naha c.	Naminouegu	26.22050	127.67171	-	-	6158	35	NA	2	1	2	30
133	Naha133	7	Naha c.	Gokoku jinja: Yomochi jinja	26.20347	127.67528	7	5.1	9902	67	103	1	4	2	60
134	Naha134	7	Naha c.	Okimiya	26.20278	127.67722	7	5.1	9902	63	76	1	2	1	59
135	Haeba135	7	Haebaru v.	Miyagi 'Miyaginotaki'	26.20667	127.74389	43	11.6	9072	28	NA	1	0	1	26
136	Haeba136	7	Haebaru v.	Miyagi 'Ushokuga'	26.20861	127.73972	65	16.1	9047	21	NA	0	1	1	19
137	Haeba137	7	Haebaru v.	Kyan 'Kyan no taki'	26.19028	127.73194	22	12.2	9072	34	NA	3	3	0	28
138	Haeba138	7	Haebaru v.	Kyan 'Nago no den'	26.18611	127.73083	22	12.2	9072	32	NA	0	2	0	30
139	Haeba139	7	Haebaru v.	Teruya 'Ahedano taki'	26.18444	127.72750	22	12.2	7064	37	NA	1	1	1	34
140	Haeba140	7	Haebaru v.	Tsukayama 'Takatukayama no taki'	26.18750	127.72139	15	7.9	6158	17	NA	0	0	1	16
141	Haeba141	7	Haebaru v.	Tsukuyama 'Iinotaki'	26.18417	127.71917	15	7.9	9072	35	NA	2	4	0	29
142	Haeba142	7	Haebaru v.	Tsukayama 'Ikei no taki'	26.18417	127.72083	15	7.9	6158	30	NA	2	3	0	25
143	Haeba143	7	Haebaru v.	Tsukayama 'Kubou no taki'	26.18250	127.71611	10	5	9072	44	239	2	5	2	35
144	Iheya144	1	Iheya v.	Tanamisaki utaki	27.09139	128.02028	-	-	6155	34	NA	3	1	1	29
145	Iheya145	1	Iheya v.	Tana jinja	27.06417	127.98750	57	25.5	6165	36	NA	4	2	2	28
146	Iheya146	1	Iheya v.	Tana jotaki	27.02664	127.98674	-	-	6165	54	322	5	3	4	42
147	Iheya147	1	Iheya v.	Majaha keisho	27.04083	127.98278	17	7.4	9072	30	NA	5	2	2	21

148	Iheya148	1	Iheya v.	Katasumi jinja	27.04111	127.95833	32	19.9	7068	33	NA	2	1	3	27
149	Iheya149	1	Iheya v.	Koshidake top	27.04611	127.96083	-	-	6101	66	191	3	4	3	56
150	Iheya150	2	Iheya v.	Ooyama utaki	26.99389	127.92000	-	-	9072	31	NA	3	0	2	26
151	Iheya151	2	Iheya v.	Benno jinja	26.99667	127.92472	-	-	6158	26	NA	1	1	3	21
152	Izena152	4	Izena v.	Izena joshi	26.91500	127.95222	-	-	6101	49	306	4	4	2	39
153	Izena153	4	Izena v.	Akara utaki	26.91681	127.94167	35	9.2	6165	32	NA	3	2	0	27
154	Izena154	4	Izena v.	Nakata ufuruga	26.92417	127.94472	35	9.2	6165	42	443	6	2	2	32
155	Izena155	4	Izena v.	Shizanu utaki	26.92014	127.94778	35	9.2	6116	35	NA	5	2	0	28
156	Izena156	4	Izena v.	Izena no Ru	26.86417	127.93722	-	-	9931	23	NA	2	3	1	17
157	Izena157	4	Izena v.	Izena ogami	26.92278	127.92861	20	5	9072	36	NA	4	1	1	30
158	Izena158	4	Izena v.	Jicchaku amaikura	26.93333	127.92833	18	7.3	9072	30	NA	2	1	1	26
159	Izena159	4	Izena v.	Oonoyama utaki	26.94167	127.92833	4	7.4	6113	49	337	5	2	4	38
160	Izena160	4	Izena v.	Oonoyama shicganu kigansho	26.93944	127.92667	27	12.7	6165	48	281	4	2	3	39
161	Izena161	4	Izena v.	Mennayama utaki	26.94139	127.94889	16	5.5	6165	30	NA	5	1	1	23
162	Izena162	3	Izena v.	Gushikawa-jima utaki	26.97472	127.95722	-	-	6155	30	NA	2	2	3	23
163	Izena163	6	Izena v.	Yanaha-jima keisho	26.89472	127.93139	-	-	6184	4	NA	1	0	0	3
164	Izena164	5	Izena v.	Yanoshita-jima keisho	26.93528	127.91417	7	2	9083	9	NA	0	1	0	8
165	Onnna165	7	Onnna v.	Nakama 'Ifu utaki'	26.52000	127.92278	-	-	6165	33	NA	2	2	2	27
166	Onnna166	7	Onnna v.	Atta 'utaki'	26.51361	127.90222	16	11.7	7064	30	NA	3	2	4	21
167	Onnna167	7	Onnna v.	Yafuso 'Muigusu utaki'	26.49861	127.89083	33	9.1	6165	42	250	3	2	2	35
168	Onnna168	7	Onnna v.	Onna 'Onna gusuku'	26.50028	127.85444	-	-	9072	NA	NA	4	1	1	28
169	Onnna169	7	Onnna v.	Tancha 'utaki'	26.46583	127.82528	32	10.2	6165	42	193	2	2	3	35
170	Onnna170	7	Onnna v.	Fuchaku 'utaki'	26.42806	127.81083	50	9.8	6165	43	147	2	1	0	40
171	Onnna171	7	Onnna v.	Nakadomari 'Mae utaki'	26.43444	127.79583	-	-	6165	22	NA	0	0	1	21
172	Onnna172	7	Onnna v.	Yamada 'Youhai utaki'	26.43528	127.78000	-	-	9072	38	NA	2	0	5	31
173	Onnna173	7	Onnna v.	Maeda 'Gaza gusuku'	26.43722	127.76917	-	-	9072	34	NA	1	2	1	30
174	Gushw174	7	Gushikawa c.	Agena joshi	26.38111	127.85028	17	4.2	6158	52	294	4	4	3	41
175	Gushw175	7	Gushikawa c.	Taba utaki	26.36861	127.86722	14	5.2	6158	32	NA	3	2	2	25
176	Gushw176	7	Gushikawa c.	Shukunyoi sen	26.36639	127.85250	42	5	6158	41	190	2	2	2	35
177	Gushw177	7	Gushikawa c.	Kanekadan joshi	26.37472	127.83361	39	5.5	6158	51	394	6	3	4	38
178	Gushw178	7	Gushikawa c.	Kyan joshi	26.35833	127.84694	64	5	9072	51	282	4	3	3	41
179	Gushw179	7	Gushikawa c.	Esu joshi	26.35056	127.83472	53	4.2	9072	55	338	5	5	2	43
180	Okina180	7	Okinawa c.	Noborigawa ugamintou	26.37444	127.82750	39	5.5	9072	36	NA	2	1	2	31
181	Okina181	7	Okinawa c.	Chibana joshi	26.36306	127.81917	51	4.6	9051	79	277	4	11	4	60
182	Okina182	7	Okinawa c.	Sho-seniou grave	26.34611	127.80861	67	9.8	6158	37	NA	0	4	3	30
183	Okina183	7	Okinawa c.	Nishimui utaki	26.34306	127.80944	67	9.8	6158	38	NA	1	3	1	33
184	Okina184	7	Okinawa c.	Yogi Toun	26.31333	127.81167	63	14.1	9902	40	233	2	4	1	33
185	Okina185	7	Okinawa c.	Yogi utaki	26.31528	127.81306	22	9.1	9072	19	NA	1	1	1	16
186	Uraso186	7	Urasoe c.	Takushi keisho	26.23889	127.71528	52	10.9	6158	43	216	3	1	1	38
187	Uraso187	7	Urasoe c.	Maeda utaki	26.24472	127.73528	72	12.2	6158	57	132	1	5	1	50

188	Uraso188	7	Urasoe c.	Urasoe joshi	26.24667	127.73222	72	12.2	6158	54	222	2	6	4	42
189	Uraso189	7	Urasoe c.	Kubage taki	26.24833	127.72500	42	7.4	9902	38	NA	1	2	1	34
190	Uraso190	7	Urasoe c.	Iso joshi	26.25861	127.72222	15	3.8	6158	56	241	3	5	3	45
191	Uraso191	7	Urasoe c.	Iso Takauhaka	26.25556	127.72444	28	3.2	9919	51	200	3	2	1	45
192	Uraso192	7	Urasoe c.	Nishihara keizan	26.25278	127.74639	62	12.2	9902	52	162	2	2	4	44
193	Kochi193	7	Kochinda t.	Kochinda Kochindaujigami	26.15528	127.71611	49	9.1	6158	47	198	2	4	1	40
194	Kochi194	7	Kochinda t.	Kochinda Sakuma no den	26.15500	127.71917	49	9.1	9072	NA	NA	1	5	1	21
195	Kochi195	7	Kochinda t.	Kochinda Kamiya no den	26.14861	127.71750	36	9.1	9072	37	NA	3	2	1	31
196	Kochi196	7	Kochinda t.	Tomori Yaese joshi	26.13194	127.71944	67	14.6	6158	NA	NA	3	2	3	39
197	Kochi197	7	Kochinda t.	Tomori Nakama no taki	26.13528	127.72333	34	5	6158	35	NA	2	5	2	26
198	Kochi198	7	Kochinda t.	Tomori Jiri gusuku	26.13750	127.72472	34	5	9902	34	NA	1	3	0	30
199	Kochi199	7	Kochinda t.	Tomori Nohara no den	26.13000	127.73083	60	10.9	6158	33	NA	2	1	1	29
200	Kochi200	7	Kochinda t.	Yonagusuku ugansho	26.13361	127.71611	34	5	6158	59	112	1	4	1	53
201	Kochi201	7	Kochinda t.	Takara Naka no den	26.13361	127.71139	29	3.5	9072	33	NA	1	1	0	31
202	Kochi202	7	Kochinda t.	Shitahaku Sotoma no den	26.15278	127.70556	56	5.2	9072	35	NA	0	4	2	29
203	Kochi203	7	Kochinda t.	Shitahaku Namihira no den	26.15278	127.70389	56	5.2	9072	40	240	2	4	2	32
204	Kochi204	7	Kochinda t.	Toume Toume joshi	26.15167	127.70028	56	5.2	6158	NA	NA	0	3	1	27
205	Kochi205	7	Kochinda t.	Toume Tomikura aji no haka	26.15194	127.69972	49	4.5	9072	30	NA	0	2	2	26
206	Kochi206	7	Kochinda t.	Toume Seihoui dai udoun	26.15056	127.69833	49	4.5	9072	29	NA	1	3	0	25
207	Kochi207	7	Kochinda t.	Toume Asato mori	26.14972	127.69806	41	5	9072	NA	NA	2	2	2	26
208	Kochi208	7	Kochinda t.	Kogusuku Atai gawa taki	26.15639	127.70056	56	5.2	9072	25	NA	2	0	1	22
209	Kochi209	7	Kochinda t.	Kogusuku Ninsei ishi	26.15722	127.70222	56	5.2	9072	36	NA	3	4	0	29
210	Kochi210	7	Kochinda t.	Kogusuku Shirokane taki	26.15861	127.70056	41	11.8	9072	38	NA	1	4	2	31
211	Chine211	7	Chinen v.	Seifa utaki	26.17306	127.82667	-	-	6158	51	376	5	5	4	37
212	Chine212	7	Chinen v.	Chinen joshi	26.16056	127.81250	91	19.1	6158	54	367	5	6	3	40
213	Chine213	7	Chinen v.	Keisho Ookawa	26.15806	127.80889	102	14.6	6158	31	NA	1	2	1	27
214	Chine214	7	Chinen v.	Azanagushiken keisho Hirabanjou	26.15667	127.80722	102	14.6	6158	44	205	2	3	3	36
215	Chine215	7	Chinen v.	Azanayamazato hajishi no taki	26.15556	127.80111	102	14.6	6158	38	NA	4	3	3	28
216	Chine216	20	Chinen v.	Kudaka-jima Izai yama	26.16000	127.88917	-	-	6158	16	NA	0	1	1	14
217	Chine217	20	Chinen v.	Kudaka-jima Naka no taki	26.16194	127.89528	-	-	7064	18	NA	1	2	1	14
218	Chine218	20	Chinen v.	Kudaka-jima Kubou no taki	26.16472	127.89694	-	-	6158	23	NA	2	2	0	19
219	Chine219	20	Chinen v.	Kudaka-jima keisho Ishikigahama	26.15172	127.89521	-	-	9931	17	NA	2	2	0	13
220	Chine220	20	Chinen v.	Kudaka-jima keisho Kaperu	26.17056	127.90833	-	-	8102	24	NA	0	1	1	22
221	Tamag221	7	Tamagusuku v.	Itokazu joshi	26.15111	127.76194	66	9.8	6158	69	261	5	4	3	57
222	Tamag222	7	Tamagusuku v.	Ueda taki	26.14778	127.76944	134	12.6	6158	68	296	5	6	4	53
223	Tamag223	22	Tamagusuku v.	Ou-jima Agari no taki	26.13028	127.77278	14	5.9	9902	48	281	4	2	3	39
224	Tamag224	7	Tamagusuku v.	Ukinju-hainju	26.13833	127.79250	60	12.6	6158	47	147	1	4	2	40
225	Tamag225	7	Tamagusuku v.	Hamakawa utaki	26.14028	127.79583	60	12.6	6158	33	NA	1	2	2	28
226	Tamag226	7	Tamagusuku v.	Tamagusuku joshi	26.14389	127.78083	138	10.9	6158	49	349	5	3	3	38
227	Tamag227	7	Tamagusuku v.	Kakinohana gusuku joshi	26.14806	127.79222	110	16.1	6158	61	325	6	3	3	49

228	Gushm228	7	Gushikami v.	Gushichan joshi: Shironaka nutaki'	26.12028	127.74861	48	6.4	8102	20	NA	1	1	1	17
229	Gushm229	7	Gushikami v.	Yutsutachi joshi'	26.12250	127.75056	18	6.2	6158	24	NA	2	1	0	21
230	Gushm230	7	Gushikami v.	Yafuso ido'	26.12028	127.74444	48	6.4	6158	20	NA	0	1	0	19
231	Gushm231	7	Gushikami v.	Midori joshi'	26.12556	127.74694	57	6.4	9072	33	NA	3	3	2	25
232	Gushm232	7	Gushikami v.	Yozano den'	26.10889	127.73222	78	9.4	9072	29	NA	0	1	0	28
233	Gushm233	7	Gushikami v.	Ueshiro no den'	26.10278	127.72889	74	9.4	7064	25	NA	1	1	2	21
234	Gushm234	7	Gushikami v.	Shinjo no omiya'	26.13944	127.73889	48	9.8	9902	40	210	2	3	1	34
235	Gushm235	7	Gushikami v.	Shinjo 'Uezu hira taki'	26.14250	127.74222	53	5.2	9072	38	NA	2	5	2	29
236	Nakaz236	11	Nakazato v.	Shimajiri nedenchi utaki	26.30944	126.80222	61	16.9	6158	43	237	3	2	1	37
237	Nakaz237	11	Nakazato v.	Shimajiri Yonamine joshi	26.29556	126.80750	51	12.2	9083	29	NA	4	3	1	21
240	Nakaz240	11	Nakazato v.	Higa higa Namizato utaki	26.34111	126.79583	28	7.4	9072	56	214	3	4	1	48
241	Nakaz241	11	Nakazato v.	Higa higa utaki	26.34250	126.79611	79	15.8	6101	46	189	2	3	2	39
242	Nakaz242	11	Nakazato v.	Higa nakou utaki	26.34389	126.79667	79	15.8	7064	46	430	6	3	3	34
243	Nakaz243	11	Nakazato v.	Une Tonnaha utaki	26.34583	126.80944	39	19.1	9072	32	NA	4	3	1	24
244	Nakaz244	11	Nakazato v.	Une Senokuse utaki	26.34722	126.80750	39	19.1	9072	32	NA	2	4	1	25
245	Nakaz245	11	Nakazato v.	Janado oreotaki	26.34278	126.81111	39	19.1	7064	64	309	6	3	3	52
248	Nakaz248	11	Nakazato v.	Uegusuku Yakena utaki	26.38111	126.77111	98	23.4	9072	29	NA	0	3	1	25
249	Nakaz249	11	Nakazato v.	Uegusuku nakashiro utaki	26.37667	126.76944	98	23.4	7050	42	379	4	4	5	29
250	Nakaz250	11	Nakazato v.	Uegusuku joshi	26.37694	126.76944	98	23.4	7050	10	NA	1	0	1	8
251	Nakaz251	11	Nakazato v.	Uegusuku Kannondou	26.37736	126.77167	98	23.4	7064	62	271	4	5	5	48
253	KGush253	11	Gushikawa v.	Ishikinaha utaki	26.34250	126.76333	43	9.8	6158	38	NA	2	6	1	29
254	KGush254	11	Gushikawa v.	Uyamazato Tamanaha utaki	26.36389	126.74806	60	8.6	9902	57	221	3	4	3	47
255	KGush255	11	Gushikawa v.	Ukanegusuku Kanegusuku utaki	26.34222	126.75306	34	7.4	6158	52	335	4	7	1	40
256	KGush256	11	Gushikawa v.	Ukanegusuku Chinin utaki	26.34167	126.75000	18	7.4	6158	46	307	4	3	2	37
257	KGush257	11	Gushikawa v.	Uesu utaki	26.35500	126.75083	82	16.9	6165	60	265	4	5	2	49
258	KGush258	11	Gushikawa v.	Gushikawa joshi	26.38278	126.75056	69	10.2	6158	42	221	2	4	1	35
259	KGush259	11	Gushikawa v.	Unakandakari keisho Nuru dennai	26.37889	126.75167	69	10.2	6165	36	NA	2	2	2	30
260	Tokas260	37	Tokashiki v.	Aharen 'Maetaki'	26.16278	127.34861	-	-	6165	31	NA	3	2	1	25
261	Tokas261	37	Tokashiki v.	Aharen 'Gotaki'	26.17389	127.34528	-	-	7064	18	NA	0	1	1	16
262	Tokas262	37	Tokashiki v.	Tokashiki 'Maetaki'	26.19167	127.36472	66	23.4	9007	48	269	3	3	7	35
263	Tokas263	37	Tokashiki v.	Tokashiki 'Nakataki'	26.19556	127.36667	66	23.4	9007	23	NA	1	0	1	21
264	Tokas264	37	Tokashiki v.	Tokashiki 'Samikataki'	26.19556	127.36917	66	23.4	7054	33	NA	3	0	1	29
265	Tokas265	37	Tokashiki v.	Tokashiki 'Ishimoutaki'	26.19611	127.36139	94	22.6	9902	30	NA	1	1	1	27
266	Tokas266	37	Tokashiki v.	Tokashiki 'Nishitaki'	26.20806	127.36222	109	22.6	6165	26	NA	0	3	1	22
267	Zamam267	37	Zamami v.	Zamami-jima Ukama keisho hiramatsu	26.22917	127.29917	57	99.9	6165	32	NA	3	2	3	24
268	Zamam268	37	Zamami v.	Zamami-jima Ukama keisho uehiramatsukyu	26.22889	127.29556	57	99.9	7064	26	NA	3	3	1	19
269	Zamam269	37	Zamami v.	Zamami-jima Amachiji keisho Megusuku	26.22639	127.29694	57	99.9	6165	25	NA	3	2	2	18
270	Zamam270	37	Zamami v.	Zamami-jima keisho bansho	26.23250	127.30639	71	16.9	6165	35	NA	3	3	2	27
271	Zamam271	37	Zamami v.	Zamami-jima Takatukiyama keisho Futokinume	26.22972	127.30861	71	16.9	6165	27	NA	3	4	2	18
272	Zamam272	37	Zamami v.	Zamami-jima Akasakiutaki	26.24556	127.31000	-	-	6101	41	256	3	2	2	34

273	Zamam273	37	Zamami v.	Zamami-jima Nakadake	26.24472	127.31722	-	-	6101	36	NA	4	3	2	27
274	Zamam274	37	Zamami v.	Zamami-jima Oodake	26.24222	127.32694	-	-	6155	33	NA	3	2	2	26
275	Zamam275	37	Zamami v.	Zamami-jima Kudake	26.24000	127.32944	-	-	6155	34	NA	3	2	2	27
276	Zamam276	37	Zamami v.	Aka-jima keisho gusuku	26.19278	127.28028	79	19.1	7064	43	293	3	4	3	33
277	Zamam277	37	Zamami v.	Aka-jima Nakadake	26.20167	127.27944	-	-	6165	31	NA	3	3	4	21
278	Zamam278	37	Zamami v.	Aka-jima Oodake	26.20389	127.27528	-	-	6165	48	325	4	4	4	36
279	Zamam279	37	Zamami v.	Aka-jima Kubou taki	26.20250	127.28361	-	-	6165	38	NA	2	4	2	30
280	Zamam280	37	Zamami v.	Geruma-jima keisho ibi	26.17750	127.29083	-	-	6165	16	NA	1	0	0	15
281	Zamam281	37	Zamami v.	Geruma-jima keisho ufudonchi	26.17889	127.29250	-	-	6155	20	NA	0	0	2	18
282	Zamam282	37	Zamami v.	Geruma-jima keisho Kayama	26.18083	127.29028	-	-	6165	23	NA	4	2	1	16
283	Zamam283	37	Zamami v.	Geruma-jima ufutaki	26.18417	127.29028	-	-	6101	49	318	4	4	4	37
284	Zamam284	37	Zamami v.	Yakabi-jima yakabi utaki	26.21611	127.24389	101	38	6165	15	NA	2	2	0	11
285	Zamam285	37	Zamami v.	Kuba-jima kubajima utaki	26.16708	127.23570	-	-	7064	27	NA	4	2	3	18
286	Aguni286	9	Aguni v.	Fetaki	26.57917	127.24111	9	1.7	9072	28	NA	2	1	0	25
287	Aguni287	9	Aguni v.	Nakanutaki	26.58417	127.24583	12	1.7	9051	14	NA	2	0	0	12
288	Aguni288	9	Aguni v.	Ufutaki	26.58889	127.24556	12	1.7	6158	24	NA	2	1	1	20
289	Aguni289	9	Aguni v.	Yaegawagusuku	26.58444	127.22222	-	-	9072	50	276	4	3	1	42
290	Aguni290	9	Aguni v.	Gadanoko utaki	26.58208	127.22125	70	5.9	9072	51	171	2	3	2	44
291	Aguni291	9	Aguni v.	Miruku utaki	26.58361	127.22222	-	-	6158	32	NA	2	3	1	26
292	Aguni292	9	Aguni v.	Matsuu utaki	26.58028	127.21611	70	5.9	7064	31	NA	1	2	1	27
293	Aguni293	9	Aguni v.	Doudera	26.59361	127.22389	-	-	7064	25	NA	0	2	2	21
294	Aguni294	9	Aguni v.	Yagan utaki	26.59889	127.22722	-	-	7064	14	NA	0	0	0	14
295	Kitad295	38	Kitadaito v.	Daitougu'	25.94417	131.30250	20	7.4	8008	26	NA	2	1	0	23
297	Kitad297	38	Kitadaito v.	Kannonsama'	25.95222	131.29583	32	5.9	9072	21	NA	2	0	0	19
298	Minam298	38	Minamidaito v.	Akiba jinja	25.84556	131.25611	28	5.3	6165	24	NA	2	2	0	20
299	Minam299	38	Minamidaito v.	Kanpira	25.84194	131.21917	21	4.6	9919	6	NA	1	0	0	5
300	Minam300	38	Minamidaito v.	Daitou jinja	25.84271	131.22632	3	99.9	9072	43	147	1	4	0	38
301	Minam301	38	Minamidaito v.	Kannonyama	25.85208	131.22778	6	5.2	9072	21	NA	0	1	0	20
302	Ogimi302	7	Ogimi v.	Untouugami	26.71028	128.16889	79	23.4	9072	45	247	3	2	4	36
303	Ogimi303	7	Ogimi v.	Nejame gusuku	26.71000	128.16111	28	11.7	6165	70	377	6	10	4	50
304	Ogimi304	7	Ogimi v.	Ganahana taki	26.71319	128.15361	28	11.7	9047	47	491	7	4	2	34
305	Ogimi305	7	Ogimi v.	Tsuryu keisho	26.70389	128.14778	-	-	6165	84	332	6	11	6	61
306	Ogimi306	7	Ogimi v.	Ogimi utaki	26.70111	128.12083	-	-	6165	60	250	4	3	5	48
307	Ogimi307	7	Ogimi v.	Taminato ugan	26.66889	128.12694	178	27.3	9919	94	262	6	8	4	76
308	Ogimi308	7	Ogimi v.	Tuha 'Asagi'	26.65583	128.09333	-	-	9902	37	NA	3	1	1	32
309	Ie309	8	Ie v.	Gusukuyama	26.71972	127.80681	64	12.2	6158	66	355	6	7	3	50
310	Ie310	8	Ie v.	Koshateimui	26.71444	127.80750	53	11	9902	36	NA	1	2	1	32
311	Ie311	8	Ie v.	Nyateiya utaki	26.70917	127.77028	47	5	8064	28	NA	2	1	2	23
312	Ie312	8	Ie v.	Shouooji	26.71333	127.77139	47	5	6158	27	NA	3	1	1	22
313	Ie313	8	Ie v.	Wakui	26.73306	127.79083	55	13.6	6152	20	NA	0	0	1	19

314	Nago314	7	Nago c.	Yaga Yagagusuku	26.65389	128.02833	10	3.7	6158	34	NA	3	1	3	27
315	Nago315	7	Nago c.	Yohena Shimanokawa utaki	26.65972	128.01000	27	5	9072	59	178	2	5	2	50
316	Nago316	7	Nago c.	Makiya Uenoutaki	26.62833	128.03944	15	14.6	9902	45	107	1	2	1	41
317	Nago317	7	Nago c.	Nakaoji ufu utaki	26.62333	128.02972	31	21.3	6165	79	247	4	8	5	62
318	Nago318	7	Nago c.	Nakao Nakaokoson	26.62778	128.01389	-	-	9072	59	366	6	5	3	45
319	Nago319	7	Nago c.	Kogachi Kogachi utaki	26.62333	127.99389	19	8.8	6165	73	234	4	5	6	58
320	Nago320	7	Nago c.	Gabusoka Gabusoka utaki	26.62083	128.00306	5	3.8	9072	54	339	4	7	4	39
321	Nago321	7	Nago c.	Awa Bumagogen	26.60833	127.90083	61	21.3	9919	46	320	4	3	4	35
322	Nago322	7	Nago c.	Awa Kuba utaki	26.61333	127.93056	65	31.2	6158	60	220	3	4	5	48
323	Nago323	7	Nago c.	Yabe Kushi utaki	26.60833	127.94972	27	14.6	9072	42	186	1	5	2	34
324	Nago324	7	Nago c.	Kise Shigamamui	26.52528	127.95056	40	10.6	6088	71	414	9	4	5	53
325	Nago325	7	Nago c.	Kayou Mankabara utaki	26.54889	128.10444	41	14.6	6088	48	400	6	2	4	36
326	Nago326	7	Nago c.	Kayou Kamigusuku	26.55333	128.10833	74	21.3	6088	52	265	4	3	1	44
327	Nago327	7	Nago c.	Abu R. Kuba utaki	26.54361	128.09083	66	9.8	6088	33	NA	4	0	2	27
328	Nago328	7	Nago c.	Teima Kominato taki	26.55167	128.06611	38	13.7	6165	81	289	7	3	6	65
329	Nago329	7	Nago c.	Ooura Ooura utaki	26.55139	128.04444	44	12.2	6088	58	295	5	2	6	45
330	Nago330	7	Nago c.	Henoko Henoko utaki	26.52194	128.03583	32	7	6158	45	147	1	3	4	37
331	Nago331	7	Nago c.	Kushi Kushi utaki	26.52000	128.01528	51	7.4	6088	45	427	6	2	4	33
332	Sashi332	7	Sashiki t.	Ooishi ugansho	26.18389	127.77222	53	13.1	6158	47	217	3	2	1	41
333	Sashi333	7	Sashiki t.	Oomatsudou	26.17861	127.76639	60	16.1	9072	31	NA	2	0	2	27
334	Sashi334	7	Sashiki t.	Tawatai (Ka)	26.18056	127.76500	60	16.1	9072	32	NA	0	1	0	31
335	Sashi335	7	Sashiki t.	Hokamashi grave	26.17806	127.76250	71	9.8	9072	33	NA	1	1	1	30
336	Sashi336	7	Sashiki t.	Azanakotani 'Uenoi'	26.17361	127.76222	70	16.1	6158	33	NA	1	3	2	27
337	Sashi337	7	Sashiki t.	Azanakotani 'Kamonoi'	26.17417	127.76694	44	16.1	7064	34	NA	1	2	0	31
338	Sashi338	7	Sashiki t.	Azanashinzato R. Nakadoi	26.16806	127.76972	44	16.1	9072	40	158	1	4	0	35
341	Sashi341	7	Sashiki t.	Matsuo taki	26.16611	127.78722	56	19.1	7064	32	NA	0	3	0	29
342	Sashi342	7	Sashiki t.	Yonamine no den	26.16444	127.79861	41	21.3	7064	16	NA	0	2	0	14
343	Sashi343	7	Sashiki t.	Nawashiro den	26.16611	127.78694	56	19.1	7064	29	NA	1	1	0	27
344	Sashi344	7	Sashiki t.	Tsukishiro iwa: Ui	26.16528	127.79167	41	21.3	7064	28	NA	0	2	1	25
345	Sashi345	7	Sashiki t.	Takinou taki	26.16389	127.78556	56	19.1	6158	69	222	4	4	3	58
346	Hirar346	25	Hirara c.	Ikema-jima Uharuzu utaki	24.92278	125.24694	-	-	9902	33	NA	2	2	2	27
347	Hirar347	26	Hirara c.	Karimata utaki	24.89833	125.27486	9	99.9	6161	58	259	4	4	2	48
348	Hirar348	26	Hirara c.	Uyagan utaki	24.87778	125.29194	-	-	9072	26	NA	1	1	1	23
349	Hirar349	26	Hirara c.	Sato utaki	24.88000	125.28778	-	-	9072	27	NA	3	2	0	22
350	Hirar350	26	Hirara c.	Ubujira utaki	24.87139	125.29889	10	5.2	9072	29	NA	1	2	1	25
351	Hirar351	26	Hirara c.	Nishihara uharuzu utaki	24.83500	125.29417	8	99.9	6101	35	NA	4	4	1	26
352	Hirar352	26	Hirara c.	Nakama utaki	24.83222	125.29778	12	3.5	6101	36	NA	2	2	2	30
353	Hirar353	26	Hirara c.	Izunusato utaki	24.82056	125.29361	21	4	9072	33	NA	4	1	2	26
354	Hirar354	26	Hirara c.	Nmanuba utaki	24.81611	125.29611	29	4.7	9072	32	NA	3	1	1	27
355	Hirar355	26	Hirara c.	Fusatoteda utaki	24.81556	125.28472	-	-	9902	38	NA	2	2	1	33

356	Hirar356	26	Hirara c.	Tsukasa utaki	24.79222	125.26694	11	2.6	9072	25	NA	2	0	0	23
357	Hirar357	26	Hirara c.	Kani utaki	24.78750	125.26778	18	5.4	9072	24	NA	1	0	1	22
358	Hirar358	26	Hirara c.	Topitozu utaki	24.78861	125.34778	40	3	6101	44	293	4	2	1	37
359	Hirar359	26	Hirara c.	Zaratsuki utaki	24.77139	125.34917	46	5	9072	37	NA	5	2	2	28
360	Hirar360	26	Hirara c.	Arapa utaki	24.78833	125.31694	37	3.8	6101	37	NA	5	2	2	28
361	Gusuk361	26	Gusukube t.	Saratake Tennumatsugani utaki	24.76972	125.35500	58	2.2	9072	43	349	4	4	2	33
362	Gusuk362	26	Gusukube t.	Uzanmi utaki	24.77778	125.33083	40	4.7	9072	45	367	5	3	1	36
363	Gusuk363	26	Gusukube t.	Toundaki utaki	24.75944	125.34028	59	6.7	9072	40	488	6	3	2	29
364	Gusuk364	26	Gusukube t.	Agazunemazu utaki	24.77361	125.33056	51	4.7	9072	34	NA	3	2	1	28
365	Gusuk365	26	Gusukube t.	Marasekanidonu utaki	24.76472	125.32722	56	6.7	9051	35	NA	2	2	0	31
366	Gusuk366	26	Gusukube t.	Osanaka tukasa utaki	24.77222	125.36583	65	2.5	6101	35	NA	2	2	3	28
367	Gusuk367	26	Gusukube t.	Kyagi shinden utaki	24.77694	125.36417	69	11.7	9072	36	NA	2	3	2	29
368	Gusuk368	26	Gusukube t.	Tennumatsukani utaki	24.75389	125.36028	65	7.4	9072	42	229	2	4	2	34
369	Gusuk369	26	Gusukube t.	Mainuya utaki	24.72972	125.35250	49	7.9	9072	47	262	3	4	2	38
370	Gusuk370	26	Gusukube t.	Isukaki utaki	24.72944	125.36222	49	7.9	9072	27	NA	0	3	0	24
371	Gusuk371	26	Gusukube t.	Higa iharazu utaki	24.77722	125.37694	81	10.7	6101	36	NA	3	2	3	28
372	Gusuk372	26	Gusukube t.	Higa tsukasaya utaki	24.76694	125.37889	85	3.1	9072	28	NA	3	0	3	22
373	Gusuk373	26	Gusukube t.	Higa akadonu utaki	24.76583	125.37694	66	3.1	9072	25	NA	2	2	1	20
374	Gusuk374	26	Gusukube t.	Teinteifukuchounununusu utaki	24.76194	125.38806	64	16.2	6101	32	NA	5	2	2	23
375	Gusuk375	26	Gusukube t.	Fukunan Akadono utaki	24.75222	125.38444	62	10.1	9072	41	322	4	2	2	33
376	Gusuk376	26	Gusukube t.	Agaritakaarago akadonu utaki	24.75222	125.37806	62	10.1	9072	42	400	5	3	2	32
377	Gusuk377	26	Gusukube t.	Nisukata utaki	24.75639	125.41250	58	3.2	9072	27	NA	2	1	1	23
378	Gusuk378	26	Gusukube t.	Pyouragan utaki	24.75444	125.41639	53	13.4	9072	34	NA	1	2	2	29
379	Gusuk379	26	Gusukube t.	Takenaka utaki	24.72944	125.42639	49	2.7	6101	25	NA	2	2	1	20
380	Gusuk380	26	Gusukube t.	Pagapou utaki	24.73417	125.45167	-	-	6101	19	NA	0	2	1	16
381	Gusuk381	26	Gusukube t.	Yokotake akaden utaki	24.74778	125.38111	78	7.2	6101	33	NA	4	2	2	25
382	Ueno382	26	Ueno v.	Kouzen Migagama utaki	24.72167	125.32250	32	4.5	9902	24	NA	0	1	0	23
383	Ueno383	26	Ueno v.	Naka utaki	24.76444	125.32472	-	-	9083	48	156	2	2	1	43
384	Ueno384	26	Ueno v.	Ubu utaki	24.75926	125.32880	56	6.7	6101	62	256	4	5	2	51
385	Ueno385	26	Ueno v.	Takayama utaki	24.74361	125.31944	49	2	9051	36	NA	3	1	2	30
386	Ueno386	26	Ueno v.	Kitakata utaki	24.73889	125.33139	48	1.5	9072	29	NA	4	2	1	22
387	Ueno387	26	Ueno v.	Tsukasaya utaki	24.72917	125.34639	60	5.4	9072	23	NA	2	3	0	18
388	Ueno388	26	Ueno v.	Maimuteiya utaki	24.73139	125.34556	60	5.4	9072	27	NA	3	1	1	22
389	Ueno389	26	Ueno v.	Naifa utaki	24.72361	125.32833	39	6.4	9072	29	NA	2	3	1	23
390	Shimo390	26	Shimoji t.	Kasama utaki	24.76000	125.29083	34	2.5	9072	33	NA	3	0	1	29
391	Shimo391	26	Shimoji t.	Nuzuma utaki	24.76028	125.28750	-	-	9072	31	NA	2	1	2	26
392	Shimo392	26	Shimoji t.	Tomari utaki	24.75111	125.26528	-	-	9072	41	307	3	5	0	33
393	Shimo393	26	Shimoji t.	Ubu utaki	24.73778	125.29917	7	1.9	9072	27	NA	1	1	2	23
394	Shimo394	26	Shimoji t.	Naka utaki	24.73972	125.29750	7	1.9	9072	31	NA	3	2	1	25
395	Shimo395	26	Shimoji t.	Ishigusuku utaki	24.74417	125.26194	-	-	8102	17	NA	1	1	0	15

396	Shimo396	26	Shimoji t.	Uinunmi utaki	24.74306	125.30583	38	2.5	6101	24	NA	1	3	1	19
397	Shimo397	28	Shimoji t.	Kurima-jima Akazui utaki	24.71944	125.25667	-	-	6161	24	NA	2	1	1	20
398	Shimo398	28	Shimoji t.	Kurima-jima Ka utaki	24.72389	125.25444	-	-	6161	29	NA	1	0	1	27
399	Shimo399	28	Shimoji t.	Kurima-jima Izuinu utaki	24.72694	125.25028	-	-	6161	22	NA	1	0	2	19
400	Shimo400	26	Shimoji t.	Akasaki utaki	24.72667	125.27917	8	1.7	9051	27	NA	2	2	1	22
401	Irabu401	27	Irabu v.	Nehara no naka Dozu utaki	24.82333	125.18583	29	3.5	9072	35	NA	4	3	1	27
402	Irabu402	27	Irabu v.	Kuninka utaki	24.82694	125.17389	12	2.2	6101	48	388	5	5	2	36
403	Irabu403	27	Irabu v.	Kurohama utaki	24.84500	125.15944	-	-	9072	22	NA	1	0	1	20
404	Irabu404	27	Irabu v.	Sawada utaki	24.84556	125.16667	34	4	9072	36	NA	3	4	2	27
405	Irabu405	27	Irabu v.	Nagahama utaki	24.84167	125.17000	34	4	9051	35	NA	2	4	2	27
406	Irabu406	27	Irabu v.	Hiyachi utaki	24.82111	125.21389	43	10.1	6101	32	NA	3	4	2	23
407	Taram407	29	Tarama v.	Futenma utaki	24.64889	124.72278	6	0.7	9051	36	NA	3	2	1	30
408	Taram408	29	Tarama v.	Shiokawa utaki	24.66444	124.71361	11	0.6	9072	28	NA	1	1	1	25
409	Taram409	29	Tarama v.	Futtaji utaki	24.65417	124.70611	12	0.5	9072	23	NA	1	2	0	20
410	Taram410	29	Tarama v.	Dohara ugan	24.67111	124.70000	16	3	9028	28	NA	1	2	1	24
411	Taram411	29	Tarama v.	Unjo utaki	24.67278	124.70139	10	2	9028	38	NA	2	2	1	33
412	Taram412	29	Tarama v.	Tomari utaki	24.67444	124.70417	10	2	9028	16	NA	0	2	0	14
413	Ishig413	30	Ishigaki c.	Misaki utaki	24.33694	124.16028	7	2.5	9902	36	NA	1	1	2	32
414	Ishig414	30	Ishigaki c.	Ookawa utaki	24.33500	124.16306	18	2.2	9902	29	NA	2	2	2	23
415	Ishig415	30	Ishigaki c.	Miyadori utaki	24.34417	124.15722	12	2.2	9902	45	187	2	3	1	39
416	Ishig416	30	Ishigaki c.	Maitsuba utaki	24.34806	124.15333	12	2.2	9902	38	NA	1	2	0	35
417	Ishig417	30	Ishigaki c.	Nagataki taki	24.35472	124.14528	21	4.2	9072	18	NA	1	1	0	16
418	Ishig418	30	Ishigaki c.	Ooishigaki utaki	24.34361	124.16194	12	2.2	9902	32	NA	0	2	1	29
419	Ishig419	30	Ishigaki c.	Konamihon on	24.34806	124.17028	27	3	9072	33	NA	1	2	1	29
420	Ishig420	30	Ishigaki c.	Nagura utaki	24.40111	124.16167	22	19.1	9072	51	112	1	3	1	46
421	Ishig421	30	Ishigaki c.	Mizuse utaki	24.40028	124.15944	22	19.1	9072	45	227	3	2	1	39
422	Ishig422	30	Ishigaki c.	Sakieda utaki	24.44639	124.10389	-	-	7064	33	NA	2	2	0	29
423	Ishig423	30	Ishigaki c.	Aimori utaki	24.33694	124.17667	23	1.7	9072	34	NA	0	0	0	34
424	Ishig424	30	Ishigaki c.	Ooamo taki	24.33861	124.17444	18	2.2	9902	17	NA	0	1	0	16
425	Ishig425	30	Ishigaki c.	Ube taki	24.34222	124.17639	40	2.5	7052	37	NA	3	1	1	32
426	Ishig426	30	Ishigaki c.	Inatsukion	24.33750	124.17944	23	1.7	7052	44	252	3	3	1	37
427	Ishig427	30	Ishigaki c.	Chijo taki	24.35056	124.17833	52	4.5	9072	63	133	2	3	1	57
428	Ishig428	30	Ishigaki c.	Kurabara utaki	24.33472	124.17750	23	1.7	7052	43	244	3	2	2	36
429	Ishig429	30	Ishigaki c.	Itokazu utaki	24.33139	124.17056	6	2	9931	30	NA	2	1	1	26
430	Ishig430	30	Ishigaki c.	yasui taki	24.33639	124.17194	18	2.2	9083	16	NA	0	1	0	15
431	Ishig431	30	Ishigaki c.	Sakibara taki	24.34639	124.20028	-	-	6159	46	222	3	2	1	40
432	Ishig432	30	Ishigaki c.	Oose keisho	24.34694	124.19944	19	5.2	6159	18	NA	0	2	1	15
433	Ishig433	30	Ishigaki c.	Ooishitaki	24.34750	124.19889	19	5.2	6159	40	210	3	0	1	36
434	Ishig434	30	Ishigaki c.	Koruse utaki	24.34778	124.19861	19	5.2	6159	44	327	4	4	0	36
435	Ishig435	30	Ishigaki c.	Funaon	24.34944	124.19861	19	5.2	9902	12	NA	0	0	0	12

436	Ishig436	30	Ishigaki c.	Junsui taki	24.35222	124.19667	14	5.2	6165	52	98	1	2	2	47
437	Ishig437	30	Ishigaki c.	Oodoko taki	24.35250	124.19556	14	5.2	9072	64	417	8	5	2	49
438	Ishig438	30	Ishigaki c.	Kadekaru taki	24.35306	124.24111	13	2	9902	34	NA	0	1	0	33
439	Ishig439	30	Ishigaki c.	Masha taki	24.35167	124.24306	13	2	9902	39	NA	1	0	1	37
440	Ishig440	30	Ishigaki c.	Tahara taki	24.35722	124.24528	13	2	9072	38	NA	1	0	1	36
441	Ishig441	30	Ishigaki c.	Hateruma utaki	24.35750	124.24361	13	2	9083	41	80	1	0	2	38
442	Ishig442	30	Ishigaki c.	Yamazaki taki	24.35556	124.21667	26	5	9083	55	191	3	2	2	48
443	Ishig443	30	Ishigaki c.	Nakatake taki	24.36944	124.22361	64	7.4	6165	64	66	0	4	2	58
444	Ishig444	30	Ishigaki c.	Sotomoto taki	24.35139	124.22111	26	5	7064	56	182	3	2	1	50
445	Ishig445	30	Ishigaki c.	Kohama utaki	24.35444	124.21944	26	5	9902	62	92	1	3	1	57
446	Ishig446	30	Ishigaki c.	Hirakubo utaki	24.58833	124.31528	45	22.3	9072	30	NA	2	4	0	24
447	Ishig447	30	Ishigaki c.	Jira on	24.56583	124.29389	11	10.1	9072	43	258	3	3	1	36
448	Ishig448	30	Ishigaki c.	Nakanoon	24.51111	124.28528	46	19.2	9083	37	NA	1	1	1	34
449	Ishig449	30	Ishigaki c.	Momobara on	24.42250	124.24389	25	14.2	9072	37	NA	2	1	1	33
450	Ishig450	30	Ishigaki c.	Yoshimishu utaki	24.33889	124.17861	23	1.7	9072	34	NA	0	1	0	33
451	Ishig451	30	Ishigaki c.	Takama utaki	24.45306	124.20472	-	-	9072	42	114	1	2	1	38
452	Ishig452	30	Ishigaki c.	Fukaion	24.45528	124.19389	-	-	9072	38	NA	2	3	0	33
453	Ishig453	30	Ishigaki c.	Piyusuon	24.45528	124.18861	-	-	9902	42	329	4	3	1	34
454	Ishig454	30	Ishigaki c.	Nakasuji son Neparu uraki	24.45083	124.15833	-	-	9072	48	344	4	6	1	37
455	Ishig455	30	Ishigaki c.	Yasura on	24.56889	124.32667	48	14.3	9083	28	NA	3	2	0	23
456	Taket456	34	Taketomi t.	Koumoto (Konamimoto) utaki	24.32556	124.08500	10	1	7064	27	NA	2	0	1	24
457	Taket457	34	Taketomi t.	Nakasuji utaki	24.32944	124.08583	10	1	6159	30	NA	2	1	0	27
458	Taket458	34	Taketomi t.	Misaki utaki	24.33917	124.08667	-	-	9072	18	NA	0	1	1	16
459	Taket459	34	Taketomi t.	Kumabara utaki	24.32806	124.09444	7	1.8	7052	17	NA	1	0	0	16
460	Taket460	34	Taketomi t.	Hanakku utaki	24.32806	124.09556	7	1.8	7052	17	NA	1	1	0	15
461	Taket461	34	Taketomi t.	Paiyaon utaki	24.32722	124.09556	7	1.8	7052	19	NA	2	1	0	16
462	Taket462	34	Taketomi t.	Namizama utaki	24.33278	124.08389	10	1	7052	32	NA	2	1	0	29
463	Taket463	34	Taketomi t.	Seimei utaki	24.32889	124.08722	10	1	9902	37	NA	1	2	0	34
464	Taket464	35	Taketomi t.	Funourawan	24.23722	123.99444	3	0.7	7064	19	NA	1	0	0	18
465	Taket465	35	Taketomi t.	Ngishitouwan	24.23444	123.99667	3	0.7	7064	32	NA	2	1	1	28
466	Taket466	35	Taketomi t.	Paifutawan	24.23194	123.99861	-	-	6159	18	NA	0	0	0	18
467	Taket467	35	Taketomi t.	Horiwan	24.25306	124.00000	-	-	7064	24	NA	3	1	1	19
468	Taket468	35	Taketomi t.	Fukiwan	24.24083	123.99194	3	0.7	8064	17	NA	1	0	0	16
469	Taket469	35	Taketomi t.	Anadomariwan	24.24528	124.02306	-	-	7064	34	NA	4	2	1	27
470	Taket470	35	Taketomi t.	Nishihamemawan	24.24750	124.02472	-	-	8102	8	NA	1	0	0	7
471	Taket471	35	Taketomi t.	Paihamemawan	24.23278	124.01972	2	0.7	8102	19	NA	4	1	0	14
472	Taket472	35	Taketomi t.	Kenwan	24.23028	124.02444	2	0.7	8102	27	NA	2	1	0	24
473	Taket473	35	Taketomi t.	Nakamotowan	24.24556	124.01611	-	-	8102	36	NA	4	1	0	31
474	Taket474	35	Taketomi t.	Pejiwan	24.23556	124.01361	2	0.7	7064	3	NA	0	0	0	3
475	Taket475	35	Taketomi t.	Kanreidouwan	24.24083	124.00778	7	0.7	7064	19	NA	1	1	1	16

476	Taket476	33	Taketomi t.	Terugo: Kawata utaki	24.34694	123.97611	34	7.4	9047	22	NA	3	1	0	18
477	Taket477	33	Taketomi t.	Sakui: Nakayama utaki	24.34639	123.97833	34	7.4	9047	40	203	2	3	0	35
478	Taket478	33	Taketomi t.	Kahone utaki	24.34194	123.98139	34	7.4	9098	22	NA	0	1	0	21
479	Taket479	33	Taketomi t.	Soku utaki	24.33389	123.99667	-	-	9098	38	NA	3	2	1	32
480	Taket480	31	Taketomi t.	Konari utaki	24.32149	123.91416	-	-	6184	26	NA	0	2	1	23
481	Taket481	31	Taketomi t.	Sanri utaki	24.34417	123.92500	84	23.4	8008	55	164	3	1	0	51
482	Taket482	31	Taketomi t.	Ukebara taki	24.34833	123.92389	84	23.4	9072	32	NA	1	1	2	28
483	Taket483	31	Taketomi t.	Sendati utaki	24.39667	123.75667	41	21.3	6155	54	233	3	4	3	44
484	Taket484	31	Taketomi t.	Nishidomari: hanare utaki	24.39111	123.74972	-	-	9902	42	143	1	3	2	36
485	Taket485	31	Taketomi t.	Kunmori utaki	24.39139	123.74500	-	-	9072	14	NA	0	1	0	13
486	Taket486	31	Taketomi t.	Ootaki utaki	24.38972	123.74361	-	-	9072	32	NA	1	1	2	28
487	Taket487	31	Taketomi t.	Maedomari utaki	24.38833	123.74667	-	-	9902	32	NA	0	3	1	28
488	Taket488	31	Taketomi t.	Shirahama utaki	24.36194	123.74889	-	-	6096	53	374	6	3	3	41
489	Taket489	31	Taketomi t.	Funauki utaki	24.33861	123.72917	-	-	9931	23	NA	1	1	0	21
490	Taket490	31	Taketomi t.	Tunatori unaki	24.32889	123.69028	-	-	7064	20	NA	0	2	1	17
492	Taket492	36	Taketomi t.	Oomine utaki	24.06250	123.76694	15	3.7	9072	15	NA	1	2	1	11
493	Taket493	36	Taketomi t.	Hoda utaki	24.05917	123.76417	15	3.7	9072	25	NA	0	3	1	21
494	Taket494	36	Taketomi t.	Nagata utaki	24.06083	123.77611	29	5.2	9902	29	NA	1	2	0	26
495	Taket495	36	Taketomi t.	Buishiwa (Oodoko utaki)	24.06139	123.77778	29	5.2	9072	22	NA	0	1	1	20
497	Taket497	36	Taketomi t.	Misukuwa (Midoko utaki)	24.06500	123.78083	29	5.2	9919	16	NA	0	1	0	15
498	Taket498	36	Taketomi t.	Inasai remains	24.06750	123.76944	-	-	8064	26	NA	2	1	1	22
499	Taket499	36	Taketomi t.	Mishuku village remains	24.06139	123.75778	-	-	9047	23	NA	1	1	1	20
500	Taket500	36	Taketomi t.	Pemishuku village remains	24.05722	123.76611	32	3.8	9072	40	203	2	3	0	35
501	Taket501	36	Taketomi t.	Shimokaibara jo	24.06917	123.77806	-	-	6159	32	NA	1	1	0	30
502	Taket502	36	Taketomi t.	Matoruwa (Matori utaki)	24.05167	123.76556	32	3.8	9072	28	NA	1	3	1	23
503	Taket503	36	Taketomi t.	Abateiwa (Abatei utaki)	24.04833	123.78514	25	3.7	9072	40	188	2	2	1	35
504	Taket504	36	Taketomi t.	Shisabaruwa (Shisabara utaki)	24.05333	123.79222	36	2.5	6159	29	NA	1	2	1	25
505	Taket505	36	Taketomi t.	Minato utaki	24.06417	123.76222	-	-	9072	27	NA	1	3	1	22
506	Yonag506	32	Yonaguni t.	Urano utaki	24.46750	123.02167	-	-	9072	29	NA	2	1	0	26
507	Yonag507	32	Yonaguni t.	Ndan utaki	24.46083	123.02667	-	-	7064	36	NA	3	2	1	30
508	Yonag508	32	Yonaguni t.	Araga utaki	24.45667	122.99972	43	9	9098	37	NA	2	2	1	32
509	Yonag509	32	Yonaguni t.	Naunni utaki	24.45611	122.99778	43	9	9072	33	NA	1	3	1	28
510	Yonag510	32	Yonaguni t.	Oyabaru utaki	24.46417	123.00083	13	12.2	6159	40	255	3	2	1	34
511	Yonag511	32	Yonaguni t.	Nukku utaki	24.46528	123.00750	13	12.2	9072	32	NA	0	2	1	29
513	Yonag513	32	Yonaguni t.	Tei utaki	24.47000	122.99861	-	-	7064	7	NA	0	0	0	7
514	Yonag514	32	Yonaguni t.	Touguru utaki	24.46278	122.96944	23	5	9072	27	NA	2	3	1	21
515	Yonag515	32	Yonaguni t.	Deiteigu utaki	24.46472	122.96194	-	-	6159	31	NA	3	2	1	25
516	Yonag516	32	Yonaguni t.	Kubera utaki	24.45139	122.94389	-	-	9902	24	NA	1	0	0	23
517	Yonag517	32	Yonaguni t.	Ntei utaki	24.44111	122.98083	23	14.6	8048	19	NA	1	0	1	17

List of Island and vegetation with corresponding IDs used in table D3.

Island	Vegetation type
1. Iheya-jima	6088. Psychotria rubra-Castanopsis sieboldii var. sieboldii
2. Noho-jima	6096. Adinandro yaeyamaensis-Castanopsietum sieboldii
3. Gushikawa-jima	6101. Persea thunbergii community
4. Izena-jima	6113. Actinodaphne lancifolia community
5. Yanoshita-jima	6116. Quercus phillyraeoides community
6. Yanaha-jima	6129. Planchonello-Litseetum japonicae
7. Okinawa-jima	6152. Cycas revoluta community
8. Ie-jima	6155. Livistona chinensis community
9. Aguni-jima	6158. Psychotria manillensis-Acer oblongum var. itoanum
10. Ikei-jima	6159. Psychotria manilensis-Acer oblongum ssp. itoanum
11. Kume-jima	6161. Fico microcarpae-Pongamietum pinnatae
12. Miyagi-jima	6165. Pinus luchuensis
13. Henza-jima	6184. Hernandia nymphaefolia association
14. Tsuken-jima	7050. Bamboo community
20. Kudaka-jima	7052. Leucaena leucocephala community
22. Ou-jima	7054. Miscanthion sinensis
25. Ikema-jima	7064. Imperata cylindrica-Miscanthus sinensis
26. Miyako-jima	7068. Zoysion japonicae
27. Irabu-jima	8008. Phragmitetea
28. Kurima-jima	8048. Ipomoea pescaprae-Thuarea involuta community
29. Tarama-jima	8064. Plant community on raised coral-reef
30. Ishigaki-jima	8066. Plant community on raised coral-reef
31. Iriomote-jima	8102. Pandanus oboratissimus-Hibiscus tiliaceus community
32. Yonaguni-jima	9007. Conifer plantation
33. Kohama-jima	9028. Evergreen broad-leaved plantation
34. Taketomi-jima	9047. Exotic broad-leaf plantation
35. Kuro-shima	9051. Casuarinaceae plantation
36. Hateruma-jima	9072. Weedy cropland
37. Tokashiki-jima	9083. Cultivated meadow
37. Zamami-jima	9091. Cultivated meadow
37. Aka-jima	9098. Paddy-field weed communities
37. Geruma-jima	9902. Urban area
37. Yakabi-jima	9914. Urban and residential district with many trees
37. Kuba-jima	9919. Developed land
38. Kitadaito-jima	9920. Land constructed for residence and factory
38. Minamidaito-jima	9931. Open water

D4. Checklist of selected islands

Table D4: Summary of selected checklists databased. Sample = ID for a checklist, ref. = reference (Shinzato85 (Shinzato, 1985); Sako78 (Sako, 1978); SakoK80 (Sako and Kirino, 1980); SakoU81 (Sako and Ueno, 1981); SakoF85 (Sako and Fukushima, 1985); Sako84 (Sako, 1984); SakoM83 (Sako and Maruno, 1983); Sako88Uji (Sako *et al.*, 1988); Sasaki60 (Sasaki *et al.*, 1960); SasakiO53 (Sasaki and Ouchiyama, 1953); Tanimoto95 (Tanimoto *et al.*, 1995); Shimizu94hh (Shimizu, 1994); Shimizu94mu (Shimizu, 1993)); group = island group; lat = latitude (°N); long = longitude (°E); rec. = total number of recorded species; sp. = total number of unique species; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN.

ID	sample	ref.	group	island	lat	long	rec.	sp.	GHI	BK	GD	BU	GN
2002	TAKETOMI	Shinzato85	Yaeyama	Tatekomijima	24.3167	124.083	362	353	362	30	19	27	217
2003	KUCHIER	Sako78	Osumi	Kuchinoerabujima	30.45933	130.2189	401	389	538	48	52	42	209
2004	SUWANOSE	SakoK80	Tokara	Suwanosejima	29.63949	129.7159	351	340	588	50	44	38	184
2005	TAKARAJI	SakoU81	Tokara	Takarajima	29.14377	129.215	545	522	600	83	53	55	289
2006	KODAKARA	SakoU81	Tokara	Kodakarajima	29.2199	129.3283	245	241	520	31	26	23	139
2007	TAIRATOK	SakoF85	Tokara	Tairajima	29.68567	129.535	277	245	620	37	35	25	127
2008	AKUSEKIJI	Sako84	Tokara	Akusekijima	29.45634	129.6105	788	380	582	52	60	45	200
2009	KUROSHIM	SakoM83	Osumi	Kuroshima	30.85272	129.9408	593	559	586	79	78	81	287
2010	IEJIMAUJI	Sako88Uji	Uji	Iejima	31.18333	129.45	163	161	587	23	19	16	85
2011	MUKAIUJI	Sako88Uji	Uji	Mukaijima	31.18333	129.45	177	175	516	21	23	21	97
2012	MAGESHI	Sasaki60	Osumi	Mageshima	30.74262	130.8539	576	408	113	12	6	17	344
2013	TANEGASHI	SasakiO53	Osumi	Tanegashima	30.60412	130.9687	724	519	113	14	11	29	443
2017	OGCHICHI	Tanimoto95	Ogasawara	Chichijima	27.0625	142.2185	445	348	773	87	15	5	216
2020	OGHAHA	Shimizu94hh	Ogasawara	Hahajima islands	26.61953	142.1794	160	128	798	32	7	5	74
2021	OGHHMEI	Shimizu94hh	Ogasawara	Mei-jima	26.5696	142.2314	82	71	1128	27	3	0	37
2022	OGHHIMO	Shimizu94hh	Ogasawara	Imouto-jima	26.55881	142.2092	107	93	1105	35	4	1	49
2023	OGHHANE	Shimizu94hh	Ogasawara	Ane-jima	26.55535	142.1561	95	78	1012	27	3	1	44
2024	OGHHTAIR	Shimizu94hh	Ogasawara	Taira-jima	26.58592	142.1553	61	52	531	9	1	1	37
2025	OGHHMUKOU	Shimizu94hh	Ogasawara	Mukou-jima	26.60373	142.1303	100	87	1048	30	4	1	46
2026	OGMUKO	Shimizu94mu	Ogasawara	Mukojima islands	27.68305	142.1377	368	184	732	33	11	7	87
2027	OGMKKITA	Shimizu94mu	Ogasawara	Kitanoshima	27.71763	142.1006	31	26	NA	6	3	0	14
2028	OGMKMUKO	Shimizu94mu	Ogasawara	Muko-jima	27.68018	142.142	170	142	863	40	7	2	84
2029	OGMKNAKO	Shimizu94mu	Ogasawara	Nakoudo-jima	27.62835	142.1785	111	93	723	21	5	1	58
2030	OGMKYOME	Shimizu94mu	Ogasawara	Yome-jima	27.49805	142.2105	25	18	NA	3	0	0	11

D5. Prefecture FOJ data

Table D5: Summary of botanical prefecture (pref) sample plots extracted from the Flora of Japan database. lat = latitude (°N); long = longitude (°E) of the prefecture capital; rec. = total number of recorded species; sp. = total number of unique species; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN.

ID	island	district	Pref.	Area (km^2)	lat	long	rec.	sp.	GHI	BK	GD	BU	GN
1	Hokkaido	Hokkaido	Hokkaido	87099.16	43.0642	141.3469	1431	1422	187	58	75	116	1129
2	Honshu	Tohoku	Aomori	10276.45	40.8244	140.7400	1609	1608	84	7	46	229	1246
3	Honshu	Tohoku	Iwate	16019.04	39.7036	141.1525	1652	1651	98	19	40	229	1288
4	Honshu	Tohoku	Miyagi	7516.88	38.2689	140.8719	1691	1690	81	9	39	242	1323
5	Honshu	Tohoku	Akita	12231.67	39.7181	140.1033	1664	1663	105	17	55	239	1270
6	Honshu	Tohoku	Yamagata	9624.63	38.2406	140.3633	1762	1761	120	23	68	259	1323
7	Honshu	Tohoku	Fukushima	14014.62	37.7500	140.4678	1769	1768	97	15	47	269	1349
8	Honshu	Kanto	Ibaraki	6115.6	36.3414	140.4467	1884	1883	94	11	57	295	1426
9	Honshu	Kanto	Tochigi	6462.8	36.5658	139.8836	1906	1905	107	18	65	288	1435
10	Honshu	Kanto	Gunma	6400.98	36.3911	139.0608	1917	1915	118	26	64	288	1437
11	Honshu	Kanto	Saitama	3794.91	35.8569	139.6489	1865	1864	103	21	47	280	1422
12	Honshu	Kanto	Chiba	5124.5	35.6047	140.1233	1964	1963	95	12	60	304	1491
13	Honshu	Kanto	Tokyo	1781.14	35.6894	139.6917	1979	1978	111	24	62	299	1494
14	Honshu	Kanto	Kanagawa	2403.73	35.4478	139.6425	2058	2057	136	39	73	312	1521
15	Honshu	Chubu	Niigata	12815.64	37.9022	139.0236	2152	2148	143	35	100	352	1533
16	Honshu	Chubu	Toyama	4287.19	36.6953	137.2114	2137	2134	131	27	97	348	1539
17	Honshu	Chubu	Ishikawa	4222.49	36.5944	136.6256	2130	2127	117	20	85	353	1548
18	Honshu	Chubu	Fukui	4176.84	36.0653	136.2219	2154	2151	125	24	92	357	1559
19	Honshu	Chubu	Yamanashi	4446.85	35.6639	138.5683	2196	2194	150	47	91	346	1591
20	Honshu	Chubu	Nagano	13572.72	36.6514	138.1811	2286	2284	184	72	109	347	1623
21	Honshu	Chubu	Gifu	10588.3	35.3911	136.7222	2231	2229	149	44	97	363	1605
22	Honshu	Chubu	Shizuoka	7676.77	34.9769	138.3831	2394	2390	174	62	121	386	1679
23	Honshu	Chubu	Aichi	5109.07	35.1803	136.9067	2276	2274	131	30	96	387	1640
24	Honshu	Kinki	Mie	5669.85	34.7303	136.5086	2160	2142	129	31	79	364	1563
25	Honshu	Kinki	Shiga	3976.74	35.0044	135.8683	1983	1982	104	15	56	349	1459
26	Honshu	Kinki	Kyoto	4567.44	35.0214	135.7556	1988	1987	100	14	52	350	1468
27	Honshu	Kinki	Osaka	1877.41	34.6864	135.5200	1915	1914	72	3	29	328	1460
28	Honshu	Kinki	Hyogo	8296.68	34.6914	135.1831	1993	1992	95	13	45	353	1481
29	Honshu	Kinki	Nara	3616.02	34.6853	135.8328	2052	2051	104	16	59	356	1519
30	Honshu	Kinki	Wakayama	4601.51	34.2261	135.1675	2096	2094	113	22	66	360	1548
31	Honshu	Chugoku	Tottori	3476.29	35.5036	134.2383	1908	1907	84	9	37	318	1449
32	Honshu	Chugoku	Shimane	6631.6	35.4722	133.0506	1899	1898	90	13	40	310	1441
33	Honshu	Chugoku	Okayama	7014.2	34.6617	133.9350	1881	1880	80	12	23	305	1448
34	Honshu	Chugoku	Hiroshima	8330.87	34.3964	132.4594	1883	1882	79	10	27	304	1451
35	Honshu	Chugoku	Yamaguchi	5972.88	34.1858	131.4714	1943	1942	86	10	42	312	1474
36	Shikoku	Shikoku	Tokushima	4037.98	34.0658	134.5594	1849	1849	139	30	83	311	1359

37	Shikoku	Shikoku	Kagawa	1832.96	34.3403	134.0433	1770	1770	114	18	62	303	1322
38	Shikoku	Shikoku	Ehime	5504.06	33.8417	132.7661	1795	1795	123	22	69	307	1329
39	Shikoku	Shikoku	Kochi	6881.96	33.5597	133.5311	1884	1883	149	37	86	311	1374
40	Kyushu	Kyushu	Fukuoka	4834.41	33.6064	130.4181	1835	1829	108	20	60	275	1395
41	Kyushu	Kyushu	Saga	2366.12	33.2494	130.2989	1820	1814	99	15	56	274	1391
42	Kyushu	Kyushu	Nagasaki	3977.91	32.7447	129.8736	1893	1887	120	27	68	280	1435
43	Kyushu	Kyushu	Kumamoto	7118.55	32.7897	130.7417	1969	1963	153	47	85	279	1462
44	Kyushu	Kyushu	Oita	6124.53	33.2381	131.6125	1875	1869	116	22	72	283	1412
45	Kyushu	Kyushu	Miyazaki	7395.13	31.9111	131.4239	1933	1927	167	55	86	276	1424
46	Kyushu	Kyushu	Kagoshima	7535.16	31.5603	130.5581	2192	2186	255	126	123	276	1562
47	Ryukyu	Ryukyu	Ryukyu	3173.66	26.2125	127.6811	1352	1352	371	146	95	44	1042
48	Izu	Izu	Izu	289.15	NA	NA	113	112	647	18	17	7	60
49	Ogasawara	Ogasawara	Ogasawara	99.4	NA	NA	262	262	1005	89	18	3	146
50	Kazan	Kazan	Kazan	2403.73	NA	NA	33	33	1581	19	1	0	13
51	Kuriles	Kuriles	Kuriles	5716.24	NA	NA	377	377	43	2	6	18	343

D6. Horikawa geoquadrat maps

Table D6: Summary of Horikawa geoquadrat map data. sample = ID of geoquadrat. lat = latitude (°N); long = longitude (°E) of central point of the geoquadrat; rec. = total number of recorded species; sp. = total number of unique species; GHI = Genetic Heat Index; Stars abbreviated as Black, BK; Gold, GD; Blue, BU; Green, GN; * = the number of endemic species; sum_WE = summed weighted endemism, CWE = Corrected Weighted Endemism; ocean, main isl,, small isl, total land, total area = area of ocean, mainland, small islands, total land, and aerial area of the geoquadrat (km^2).

ID	sample	lat	long	rec.	sp.	GHI	BK	GD	BU	GN	*	sum_WE	CWE	ocean	main isl.	small isl.	total land	total area
1	horim001	45.5833	141.875	26	26	NA	0	0	1	25	0	0.2261	0.0087	352.517	8.801	0.011	8.812	361.329
2	horim002	45.4167	140.875	16	16	NA	0	0	0	15	0	0.1953	0.0122	354.864	0.000	7.522	7.522	362.386
3	horim003	45.4167	141.125	78	78	50	1	0	2	62	2	1.0149	0.0130	306.145	0.000	56.241	56.241	362.386
4	horim004	45.4167	141.625	66	66	9	0	0	2	59	2	0.2265	0.0034	293.213	69.173	0.000	69.173	362.386
5	horim005	45.4167	141.875	46	46	13	0	0	2	41	0	0.2410	0.0052	104.311	258.073	0.002	258.075	362.386
6	horim006	45.4167	142.125	11	11	NA	0	0	0	10	0	0.0373	0.0034	278.207	84.174	0.005	84.178	362.386
7	horim007	45.2500	141.125	98	98	50	1	1	2	79	4	2.1171	0.0216	275.985	0.000	87.454	87.454	363.440
8	horim008	45.2500	141.375	55	55	33	0	1	2	42	3	1.2972	0.0236	328.020	0.000	35.420	35.420	363.440
9	horim009	45.2500	141.625	43	43	15	0	0	2	36	1	0.1224	0.0028	144.123	219.310	0.007	219.317	363.440
10	horim010	45.2500	141.875	31	31	NA	0	0	1	29	0	0.0888	0.0029	0.000	363.440	0.000	363.440	363.440
11	horim011	45.2500	142.125	35	35	NA	0	0	2	32	1	0.0947	0.0027	23.282	340.158	0.000	340.158	363.440
12	horim012	45.2500	142.375	19	19	NA	0	0	1	17	0	0.0414	0.0022	321.133	42.307	0.000	42.307	363.440
13	horim013	45.0833	141.125	57	57	5	0	0	1	52	1	0.2663	0.0047	322.968	0.000	41.523	41.523	364.491
14	horim014	45.0833	141.375	69	69	10	0	0	2	58	1	0.3512	0.0051	329.290	0.000	35.200	35.200	364.491
15	horim015	45.0833	141.625	70	70	22	0	0	5	63	5	0.3059	0.0044	195.278	169.213	0.000	169.213	364.491
16	horim016	45.0833	141.875	61	61	10	0	0	2	54	2	0.1707	0.0028	0.000	364.491	0.000	364.491	364.491
17	horim017	45.0833	142.125	46	46	20	0	0	3	42	5	0.2033	0.0044	0.000	364.491	0.000	364.491	364.491
18	horim018	45.0833	142.375	45	45	13	0	0	2	42	1	0.2381	0.0053	75.704	288.787	0.000	288.787	364.491
19	horim019	45.0833	142.625	46	46	6	0	0	1	44	1	0.1401	0.0030	352.346	12.114	0.030	12.144	364.491
20	horim020	44.9167	141.625	64	64	14	0	0	3	58	3	0.2742	0.0043	327.232	38.306	0.000	38.306	365.538
21	horim021	44.9167	141.875	71	71	13	0	0	3	64	4	0.2251	0.0032	0.906	364.632	0.000	364.632	365.538
22	horim022	44.9167	142.125	58	58	16	0	0	3	50	4	0.2470	0.0043	0.000	365.538	0.000	365.538	365.538
23	horim023	44.9167	142.375	102	102	26	0	1	5	83	8	1.6123	0.0158	0.000	365.538	0.000	365.538	365.538
24	horim024	44.9167	142.625	64	64	9	0	0	2	59	2	0.2709	0.0042	212.996	152.485	0.057	152.542	365.538
25	horim025	44.7500	141.875	88	88	10	0	0	3	80	4	0.3017	0.0034	43.517	323.066	0.000	323.066	366.583
26	horim026	44.7500	142.125	84	84	20	0	0	5	67	7	0.3399	0.0040	0.000	366.583	0.000	366.583	366.583
27	horim027	44.7500	142.375	70	70	9	0	0	2	62	2	0.2405	0.0034	0.000	366.583	0.000	366.583	366.583
28	horim028	44.7500	142.625	14	14	NA	0	0	0	13	0	0.0495	0.0035	26.726	339.856	0.000	339.856	366.583
29	horim029	44.7500	142.875	25	25	NA	0	0	0	24	0	0.0825	0.0033	321.969	44.600	0.014	44.614	366.583
30	horim030	44.5833	141.875	53	53	12	0	0	2	46	3	0.1380	0.0026	50.117	317.507	0.000	317.507	367.624
31	horim031	44.5833	142.125	8	8	NA	0	0	1	7	0	0.0291	0.0036	0.000	367.624	0.000	367.624	367.624
32	horim032	44.5833	142.375	32	32	NA	0	0	2	29	0	0.1089	0.0034	0.000	367.624	0.000	367.624	367.624
33	horim033	44.5833	142.625	4	4	NA	0	0	0	4	0	0.0150	0.0038	0.000	367.624	0.000	367.624	367.624

34	horim034	44.5833	142.875	27	27	NA	0	0	1	26	0	0.0780	0.0029	61.295	306.329	0.000	306.329	367.624
35	horim035	44.5833	143.125	23	23	NA	0	0	0	23	0	0.0979	0.0043	343.578	24.046	0.000	24.046	367.624
36	horim036	44.4167	141.375	16	16	NA	0	0	2	12	2	0.0509	0.0032	357.968	0.000	10.694	10.694	368.662
37	horim037	44.4167	141.625	36	36	NA	0	0	1	35	1	0.1109	0.0031	337.163	31.499	0.000	31.499	368.662
38	horim038	44.4167	141.875	69	69	19	0	0	4	59	5	0.2207	0.0032	7.014	361.648	0.000	361.648	368.662
39	horim039	44.4167	142.125	25	25	NA	0	0	0	24	1	0.0695	0.0028	0.000	368.662	0.000	368.662	368.662
40	horim040	44.4167	142.375	37	37	NA	0	0	2	35	0	0.1037	0.0028	0.000	368.662	0.000	368.662	368.662
41	horim041	44.4167	142.625	72	72	23	0	0	5	60	7	0.2614	0.0036	0.000	368.662	0.000	368.662	368.662
42	horim042	44.4167	142.875	22	22	NA	0	0	1	21	1	0.0650	0.0030	0.000	368.662	0.000	368.662	368.662
43	horim043	44.4167	143.125	41	41	7	0	0	1	40	1	0.1121	0.0027	54.558	314.103	0.000	314.103	368.662
44	horim044	44.4167	143.375	44	44	14	0	0	2	40	0	0.1214	0.0028	314.783	53.879	0.000	53.879	368.662
45	horim045	44.4167	145.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	367.300	1.361	0.000	1.361	368.662
46	horim046	44.2500	141.625	31	31	NA	0	0	0	31	1	0.0727	0.0023	236.822	132.872	0.002	132.875	369.697
47	horim047	44.2500	141.875	56	56	17	0	0	3	49	5	0.1632	0.0029	0.000	369.697	0.000	369.697	369.697
48	horim048	44.2500	142.125	38	38	NA	0	0	1	36	1	0.1136	0.0030	0.000	369.697	0.000	369.697	369.697
49	horim049	44.2500	142.375	36	36	NA	0	0	1	35	1	0.1007	0.0028	0.000	369.697	0.000	369.697	369.697
50	horim050	44.2500	142.625	66	66	9	0	0	2	60	1	0.2045	0.0031	0.000	369.697	0.000	369.697	369.697
51	horim051	44.2500	142.875	98	98	24	0	0	7	80	10	0.4678	0.0048	0.000	369.697	0.000	369.697	369.697
52	horim052	44.2500	143.125	78	78	23	0	0	6	71	5	0.2625	0.0034	0.000	369.697	0.000	369.697	369.697
53	horim053	44.2500	143.375	48	48	6	0	0	1	47	0	0.1595	0.0033	38.083	331.614	0.000	331.614	369.697
54	horim054	44.2500	143.625	44	44	13	0	0	2	41	0	0.1848	0.0042	228.877	140.820	0.000	140.820	369.697
55	horim055	44.2500	143.875	19	19	NA	0	0	0	19	0	0.1519	0.0080	361.090	8.606	0.000	8.606	369.697
56	horim056	44.2500	145.125	77	77	28	0	1	4	70	6	0.4674	0.0061	332.756	36.929	0.012	36.940	369.697
57	horim057	44.2500	145.375	117	117	30	0	1	7	92	9	0.9184	0.0078	250.361	119.322	0.014	119.336	369.697
58	horim058	44.0833	141.625	34	34	NA	0	0	1	32	1	0.1135	0.0033	241.877	128.851	0.000	128.851	370.728
59	horim059	44.0833	141.875	6	6	NA	0	0	0	6	1	0.0141	0.0024	0.000	370.728	0.000	370.728	370.728
60	horim060	44.0833	142.125	68	68	28	0	0	6	58	8	0.2190	0.0032	0.000	370.728	0.000	370.728	370.728
61	horim061	44.0833	142.375	36	36	NA	0	0	2	33	1	0.0935	0.0026	0.000	370.728	0.000	370.728	370.728
62	horim062	44.0833	142.625	11	11	NA	0	0	1	10	1	0.0328	0.0030	0.000	370.728	0.000	370.728	370.728
63	horim063	44.0833	142.875	93	93	25	0	0	7	76	9	0.4311	0.0046	0.000	370.728	0.000	370.728	370.728
64	horim064	44.0833	143.125	96	96	13	0	0	4	82	5	0.3410	0.0036	0.000	370.728	0.000	370.728	370.728
65	horim065	44.0833	143.375	74	74	13	0	0	3	66	2	0.2192	0.0030	0.000	370.728	0.000	370.728	370.728
66	horim066	44.0833	143.625	36	36	NA	0	0	1	34	1	0.1476	0.0041	0.000	370.728	0.000	370.728	370.728
67	horim067	44.0833	143.875	51	51	24	0	1	1	48	2	0.2679	0.0053	26.575	344.153	0.000	344.153	370.728
68	horim068	44.0833	144.125	44	44	6	0	0	1	42	0	0.2475	0.0056	114.588	256.137	0.002	256.140	370.728
69	horim069	44.0833	144.375	45	45	0	0	0	0	40	0	0.1482	0.0033	355.087	15.609	0.032	15.641	370.728
70	horim070	44.0833	144.875	96	96	19	0	1	3	88	4	0.5630	0.0059	338.562	32.166	0.000	32.166	370.728
71	horim071	44.0833	145.125	154	154	32	0	2	9	126	12	1.2986	0.0084	74.440	296.288	0.000	296.288	370.728
72	horim072	44.0833	145.375	24	24	NA	0	0	1	23	0	0.1119	0.0047	356.785	13.943	0.000	13.943	370.728
73	horim073	43.9167	141.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	371.684	0.072	0.000	0.072	371.757

74	horim074	43.9167	141.625	54	54	11	0	0	2	51	1	0.1528	0.0028	162.844	208.901	0.012	208.912	371.757
75	horim075	43.9167	141.875	55	55	18	0	0	3	47	5	0.1471	0.0027	0.000	371.757	0.000	371.757	371.757
76	horim076	43.9167	142.125	75	75	25	0	0	6	64	8	0.3142	0.0042	0.000	371.757	0.000	371.757	371.757
77	horim077	43.9167	142.375	41	41	14	0	0	2	39	1	0.1062	0.0026	0.000	371.757	0.000	371.757	371.757
78	horim078	43.9167	142.625	37	37	NA	0	0	2	34	1	0.0971	0.0026	0.000	371.757	0.000	371.757	371.757
79	horim079	43.9167	142.875	110	110	24	0	0	8	90	9	0.7244	0.0066	0.000	371.757	0.000	371.757	371.757
80	horim080	43.9167	143.125	60	60	21	0	0	4	52	3	0.1997	0.0033	0.000	371.757	0.000	371.757	371.757
81	horim081	43.9167	143.375	75	75	13	0	0	3	62	3	0.2529	0.0034	0.000	371.757	0.000	371.757	371.757
82	horim082	43.9167	143.625	38	38	NA	0	0	2	35	1	0.1266	0.0033	0.000	371.757	0.000	371.757	371.757
83	horim083	43.9167	143.875	28	28	NA	0	0	2	26	0	0.0821	0.0029	0.000	371.757	0.000	371.757	371.757
84	horim084	43.9167	144.125	46	46	6	0	0	1	44	0	0.1289	0.0028	0.000	371.757	0.000	371.757	371.757
85	horim085	43.9167	144.375	50	50	12	0	0	2	48	1	0.2571	0.0051	93.906	277.850	0.000	277.850	371.757
86	horim086	43.9167	144.625	54	54	5	0	0	1	50	1	0.3067	0.0057	183.578	188.179	0.000	188.179	371.757
87	horim087	43.9167	144.875	108	108	18	0	0	6	92	5	0.6475	0.0060	66.730	305.027	0.000	305.027	371.757
88	horim088	43.9167	145.125	58	58	11	0	0	2	51	1	0.2247	0.0039	187.357	184.399	0.000	184.399	371.757
89	horim089	43.7500	141.375	43	43	28	0	0	4	38	4	0.1389	0.0032	174.264	198.499	0.019	198.518	372.782
90	horim090	43.7500	141.625	93	93	38	0	1	8	76	10	1.5333	0.0165	0.000	372.782	0.000	372.782	372.782
91	horim091	43.7500	141.875	31	31	NA	0	0	2	28	1	0.0996	0.0032	0.000	372.782	0.000	372.782	372.782
92	horim092	43.7500	142.125	46	46	13	0	0	2	41	1	0.1200	0.0026	0.000	372.782	0.000	372.782	372.782
93	horim093	43.7500	142.375	86	86	11	0	0	3	78	2	0.2380	0.0028	0.000	372.782	0.000	372.782	372.782
94	horim094	43.7500	142.625	43	43	14	0	0	2	40	1	0.1077	0.0025	0.000	372.782	0.000	372.782	372.782
95	horim095	43.7500	142.875	132	132	81	2	1	10	101	15	2.6072	0.0198	0.000	372.782	0.000	372.782	372.782
96	horim096	43.7500	143.125	78	78	24	0	0	5	57	5	0.9601	0.0123	0.000	372.782	0.000	372.782	372.782
97	horim097	43.7500	143.375	59	59	26	0	0	4	42	3	0.2517	0.0043	0.000	372.782	0.000	372.782	372.782
98	horim098	43.7500	143.625	49	49	20	0	0	3	41	1	0.1750	0.0036	0.000	372.782	0.000	372.782	372.782
99	horim099	43.7500	143.875	23	23	NA	0	0	1	22	0	0.0692	0.0030	0.000	372.782	0.000	372.782	372.782
100	horim100	43.7500	144.125	14	14	NA	0	0	2	12	0	0.0534	0.0038	0.000	372.782	0.000	372.782	372.782
101	horim101	43.7500	144.375	63	63	11	0	0	2	49	2	0.2979	0.0047	0.000	372.782	0.000	372.782	372.782
102	horim102	43.7500	144.625	101	101	23	0	0	7	82	7	0.6603	0.0065	0.000	372.782	0.000	372.782	372.782
103	horim103	43.7500	144.875	46	46	13	0	0	2	43	2	0.1345	0.0029	0.000	372.782	0.000	372.782	372.782
104	horim104	43.7500	145.125	57	57	5	0	0	1	54	0	0.2398	0.0042	240.667	132.115	0.000	132.115	372.782
105	horim105	43.5833	141.375	3	3	NA	0	0	0	3	0	0.0074	0.0025	181.175	192.629	0.000	192.629	373.804
106	horim106	43.5833	141.625	3	3	NA	0	0	0	3	0	0.0074	0.0025	0.000	373.804	0.000	373.804	373.804
107	horim107	43.5833	141.875	31	31	NA	0	0	1	30	0	0.0843	0.0027	0.000	373.804	0.000	373.804	373.804
108	horim108	43.5833	142.125	45	45	13	0	0	2	43	1	0.1154	0.0026	0.000	373.804	0.000	373.804	373.804
109	horim109	43.5833	142.375	42	42	7	0	0	1	40	1	0.1108	0.0026	0.000	373.804	0.000	373.804	373.804
110	horim110	43.5833	142.625	38	38	NA	0	0	3	32	3	0.1098	0.0029	0.000	373.804	0.000	373.804	373.804
111	horim111	43.5833	142.875	105	105	103	2	1	10	77	16	2.5010	0.0238	0.000	373.804	0.000	373.804	373.804
112	horim112	43.5833	143.125	89	89	83	1	1	8	62	9	1.4682	0.0165	0.000	373.804	0.000	373.804	373.804
113	horim113	43.5833	143.375	61	61	38	0	0	6	41	5	0.4374	0.0072	0.000	373.804	0.000	373.804	373.804

114	horim114	43.5833	143.625	31	31	NA	0	0	2	26	1	0.1019	0.0033	0.000	373.804	0.000	373.804	373.804
115	horim115	43.5833	143.875	53	53	5	0	0	1	50	1	0.1669	0.0031	0.000	373.804	0.000	373.804	373.804
116	horim116	43.5833	144.125	75	75	9	0	0	2	62	2	0.2870	0.0038	0.000	373.804	0.000	373.804	373.804
117	horim117	43.5833	144.375	95	95	14	0	0	4	81	4	0.3440	0.0036	0.000	373.804	0.000	373.804	373.804
118	horim118	43.5833	144.625	70	70	10	0	0	2	56	2	0.3117	0.0045	0.000	373.804	0.000	373.804	373.804
119	horim119	43.5833	144.875	67	67	13	0	0	3	63	3	0.2294	0.0034	0.000	373.804	0.000	373.804	373.804
120	horim120	43.5833	145.125	43	43	0	0	0	0	43	0	0.2223	0.0052	60.811	312.854	0.138	312.992	373.804
121	horim121	43.5833	145.375	26	26	NA	0	0	0	25	0	0.1364	0.0052	358.651	14.804	0.348	15.153	373.804
122	horim122	43.4167	140.375	54	54	5	0	0	1	52	1	0.1620	0.0030	362.658	12.143	0.021	12.164	374.822
123	horim123	43.4167	140.625	50	50	12	0	0	2	45	1	0.1469	0.0029	365.868	8.943	0.012	8.955	374.822
124	horim124	43.4167	141.375	3	3	NA	0	0	0	3	0	0.0074	0.0025	251.013	123.805	0.005	123.809	374.822
125	horim125	43.4167	141.625	6	6	NA	0	0	0	6	0	0.0227	0.0038	0.000	374.822	0.000	374.822	374.822
126	horim126	43.4167	141.875	34	34	NA	0	0	1	33	0	0.0874	0.0026	0.000	374.822	0.000	374.822	374.822
127	horim127	43.4167	142.125	23	23	NA	0	0	1	22	1	0.0673	0.0029	0.000	374.822	0.000	374.822	374.822
128	horim128	43.4167	142.375	67	67	9	0	0	2	59	1	0.1954	0.0029	0.000	374.822	0.000	374.822	374.822
129	horim129	43.4167	142.625	48	48	61	0	1	6	37	6	0.7402	0.0154	0.000	374.822	0.000	374.822	374.822
130	horim130	43.4167	142.875	18	18	NA	0	1	1	14	2	0.6538	0.0363	0.000	374.822	0.000	374.822	374.822
131	horim131	43.4167	143.125	94	94	33	0	1	6	74	8	1.2939	0.0138	0.000	374.822	0.000	374.822	374.822
132	horim132	43.4167	143.375	71	71	14	0	0	3	58	3	0.2698	0.0038	0.000	374.822	0.000	374.822	374.822
133	horim133	43.4167	143.625	78	78	8	0	0	2	65	2	0.2944	0.0038	0.000	374.822	0.000	374.822	374.822
134	horim134	43.4167	143.875	85	85	54	1	0	4	66	5	0.7540	0.0089	0.000	374.822	0.000	374.822	374.822
135	horim135	43.4167	144.125	104	104	57	1	1	5	81	7	1.0250	0.0099	0.000	374.822	0.000	374.822	374.822
136	horim136	43.4167	144.375	33	33	NA	0	0	1	30	2	0.1222	0.0037	0.000	374.822	0.000	374.822	374.822
137	horim137	43.4167	144.625	29	29	NA	0	0	1	28	0	0.0822	0.0028	0.000	374.822	0.000	374.822	374.822
138	horim138	43.4167	144.875	23	23	NA	0	0	1	22	1	0.0516	0.0022	0.000	374.822	0.000	374.822	374.822
139	horim139	43.4167	145.125	22	22	NA	0	0	0	22	0	0.0772	0.0035	0.000	374.822	0.000	374.822	374.822
140	horim140	43.4167	145.375	4	4	NA	0	0	0	4	0	0.0092	0.0023	328.049	46.774	0.000	46.774	374.822
141	horim141	43.4167	145.625	5	5	NA	0	1	0	4	1	0.6056	0.1211	313.458	61.315	0.049	61.364	374.822
142	horim142	43.4167	145.875	20	20	NA	0	1	0	19	1	0.1867	0.0093	352.235	22.535	0.052	22.587	374.822
143	horim143	43.2500	140.375	78	78	21	0	1	2	68	5	0.3205	0.0041	151.546	224.257	0.035	224.292	375.838
144	horim144	43.2500	140.625	88	88	28	0	1	5	79	8	0.2994	0.0034	103.728	272.051	0.059	272.110	375.838
145	horim145	43.2500	140.875	48	48	13	0	0	2	42	2	0.1232	0.0026	273.342	102.481	0.014	102.495	375.838
146	horim146	43.2500	141.125	13	13	NA	0	0	1	12	0	0.0346	0.0027	358.027	17.792	0.019	17.811	375.838
147	horim147	43.2500	141.375	28	28	NA	0	0	1	26	0	0.0826	0.0030	150.299	225.408	0.132	225.539	375.838
148	horim148	43.2500	141.625	15	15	NA	0	0	0	15	0	0.0396	0.0026	0.000	375.838	0.000	375.838	375.838
149	horim149	43.2500	141.875	27	27	NA	0	0	0	27	1	0.0631	0.0023	0.000	375.838	0.000	375.838	375.838
150	horim150	43.2500	142.125	7	7	NA	1	1	0	5	3	0.5146	0.0735	0.000	375.838	0.000	375.838	375.838
151	horim151	43.2500	142.375	118	118	29	0	0	10	92	14	0.8105	0.0069	0.000	375.838	0.000	375.838	375.838
152	horim152	43.2500	142.625	9	9	NA	0	0	1	8	1	0.0281	0.0031	0.000	375.838	0.000	375.838	375.838
153	horim153	43.2500	142.875	20	20	NA	0	0	0	19	1	0.1110	0.0055	0.000	375.838	0.000	375.838	375.838

154	horim154	43.2500	143.125	42	42	23	0	0	3	36	4	0.2961	0.0071	0.000	375.838	0.000	375.838	375.838
155	horim155	43.2500	143.375	35	35	NA	0	0	2	33	0	0.1160	0.0033	0.000	375.838	0.000	375.838	375.838
156	horim156	43.2500	143.625	26	26	NA	0	0	0	25	1	0.0766	0.0029	0.000	375.838	0.000	375.838	375.838
157	horim157	43.2500	143.875	7	7	NA	0	0	0	7	0	0.0201	0.0029	0.000	375.838	0.000	375.838	375.838
158	horim158	43.2500	144.125	35	35	NA	0	0	1	33	0	0.1121	0.0032	0.000	375.838	0.000	375.838	375.838
159	horim159	43.2500	144.375	12	12	NA	0	0	1	11	0	0.0364	0.0030	0.000	375.838	0.000	375.838	375.838
160	horim160	43.2500	144.625	45	45	6	0	0	1	42	2	0.1141	0.0025	0.000	375.838	0.000	375.838	375.838
161	horim161	43.2500	144.875	15	15	NA	0	0	1	13	0	0.0397	0.0026	0.000	375.838	0.000	375.838	375.838
162	horim162	43.2500	145.125	26	26	NA	0	0	0	26	0	0.0985	0.0038	0.000	375.838	0.000	375.838	375.838
163	horim163	43.2500	145.375	59	59	58	1	0	2	53	2	0.4725	0.0080	85.450	290.381	0.007	290.388	375.838
164	horim164	43.2500	145.625	63	63	33	0	1	3	50	2	1.4504	0.0230	277.499	95.843	2.496	98.339	375.838
165	horim165	43.2500	145.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	375.767	0.000	0.070	0.070	375.838
166	horim166	43.0833	140.375	16	16	NA	0	0	1	15	1	0.0792	0.0050	327.007	49.796	0.047	49.843	376.850
167	horim167	43.0833	140.625	62	62	9	0	0	2	59	2	0.2149	0.0035	10.615	366.221	0.014	366.235	376.850
168	horim168	43.0833	140.875	28	28	NA	0	0	1	26	1	0.0679	0.0024	0.000	376.850	0.000	376.850	376.850
169	horim169	43.0833	141.125	102	102	6	0	0	2	94	1	0.3469	0.0034	16.943	359.905	0.002	359.907	376.850
170	horim170	43.0833	141.375	102	102	15	0	0	5	90	7	0.3015	0.0030	0.000	376.850	0.000	376.850	376.850
171	horim171	43.0833	141.625	87	87	14	0	0	4	79	5	0.2522	0.0029	0.000	376.850	0.000	376.850	376.850
172	horim172	43.0833	141.875	31	31	NA	0	0	0	31	3	0.0740	0.0024	0.000	376.850	0.000	376.850	376.850
173	horim173	43.0833	142.125	131	131	20	0	0	8	107	10	0.7408	0.0057	0.000	376.850	0.000	376.850	376.850
174	horim174	43.0833	142.375	81	81	194	4	1	7	59	12	4.3085	0.0532	0.000	376.850	0.000	376.850	376.850
175	horim175	43.0833	142.625	34	34	NA	0	0	2	31	0	0.1035	0.0030	0.000	376.850	0.000	376.850	376.850
176	horim176	43.0833	142.875	87	87	10	0	0	3	82	4	0.3284	0.0038	0.000	376.850	0.000	376.850	376.850
177	horim177	43.0833	143.125	18	18	NA	0	0	1	17	0	0.0512	0.0028	0.000	376.850	0.000	376.850	376.850
178	horim178	43.0833	143.375	3	3	NA	0	0	0	3	0	0.0044	0.0015	0.000	376.850	0.000	376.850	376.850
179	horim179	43.0833	143.625	41	41	7	0	0	1	39	1	0.1466	0.0036	0.000	376.850	0.000	376.850	376.850
180	horim180	43.0833	143.875	6	6	NA	0	0	1	5	0	0.0214	0.0036	0.000	376.850	0.000	376.850	376.850
181	horim181	43.0833	144.125	26	26	NA	0	0	1	25	0	0.0671	0.0026	0.000	376.850	0.000	376.850	376.850
182	horim182	43.0833	144.375	57	57	26	0	1	2	53	3	0.2884	0.0051	0.915	375.935	0.000	375.935	376.850
183	horim183	43.0833	144.625	47	47	7	0	0	1	41	0	0.2186	0.0047	1.436	375.414	0.000	375.414	376.850
184	horim184	43.0833	144.875	37	37	NA	0	1	1	34	1	0.2957	0.0080	42.843	334.007	0.000	334.007	376.850
185	horim185	43.0833	145.125	22	22	NA	0	0	1	20	0	0.1197	0.0054	198.948	173.245	4.657	177.902	376.850
186	horim186	43.0833	145.375	3	3	NA	0	0	0	2	0	0.0237	0.0079	374.825	2.025	0.000	2.025	376.850
187	horim187	43.0833	145.625	5	5	NA	0	0	0	2	0	0.0378	0.0076	375.248	1.602	0.000	1.602	376.850
188	horim188	42.9167	140.375	111	111	8	0	0	3	101	7	0.3589	0.0032	242.505	135.352	0.002	135.354	377.859
189	horim189	42.9167	140.625	112	112	25	0	0	9	96	13	0.9416	0.0084	4.189	373.639	0.031	373.670	377.859
190	horim190	42.9167	140.875	75	75	14	0	0	3	59	3	0.2977	0.0040	0.000	377.859	0.000	377.859	377.859
191	horim191	42.9167	141.125	110	110	49	1	0	7	89	9	0.7228	0.0066	0.000	377.859	0.000	377.859	377.859
192	horim192	42.9167	141.375	104	104	22	0	0	7	85	9	0.4389	0.0042	0.000	377.859	0.000	377.859	377.859
193	horim193	42.9167	141.625	79	79	8	0	0	2	73	4	0.2117	0.0027	0.000	377.859	0.000	377.859	377.859

194	horim194	42.9167	141.875	39	39	NA	0	0	1	38	1	0.0966	0.0025	0.000	377.859	0.000	377.859	377.859
195	horim195	42.9167	142.125	38	38	NA	0	0	1	36	1	0.0928	0.0024	0.000	377.859	0.000	377.859	377.859
196	horim196	42.9167	142.375	48	48	12	0	0	2	46	2	0.1211	0.0025	0.000	377.859	0.000	377.859	377.859
197	horim197	42.9167	142.625	31	31	NA	0	0	1	29	0	0.2876	0.0093	0.000	377.859	0.000	377.859	377.859
198	horim198	42.9167	142.875	115	115	21	0	0	7	92	7	0.5896	0.0051	0.000	377.859	0.000	377.859	377.859
199	horim199	42.9167	143.125	56	56	5	0	0	1	54	1	0.1624	0.0029	0.000	377.859	0.000	377.859	377.859
200	horim200	42.9167	143.375	78	78	7	0	0	2	75	3	0.2197	0.0028	0.000	377.859	0.000	377.859	377.859
201	horim201	42.9167	143.625	32	32	NA	0	0	0	32	0	0.1017	0.0032	0.000	377.859	0.000	377.859	377.859
202	horim202	42.9167	143.875	36	36	NA	0	0	2	34	0	0.1871	0.0052	52.385	325.474	0.000	325.474	377.859
203	horim203	42.9167	144.125	31	31	NA	0	0	1	30	0	0.0978	0.0032	292.148	85.711	0.000	85.711	377.859
204	horim204	42.9167	144.375	28	28	NA	0	0	1	26	1	0.1700	0.0061	317.519	60.332	0.007	60.340	377.859
205	horim205	42.9167	144.625	47	47	26	0	1	1	44	1	0.2094	0.0045	253.730	124.129	0.000	124.129	377.859
206	horim206	42.9167	144.875	7	7	NA	0	0	0	5	0	0.0253	0.0036	352.731	23.995	1.133	25.128	377.859
207	horim207	42.9167	145.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	375.856	1.998	0.005	2.002	377.859
208	horim208	42.7500	139.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	361.340	17.522	0.002	17.524	378.865
209	horim209	42.7500	140.125	59	59	15	0	0	3	55	3	0.2276	0.0039	192.739	186.010	0.116	186.126	378.865
210	horim210	42.7500	140.375	117	117	21	0	0	8	103	12	0.3621	0.0031	35.933	342.908	0.024	342.932	378.865
211	horim211	42.7500	140.625	51	51	12	0	0	2	47	3	0.1201	0.0024	0.000	378.865	0.000	378.865	378.865
212	horim212	42.7500	140.875	55	55	38	0	0	6	41	5	0.3904	0.0071	0.000	378.865	0.000	378.865	378.865
213	horim213	42.7500	141.125	56	56	16	0	0	3	50	2	0.1630	0.0029	0.000	378.865	0.000	378.865	378.865
214	horim214	42.7500	141.375	78	78	25	0	0	6	66	6	0.3598	0.0046	0.000	378.865	0.000	378.865	378.865
215	horim215	42.7500	141.625	95	95	9	0	0	3	88	5	0.3257	0.0034	0.000	378.865	0.000	378.865	378.865
216	horim216	42.7500	141.875	37	37	NA	0	0	2	35	0	0.1202	0.0032	0.000	378.865	0.000	378.865	378.865
217	horim217	42.7500	142.125	74	74	8	0	0	2	67	2	0.1737	0.0023	0.000	378.865	0.000	378.865	378.865
218	horim218	42.7500	142.375	64	64	4	0	0	1	62	1	0.1598	0.0025	0.000	378.865	0.000	378.865	378.865
219	horim219	42.7500	142.625	100	100	70	1	1	8	75	10	1.5677	0.0157	0.000	378.865	0.000	378.865	378.865
220	horim220	42.7500	142.875	80	80	15	0	0	4	76	5	0.4978	0.0062	0.000	378.865	0.000	378.865	378.865
221	horim221	42.7500	143.125	38	38	NA	0	0	1	37	0	0.1123	0.0030	0.000	378.865	0.000	378.865	378.865
222	horim222	42.7500	143.375	56	56	5	0	0	1	54	3	0.1914	0.0034	0.000	378.865	0.000	378.865	378.865
223	horim223	42.7500	143.625	72	72	12	0	0	3	69	2	0.3296	0.0046	43.790	335.074	0.000	335.074	378.865
224	horim224	42.7500	143.875	43	43	34	0	1	2	40	2	0.2674	0.0062	335.263	43.586	0.017	43.602	378.865
225	horim225	42.5833	139.875	119	119	36	0	1	10	96	16	0.6278	0.0053	142.740	237.108	0.019	237.127	379.867
226	horim226	42.5833	140.125	125	125	58	1	1	10	100	18	1.6386	0.0131	0.000	379.867	0.000	379.867	379.867
227	horim227	42.5833	140.375	111	111	14	0	0	5	100	9	0.3924	0.0035	62.079	317.788	0.000	317.788	379.867
228	horim228	42.5833	140.625	55	55	10	0	0	2	53	3	0.1387	0.0025	176.560	203.303	0.005	203.307	379.867
229	horim229	42.5833	140.875	95	95	6	0	0	2	90	3	0.2414	0.0025	12.937	366.918	0.012	366.930	379.867
230	horim230	42.5833	141.125	77	77	26	0	0	6	61	8	0.4271	0.0055	0.000	379.867	0.000	379.867	379.867
231	horim231	42.5833	141.375	52	52	23	0	1	1	49	2	0.2157	0.0041	109.731	270.136	0.000	270.136	379.867
232	horim232	42.5833	141.625	40	40	7	0	0	1	39	0	0.1467	0.0037	278.334	101.518	0.014	101.533	379.867
233	horim233	42.5833	141.875	33	33	NA	0	0	0	33	0	0.1382	0.0042	172.912	206.952	0.002	206.955	379.867

234	horim234	42.5833	142.125	32	32	NA	0	0	1	30	0	0.0985	0.0031	0.473	379.394	0.000	379.394	379.867
235	horim235	42.5833	142.375	26	26	NA	0	0	0	26	1	0.0628	0.0024	0.000	379.867	0.000	379.867	379.867
236	horim236	42.5833	142.625	70	70	4	0	0	1	65	4	0.1851	0.0026	0.000	379.867	0.000	379.867	379.867
237	horim237	42.5833	142.875	8	8	NA	0	0	0	8	0	0.2245	0.0281	0.000	379.867	0.000	379.867	379.867
238	horim238	42.5833	143.125	22	22	NA	0	0	1	21	0	0.0626	0.0028	0.000	379.867	0.000	379.867	379.867
239	horim239	42.5833	143.375	27	27	NA	0	0	1	26	0	0.0616	0.0023	7.252	372.615	0.000	372.615	379.867
240	horim240	42.5833	143.625	7	7	NA	0	0	1	6	0	0.0273	0.0039	306.246	73.621	0.000	73.621	379.867
241	horim241	42.4167	139.875	81	81	11	0	0	3	77	5	0.2416	0.0030	126.095	254.733	0.038	254.771	380.866
242	horim242	42.4167	140.125	75	75	22	0	0	5	62	7	0.2325	0.0031	0.000	380.866	0.000	380.866	380.866
243	horim243	42.4167	140.375	62	62	19	0	0	4	57	3	0.1722	0.0028	270.290	110.576	0.000	110.576	380.866
244	horim244	42.4167	140.875	42	42	7	0	0	1	41	2	0.1108	0.0026	223.184	157.649	0.033	157.682	380.866
245	horim245	42.4167	141.125	64	64	29	0	1	3	58	3	0.2693	0.0042	165.063	215.774	0.029	215.803	380.866
246	horim246	42.4167	141.375	7	7	NA	0	0	0	7	0	0.0243	0.0035	377.309	3.557	0.000	3.557	380.866
247	horim247	42.4167	142.125	29	29	NA	0	0	0	28	0	0.1327	0.0046	291.330	89.531	0.005	89.536	380.866
248	horim248	42.4167	142.375	48	48	6	0	0	1	46	1	0.1178	0.0025	30.122	350.744	0.000	350.744	380.866
249	horim249	42.4167	142.625	18	18	NA	0	0	2	15	2	0.0542	0.0030	0.000	380.866	0.000	380.866	380.866
250	horim250	42.4167	142.875	119	119	19	0	0	7	99	10	0.8155	0.0069	0.000	380.866	0.000	380.866	380.866
251	horim251	42.4167	143.125	4	4	NA	0	0	0	4	0	0.0108	0.0027	0.000	380.866	0.000	380.866	380.866
252	horim252	42.4167	143.375	28	28	NA	0	0	1	27	0	0.0712	0.0025	156.272	224.594	0.000	224.594	380.866
253	horim253	42.2500	139.375	34	34	NA	0	0	4	24	8	0.1099	0.0032	346.946	0.000	34.916	34.916	381.862
254	horim254	42.2500	139.625	78	78	12	0	0	3	69	6	0.2402	0.0031	356.632	0.000	25.230	25.230	381.862
255	horim255	42.2500	139.875	124	124	20	0	0	8	107	14	0.5231	0.0042	101.828	280.022	0.012	280.034	381.862
256	horim256	42.2500	140.125	69	69	19	0	0	4	58	7	0.2807	0.0041	0.000	381.862	0.000	381.862	381.862
257	horim257	42.2500	140.375	50	50	6	0	0	1	49	3	0.1249	0.0025	252.024	129.838	0.000	129.838	381.862
258	horim258	42.2500	140.875	82	82	7	0	0	2	78	4	0.3197	0.0039	370.378	11.474	0.010	11.484	381.862
259	horim259	42.2500	141.125	4	4	NA	0	1	0	3	1	0.0844	0.0211	376.534	5.326	0.002	5.328	381.862
260	horim260	42.2500	142.375	20	20	NA	0	0	0	20	0	0.0684	0.0034	339.919	41.919	0.024	41.943	381.862
261	horim261	42.2500	142.625	54	54	11	0	0	2	51	2	0.1393	0.0026	120.185	261.670	0.007	261.677	381.862
262	horim262	42.2500	142.875	86	86	10	0	0	3	81	3	0.2329	0.0027	1.068	380.794	0.000	380.794	381.862
263	horim263	42.2500	143.125	133	133	17	0	0	7	112	9	0.9824	0.0074	0.000	381.862	0.000	381.862	381.862
264	horim264	42.2500	143.375	57	57	21	0	0	4	52	2	0.2318	0.0041	264.804	117.018	0.041	117.058	381.862
265	horim265	42.0833	139.375	39	39	NA	0	0	1	33	6	0.1107	0.0028	312.596	0.000	70.259	70.259	382.854
266	horim266	42.0833	139.625	15	15	NA	0	0	2	9	3	0.0538	0.0036	370.548	0.000	12.306	12.306	382.854
267	horim267	42.0833	139.875	32	32	NA	0	0	1	31	1	0.0680	0.0021	352.642	30.175	0.038	30.213	382.854
268	horim268	42.0833	140.125	28	28	NA	0	0	2	26	4	0.0580	0.0021	79.492	303.357	0.005	303.362	382.854
269	horim269	42.0833	140.375	116	116	25	0	0	9	99	16	0.4121	0.0036	3.814	379.040	0.000	379.040	382.854
270	horim270	42.0833	140.625	93	93	13	0	0	4	85	9	0.3709	0.0040	106.790	276.060	0.005	276.064	382.854
271	horim271	42.0833	140.875	20	20	NA	0	0	0	20	2	0.0455	0.0023	319.947	62.908	0.000	62.908	382.854
272	horim272	42.0833	142.875	101	101	9	0	0	3	93	6	0.4011	0.0040	305.843	77.000	0.012	77.012	382.854
273	horim273	42.0833	143.125	163	163	37	1	0	10	140	14	1.0990	0.0067	76.504	306.351	0.000	306.351	382.854

274	horim274	42.0833	143.375	65	65	9	0	0	2	62	3	0.3745	0.0058	290.184	92.671	0.000	92.671	382.854
275	horim275	41.9167	140.125	104	104	24	0	0	8	91	14	0.2658	0.0026	206.779	177.058	0.007	177.065	383.844
276	horim276	41.9167	140.375	48	48	12	0	0	2	45	5	0.1015	0.0021	0.000	383.844	0.000	383.844	383.844
277	horim277	41.9167	140.625	132	132	17	0	0	7	115	16	0.4347	0.0033	0.000	383.844	0.000	383.844	383.844
278	horim278	41.9167	140.875	133	133	19	0	0	8	116	15	0.5442	0.0041	60.514	323.327	0.002	323.329	383.844
279	horim279	41.9167	141.125	5	5	NA	0	0	1	4	1	0.0095	0.0019	319.780	64.061	0.002	64.063	383.844
280	horim280	41.9167	143.125	78	78	12	0	0	3	71	4	0.3627	0.0046	347.921	35.922	0.000	35.922	383.844
281	horim281	41.9167	143.375	13	13	NA	0	0	1	12	1	0.0729	0.0056	382.149	1.689	0.005	1.694	383.844
282	horim282	41.7500	140.125	121	121	10	0	0	4	108	12	0.3371	0.0028	95.039	289.788	0.002	289.791	384.830
283	horim283	41.7500	140.375	111	111	20	0	0	7	95	15	0.2986	0.0027	13.666	371.163	0.000	371.163	384.830
284	horim284	41.7500	140.625	157	157	15	0	0	8	143	14	0.5586	0.0036	218.315	166.510	0.005	166.514	384.830
285	horim285	41.7500	140.875	101	101	12	0	0	4	96	8	0.3408	0.0034	185.203	199.624	0.002	199.626	384.830
286	horim286	41.7500	141.125	98	98	25	0	0	8	85	13	0.4106	0.0042	255.537	129.264	0.029	129.293	384.830
287	horim287	41.5833	139.375	8	8	NA	0	0	0	8	0	0.0181	0.0023	377.276	0.000	8.536	8.536	385.812
288	horim288	41.5833	139.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	376.975	8.767	0.070	8.837	385.812
289	horim289	41.5833	140.125	110	110	30	0	0	10	88	19	0.4460	0.0041	4.453	381.354	0.005	381.359	385.812
290	horim290	41.5833	140.375	107	107	24	0	0	8	89	16	0.2816	0.0026	113.239	272.571	0.002	272.573	385.812
291	horim291	41.5833	140.875	102	102	24	0	1	5	93	9	0.8082	0.0079	370.347	15.345	0.121	15.465	385.812
292	horim292	41.4167	139.375	3	3	NA	0	0	0	3	0	0.0068	0.0023	385.618	0.000	1.173	1.173	386.791
293	horim293	41.4167	139.875	1	1	NA	0	1	0	0	1	0.5000	0.5000	385.214	0.000	1.578	1.578	386.791
294	horim294	41.4167	140.125	131	131	19	0	0	8	116	13	0.4346	0.0033	230.031	156.662	0.099	156.761	386.791
295	horim295	41.4167	140.375	77	77	20	0	0	5	69	10	0.1579	0.0021	375.256	11.531	0.005	11.535	386.791
296	horim296	41.4167	140.875	88	88	14	0	0	4	81	7	0.2035	0.0023	168.175	218.597	0.019	218.616	386.791
297	horim297	41.4167	141.125	155	155	26	0	0	13	132	22	0.4821	0.0031	149.853	236.934	0.005	236.939	386.791
298	horim298	41.4167	141.375	64	64	14	0	0	3	61	4	0.2124	0.0033	319.901	66.864	0.027	66.890	386.791
299	horim299	41.2500	140.375	49	49	12	0	0	2	47	2	0.2065	0.0042	315.317	72.360	0.090	72.450	387.767
300	horim300	41.2500	140.625	88	88	13	0	0	4	82	7	0.2069	0.0024	331.822	55.936	0.010	55.945	387.767
301	horim301	41.2500	140.875	30	30	NA	0	0	4	26	7	0.1026	0.0034	74.024	313.743	0.000	313.743	387.767
302	horim302	41.2500	141.125	145	145	29	0	0	13	121	22	0.4958	0.0034	135.097	252.617	0.053	252.670	387.767
303	horim303	41.2500	141.375	52	52	11	0	0	2	49	4	0.1619	0.0031	140.882	246.885	0.000	246.885	387.767
304	horim304	41.0833	140.375	41	41	21	0	0	3	38	11	0.0909	0.0022	102.448	286.214	0.078	286.292	388.740
305	horim305	41.0833	140.625	148	148	16	0	0	8	134	16	0.4416	0.0030	166.587	222.152	0.000	222.152	388.740
306	horim306	41.0833	140.875	70	70	12	0	0	3	67	6	0.2157	0.0031	361.166	27.328	0.246	27.574	388.740
307	horim307	41.0833	141.125	15	15	NA	0	0	0	14	0	0.0295	0.0020	383.585	5.155	0.000	5.155	388.740
308	horim308	41.0833	141.375	54	54	22	0	0	4	50	5	0.1764	0.0033	177.088	211.651	0.000	211.651	388.740
309	horim309	40.9167	140.375	57	57	26	0	0	5	51	8	0.1494	0.0026	83.663	306.046	0.000	306.046	389.709
310	horim310	40.9167	140.625	148	148	32	0	1	12	124	22	0.4665	0.0032	113.793	275.916	0.000	275.916	389.709
311	horim311	40.9167	140.875	124	124	32	0	2	7	112	14	0.4222	0.0034	189.370	200.079	0.261	200.339	389.709
312	horim312	40.9167	141.125	57	57	16	0	0	3	51	4	0.1612	0.0028	206.424	183.285	0.000	183.285	389.709
313	horim313	40.9167	141.375	8	8	NA	0	0	1	7	2	0.0107	0.0013	164.445	225.171	0.093	225.264	389.709

314	horim314	40.7500	139.875	77	77	16	0	0	4	71	4	0.1843	0.0024	377.497	13.117	0.061	13.178	390.675
315	horim315	40.7500	140.125	82	82	14	0	0	4	78	6	0.1720	0.0021	172.327	218.273	0.076	218.348	390.675
316	horim316	40.7500	140.375	44	44	20	0	0	3	41	3	0.0805	0.0018	5.113	385.562	0.000	385.562	390.675
317	horim317	40.7500	140.625	76	76	24	0	0	6	68	10	0.1572	0.0021	0.607	390.068	0.000	390.068	390.675
318	horim318	40.7500	140.875	121	121	60	0	2	16	92	24	0.5152	0.0043	1.414	389.260	0.000	389.260	390.675
319	horim319	40.7500	141.125	45	45	20	0	0	3	40	5	0.0830	0.0018	0.000	390.675	0.000	390.675	390.675
320	horim320	40.7500	141.375	28	28	NA	0	0	3	25	4	0.0696	0.0025	125.146	265.529	0.000	265.529	390.675
321	horim321	40.5833	139.625	2	2	NA	0	0	0	2	0	0.0114	0.0057	391.635	0.000	0.002	0.002	391.637
322	horim322	40.5833	139.875	166	166	17	0	0	9	148	18	0.4808	0.0029	263.822	127.730	0.086	127.816	391.637
323	horim323	40.5833	140.125	143	143	43	0	2	13	116	25	0.5162	0.0036	0.000	391.637	0.000	391.637	391.637
324	horim324	40.5833	140.375	46	46	46	0	0	6	33	9	0.2143	0.0047	0.000	391.637	0.000	391.637	391.637
325	horim325	40.5833	140.625	76	76	29	0	0	7	65	10	0.1553	0.0020	0.000	391.637	0.000	391.637	391.637
326	horim326	40.5833	140.875	187	187	61	1	2	20	147	32	0.9991	0.0053	0.000	391.637	0.000	391.637	391.637
327	horim327	40.5833	141.125	8	8	NA	0	0	1	7	1	0.0124	0.0015	0.000	391.637	0.000	391.637	391.637
328	horim328	40.5833	141.375	26	26	NA	0	0	1	25	0	0.0520	0.0020	36.931	354.706	0.000	354.706	391.637
329	horim329	40.5833	141.625	123	123	4	0	0	2	119	4	0.3338	0.0027	358.272	32.922	0.443	33.366	391.637
330	horim330	40.4167	139.875	103	103	12	0	0	4	93	8	0.2628	0.0026	341.181	51.388	0.027	51.415	392.596
331	horim331	40.4167	140.125	132	132	43	0	2	12	109	24	0.4682	0.0035	9.144	383.440	0.012	383.452	392.596
332	horim332	40.4167	140.375	106	106	51	0	1	15	89	27	0.3963	0.0037	0.000	392.596	0.000	392.596	392.596
333	horim333	40.4167	140.625	136	136	21	0	0	9	117	18	0.3657	0.0027	0.000	392.596	0.000	392.596	392.596
334	horim334	40.4167	140.875	122	122	44	0	1	14	99	24	0.3681	0.0030	0.000	392.596	0.000	392.596	392.596
335	horim335	40.4167	141.125	8	8	NA	0	0	1	7	1	0.0124	0.0015	0.000	392.596	0.000	392.596	392.596
336	horim336	40.4167	141.375	30	30	NA	0	0	2	26	3	0.0488	0.0016	0.000	392.596	0.000	392.596	392.596
337	horim337	40.4167	141.625	130	130	16	0	1	4	123	6	0.4012	0.0031	72.014	320.575	0.007	320.583	392.596
338	horim338	40.4167	141.875	12	12	NA	0	0	2	10	2	0.0654	0.0055	387.524	5.070	0.002	5.072	392.596
339	horim339	40.2500	139.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	391.105	2.437	0.010	2.447	393.552
340	horim340	40.2500	140.125	69	69	30	0	0	7	62	12	0.1702	0.0025	22.940	370.612	0.000	370.612	393.552
341	horim341	40.2500	140.375	91	91	32	0	0	10	81	15	0.1923	0.0021	0.000	393.552	0.000	393.552	393.552
342	horim342	40.2500	140.625	72	72	20	0	0	5	67	14	0.1463	0.0020	0.000	393.552	0.000	393.552	393.552
343	horim343	40.2500	140.875	142	142	38	0	1	14	117	24	0.4198	0.0030	0.000	393.552	0.000	393.552	393.552
344	horim344	40.2500	141.125	43	43	34	0	0	5	38	6	0.1012	0.0024	0.000	393.552	0.000	393.552	393.552
345	horim345	40.2500	141.375	63	63	14	0	0	3	60	5	0.1535	0.0024	0.000	393.552	0.000	393.552	393.552
346	horim346	40.2500	141.625	90	90	16	0	0	5	85	9	0.2252	0.0025	0.000	393.552	0.000	393.552	393.552
347	horim347	40.2500	141.875	103	103	32	0	1	8	94	13	0.3270	0.0032	297.714	95.740	0.098	95.838	393.552
348	horim348	40.0833	139.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	394.263	0.175	0.067	0.242	394.505
349	horim349	40.0833	139.875	5	5	NA	0	0	1	4	1	0.0126	0.0025	318.329	76.175	0.000	76.175	394.505
350	horim350	40.0833	140.125	71	71	29	0	0	7	64	15	0.1458	0.0021	0.000	394.505	0.000	394.505	394.505
351	horim351	40.0833	140.375	60	60	50	0	1	7	52	14	0.1453	0.0024	0.000	394.505	0.000	394.505	394.505
352	horim352	40.0833	140.625	41	41	73	0	1	7	33	16	0.1231	0.0030	0.000	394.505	0.000	394.505	394.505
353	horim353	40.0833	140.875	76	76	36	0	0	9	64	15	0.2200	0.0029	0.000	394.505	0.000	394.505	394.505

354	horim354	40.0833	141.125	65	65	18	0	0	4	61	5	0.1661	0.0026	0.000	394.505	0.000	394.505	394.505
355	horim355	40.0833	141.375	66	66	13	0	0	3	62	6	0.1647	0.0025	0.000	394.505	0.000	394.505	394.505
356	horim356	40.0833	141.625	172	172	24	0	0	13	148	21	0.5986	0.0035	0.000	394.505	0.000	394.505	394.505
357	horim357	40.0833	141.875	58	58	52	0	1	7	49	13	0.3263	0.0056	214.665	179.810	0.030	179.839	394.505
358	horim358	39.9167	139.625	28	28	NA	0	0	0	28	0	0.1258	0.0045	361.586	33.776	0.091	33.868	395.453
359	horim359	39.9167	139.875	100	100	12	0	0	4	95	8	0.2529	0.0025	142.622	252.824	0.007	252.831	395.453
360	horim360	39.9167	140.125	43	43	14	0	0	2	40	5	0.0959	0.0022	1.816	393.637	0.000	393.637	395.453
361	horim361	39.9167	140.375	61	61	25	0	0	5	55	12	0.1511	0.0025	0.000	395.453	0.000	395.453	395.453
362	horim362	39.9167	140.625	148	148	85	1	3	22	114	36	0.7455	0.0050	0.000	395.453	0.000	395.453	395.453
363	horim363	39.9167	140.875	188	188	67	1	2	25	149	37	1.0666	0.0057	0.000	395.453	0.000	395.453	395.453
364	horim364	39.9167	141.125	186	186	58	1	2	19	153	31	0.9250	0.0050	0.000	395.453	0.000	395.453	395.453
365	horim365	39.9167	141.375	32	32	NA	0	0	4	26	6	0.0928	0.0029	0.000	395.453	0.000	395.453	395.453
366	horim366	39.9167	141.625	144	144	27	0	1	10	132	18	0.3742	0.0026	0.000	395.453	0.000	395.453	395.453
367	horim367	39.9167	141.875	166	166	43	0	3	15	146	25	0.6675	0.0040	60.961	334.453	0.040	334.492	395.453
368	horim368	39.7500	140.125	123	123	33	0	2	7	109	13	0.3439	0.0028	78.303	317.945	0.151	318.096	396.399
369	horim369	39.7500	140.375	73	73	104	0	3	16	53	27	0.3610	0.0049	0.000	396.399	0.000	396.399	396.399
370	horim370	39.7500	140.625	101	101	56	1	0	9	85	16	0.3108	0.0031	0.000	396.399	0.000	396.399	396.399
371	horim371	39.7500	140.875	205	205	72	1	3	28	159	44	1.0712	0.0052	0.000	396.399	0.000	396.399	396.399
372	horim372	39.7500	141.125	170	170	25	0	0	14	151	21	0.4477	0.0026	0.000	396.399	0.000	396.399	396.399
373	horim373	39.7500	141.375	142	142	30	0	0	14	123	19	0.4070	0.0029	0.000	396.399	0.000	396.399	396.399
374	horim374	39.7500	141.625	73	73	25	0	0	6	66	10	0.1800	0.0025	0.000	396.399	0.000	396.399	396.399
375	horim375	39.7500	141.875	89	89	44	0	1	10	77	17	0.3179	0.0036	18.465	377.772	0.161	377.934	396.399
376	horim376	39.7500	142.125	1	1	NA	0	0	0	1	0	0.0036	0.0036	395.918	0.478	0.002	0.481	396.399
377	horim377	39.5833	140.125	44	44	20	0	0	3	41	4	0.0993	0.0023	95.433	301.908	0.000	301.908	397.341
378	horim378	39.5833	140.375	51	51	23	0	0	4	47	8	0.0984	0.0019	0.000	397.341	0.000	397.341	397.341
379	horim379	39.5833	140.625	78	78	32	0	0	8	67	12	0.1731	0.0022	0.000	397.341	0.000	397.341	397.341
380	horim380	39.5833	140.875	45	45	75	0	1	8	35	15	0.1343	0.0030	0.000	397.341	0.000	397.341	397.341
381	horim381	39.5833	141.125	104	104	47	0	1	13	87	19	0.3356	0.0032	0.000	397.341	0.000	397.341	397.341
382	horim382	39.5833	141.375	190	190	88	3	0	24	145	33	5.0109	0.0264	0.000	397.341	0.000	397.341	397.341
383	horim383	39.5833	141.625	127	127	27	0	0	11	108	15	0.3819	0.0030	0.000	397.341	0.000	397.341	397.341
384	horim384	39.5833	141.875	168	168	37	0	2	15	150	23	0.5628	0.0033	16.611	380.678	0.052	380.730	397.341
385	horim385	39.5833	142.125	67	67	63	0	1	11	54	15	0.2799	0.0042	337.665	59.580	0.097	59.677	397.341
386	horim386	39.4167	139.875	1	1	NA	0	0	0	1	0	0.0015	0.0015	398.155	0.125	0.000	0.125	398.280
387	horim387	39.4167	140.125	61	61	20	0	0	4	56	5	0.1274	0.0021	42.006	356.274	0.000	356.274	398.280
388	horim388	39.4167	140.375	29	29	NA	0	0	4	25	6	0.0540	0.0019	0.000	398.280	0.000	398.280	398.280
389	horim389	39.4167	140.625	51	51	48	0	1	5	43	9	0.1470	0.0029	0.000	398.280	0.000	398.280	398.280
390	horim390	39.4167	140.875	24	24	NA	0	0	6	18	6	0.0779	0.0032	0.000	398.280	0.000	398.280	398.280
391	horim391	39.4167	141.125	68	68	27	0	0	6	60	9	0.1580	0.0023	0.000	398.280	0.000	398.280	398.280
392	horim392	39.4167	141.375	46	46	13	0	0	2	43	3	0.0863	0.0019	0.000	398.280	0.000	398.280	398.280
393	horim393	39.4167	141.625	99	99	42	0	1	10	81	16	0.2652	0.0027	0.000	398.280	0.000	398.280	398.280

394	horim394	39.4167	141.875	192	192	32	0	1	17	169	25	0.5671	0.0030	49.705	348.321	0.254	348.575	398.280
395	horim395	39.4167	142.125	123	123	39	0	1	13	107	20	0.3425	0.0028	368.853	29.195	0.232	29.426	398.280
396	horim396	39.2500	139.625	99	99	12	0	1	1	94	4	0.2785	0.0028	396.256	0.000	2.959	2.959	399.215
397	horim397	39.2500	139.875	55	55	16	0	0	3	52	4	0.1604	0.0029	288.808	110.392	0.015	110.407	399.215
398	horim398	39.2500	140.125	37	37	NA	0	1	3	33	6	0.1173	0.0032	0.000	399.215	0.000	399.215	399.215
399	horim399	39.2500	140.375	15	15	NA	0	0	2	13	3	0.0258	0.0017	0.000	399.215	0.000	399.215	399.215
400	horim400	39.2500	140.625	73	73	16	0	0	4	68	6	0.1385	0.0019	0.000	399.215	0.000	399.215	399.215
401	horim401	39.2500	140.875	116	116	100	1	2	20	82	31	0.6124	0.0053	0.000	399.215	0.000	399.215	399.215
402	horim402	39.2500	141.125	101	101	27	0	0	9	91	14	0.2912	0.0029	0.000	399.215	0.000	399.215	399.215
403	horim403	39.2500	141.375	98	98	18	0	0	6	92	13	0.2272	0.0023	0.000	399.215	0.000	399.215	399.215
404	horim404	39.2500	141.625	175	175	39	0	1	20	152	30	0.5862	0.0033	0.000	399.215	0.000	399.215	399.215
405	horim405	39.2500	141.875	186	186	35	0	2	16	167	23	0.5761	0.0031	121.172	277.551	0.491	278.043	399.215
406	horim406	39.0833	139.875	141	141	64	1	1	17	115	27	0.5655	0.0040	200.928	199.219	0.000	199.219	400.147
407	horim407	39.0833	140.125	105	105	163	3	2	17	70	28	2.0920	0.0199	0.000	400.147	0.000	400.147	400.147
408	horim408	39.0833	140.375	64	64	24	0	0	5	57	7	0.1396	0.0022	0.000	400.147	0.000	400.147	400.147
409	horim409	39.0833	140.625	109	109	45	0	1	13	92	21	0.2754	0.0025	0.000	400.147	0.000	400.147	400.147
410	horim410	39.0833	140.875	158	158	80	1	2	25	122	39	0.8404	0.0053	0.000	400.147	0.000	400.147	400.147
411	horim411	39.0833	141.125	119	119	37	0	1	12	106	23	0.2824	0.0024	0.000	400.147	0.000	400.147	400.147
412	horim412	39.0833	141.375	51	51	23	0	0	4	47	7	0.1147	0.0022	0.000	400.147	0.000	400.147	400.147
413	horim413	39.0833	141.625	121	121	34	0	2	8	111	15	0.3835	0.0032	10.509	389.552	0.085	389.637	400.147
414	horim414	39.0833	141.875	83	83	32	0	1	6	76	11	0.2413	0.0029	250.040	150.072	0.035	150.107	400.147
415	horim415	38.9167	139.875	59	59	10	0	0	2	57	6	0.1408	0.0024	101.452	299.395	0.228	299.623	401.075
416	horim416	38.9167	140.125	17	17	NA	0	0	2	15	3	0.0357	0.0021	0.000	401.075	0.000	401.075	401.075
417	horim417	38.9167	140.375	72	72	29	0	0	7	64	14	0.2088	0.0029	0.000	401.075	0.000	401.075	401.075
418	horim418	38.9167	140.625	103	103	96	1	2	16	77	26	0.5081	0.0049	0.000	401.075	0.000	401.075	401.075
419	horim419	38.9167	140.875	165	165	82	1	3	24	124	38	0.8706	0.0053	0.000	401.075	0.000	401.075	401.075
420	horim420	38.9167	141.125	77	77	32	0	0	8	65	12	0.1682	0.0022	0.000	401.075	0.000	401.075	401.075
421	horim421	38.9167	141.375	99	99	35	0	0	11	81	17	0.2673	0.0027	0.000	401.075	0.000	401.075	401.075
422	horim422	38.9167	141.625	144	144	31	0	1	12	131	19	0.3884	0.0027	160.624	231.274	9.177	240.451	401.075
423	horim423	38.7500	139.625	50	50	12	0	0	2	48	3	0.0935	0.0019	333.062	68.873	0.065	68.938	402.000
424	horim424	38.7500	139.875	86	86	31	0	1	5	70	8	0.2273	0.0026	10.051	391.949	0.000	391.949	402.000
425	horim425	38.7500	140.125	25	25	NA	0	0	5	20	6	0.0468	0.0019	0.000	402.000	0.000	402.000	402.000
426	horim426	38.7500	140.375	65	65	18	0	0	4	60	10	0.1371	0.0021	0.000	402.000	0.000	402.000	402.000
427	horim427	38.7500	140.625	146	146	63	0	2	23	112	37	0.4800	0.0033	0.000	402.000	0.000	402.000	402.000
428	horim428	38.7500	140.875	47	47	38	0	0	6	41	6	0.0862	0.0018	0.000	402.000	0.000	402.000	402.000
429	horim429	38.7500	141.125	35	35	NA	0	0	1	34	2	0.0574	0.0016	0.000	402.000	0.000	402.000	402.000
430	horim430	38.7500	141.375	44	44	34	0	0	5	39	8	0.0842	0.0019	3.023	398.975	0.003	398.977	402.000
431	horim431	38.7500	141.625	50	50	54	0	1	6	43	10	0.2475	0.0049	332.383	69.289	0.329	69.618	402.000
432	horim432	38.5833	139.625	137	137	25	0	1	8	119	16	0.3485	0.0025	109.974	292.908	0.040	292.948	402.922
433	horim433	38.5833	139.875	153	153	76	1	4	16	124	30	0.6526	0.0043	0.000	402.922	0.000	402.922	402.922

434	horim434	38.5833	140.125	143	143	100	1	4	24	106	39	0.9335	0.0065	0.000	402.922	0.000	402.922	402.922
435	horim435	38.5833	140.375	85	85	21	0	0	6	79	12	0.2157	0.0025	0.000	402.922	0.000	402.922	402.922
436	horim436	38.5833	140.625	59	59	50	0	0	10	49	15	0.2114	0.0036	0.000	402.922	0.000	402.922	402.922
437	horim437	38.5833	140.875	31	31	NA	0	0	6	25	8	0.0589	0.0019	0.000	402.922	0.000	402.922	402.922
438	horim438	38.5833	141.125	25	25	NA	0	0	0	25	1	0.0488	0.0020	0.000	402.922	0.000	402.922	402.922
439	horim439	38.5833	141.375	127	127	37	0	1	13	113	20	0.3359	0.0026	24.956	377.744	0.221	377.966	402.922
440	horim440	38.5833	141.625	92	92	39	0	0	12	80	16	0.1989	0.0022	377.936	24.625	0.360	24.986	402.922
441	horim441	38.4167	138.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	403.832	0.000	0.008	0.008	403.840
442	horim442	38.4167	139.125	50	50	6	0	0	1	49	4	0.0946	0.0019	397.140	0.000	6.700	6.700	403.840
443	horim443	38.4167	139.375	42	42	14	0	0	2	40	3	0.0792	0.0019	363.203	37.270	3.367	40.637	403.840
444	horim444	38.4167	139.625	41	41	7	0	0	1	40	3	0.0775	0.0019	4.912	398.920	0.008	398.928	403.840
445	horim445	38.4167	139.875	156	156	82	1	4	18	118	34	0.8385	0.0054	0.000	403.840	0.000	403.840	403.840
446	horim446	38.4167	140.125	141	141	36	0	1	14	123	23	0.3543	0.0025	0.000	403.840	0.000	403.840	403.840
447	horim447	38.4167	140.375	137	137	46	0	1	18	116	29	0.4496	0.0033	0.000	403.840	0.000	403.840	403.840
448	horim448	38.4167	140.625	124	124	106	1	4	22	94	36	0.7044	0.0057	0.000	403.840	0.000	403.840	403.840
449	horim449	38.4167	140.875	33	33	NA	0	0	7	26	7	0.0660	0.0020	0.000	403.840	0.000	403.840	403.840
450	horim450	38.4167	141.125	158	158	22	0	1	9	147	18	0.4145	0.0026	73.085	328.746	2.008	330.755	403.840
451	horim451	38.4167	141.375	118	118	22	0	0	9	109	14	0.2594	0.0022	140.893	262.558	0.389	262.947	403.840
452	horim452	38.4167	141.625	86	86	31	0	0	9	77	12	0.1791	0.0021	381.168	18.614	4.058	22.672	403.840
453	horim453	38.2500	138.375	131	131	16	0	0	7	121	11	0.3270	0.0025	260.880	0.000	143.875	143.875	404.754
454	horim454	38.2500	138.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	392.641	0.000	12.113	12.113	404.754
455	horim455	38.2500	139.375	48	48	12	0	0	2	46	3	0.0803	0.0017	316.637	88.108	0.010	88.118	404.754
456	horim456	38.2500	139.625	72	72	66	0	1	12	55	20	0.1913	0.0027	0.000	404.754	0.000	404.754	404.754
457	horim457	38.2500	139.875	160	160	88	1	4	21	117	37	0.9587	0.0060	0.000	404.754	0.000	404.754	404.754
458	horim458	38.2500	140.125	112	112	50	0	2	12	93	22	0.3087	0.0028	0.000	404.754	0.000	404.754	404.754
459	horim459	38.2500	140.375	203	203	53	1	1	22	166	35	0.7138	0.0035	0.000	404.754	0.000	404.754	404.754
460	horim460	38.2500	140.625	142	142	48	0	1	19	115	29	0.4008	0.0028	0.000	404.754	0.000	404.754	404.754
461	horim461	38.2500	140.875	176	176	32	0	1	15	152	24	0.4597	0.0026	12.629	392.126	0.000	392.126	404.754
462	horim462	38.2500	141.125	107	107	36	0	1	10	95	17	0.3036	0.0028	352.770	50.316	1.668	51.984	404.754
463	horim463	38.2500	141.375	55	55	27	0	0	5	50	5	0.1079	0.0020	385.014	9.551	10.189	19.740	404.754
464	horim464	38.2500	141.625	149	149	35	0	1	14	130	21	0.4255	0.0029	375.571	18.448	10.736	29.183	404.754
465	horim465	38.0833	138.125	54	54	5	0	0	1	51	1	0.1105	0.0020	396.078	0.000	9.588	9.588	405.666
466	horim466	38.0833	138.375	178	178	17	0	0	10	160	19	0.4212	0.0024	79.979	0.000	325.687	325.687	405.666
467	horim467	38.0833	138.625	102	102	6	0	0	2	98	5	0.2089	0.0020	360.025	0.000	45.641	45.641	405.666
468	horim468	38.0833	139.125	3	3	NA	0	0	0	3	1	0.0064	0.0021	405.374	0.292	0.000	0.292	405.666
469	horim469	38.0833	139.375	57	57	36	0	0	7	50	10	0.1034	0.0018	162.270	243.396	0.000	243.396	405.666
470	horim470	38.0833	139.625	157	157	39	0	1	17	135	25	0.4041	0.0026	0.000	405.666	0.000	405.666	405.666
471	horim471	38.0833	139.875	107	107	36	0	0	13	93	17	0.2578	0.0024	0.000	405.666	0.000	405.666	405.666
472	horim472	38.0833	140.125	57	57	26	0	0	5	52	7	0.1237	0.0022	0.000	405.666	0.000	405.666	405.666
473	horim473	38.0833	140.375	148	148	86	1	2	24	108	36	0.7226	0.0049	0.000	405.666	0.000	405.666	405.666

474	horim474	38.0833	140.625	50	50	67	0	1	8	40	12	0.1417	0.0028	0.000	405.666	0.000	405.666	405.666
475	horim475	38.0833	140.875	134	134	29	0	0	13	119	17	0.3029	0.0023	105.455	300.193	0.018	300.211	405.666
476	horim476	37.9167	136.875	49	49	6	0	0	1	48	1	0.1136	0.0023	406.021	0.000	0.552	0.552	406.573
477	horim477	37.9167	138.125	21	21	NA	0	0	1	20	1	0.0404	0.0019	401.695	0.000	4.878	4.878	406.573
478	horim478	37.9167	138.375	151	151	16	0	0	8	137	15	0.3325	0.0022	135.674	0.000	270.900	270.900	406.573
479	horim479	37.9167	138.625	86	86	7	0	0	2	79	5	0.1716	0.0020	391.498	0.000	15.075	15.075	406.573
480	horim480	37.9167	138.875	8	8	NA	0	0	1	7	1	0.0109	0.0014	360.451	46.122	0.000	46.122	406.573
481	horim481	37.9167	139.125	42	42	7	0	0	1	41	3	0.0859	0.0020	105.546	300.989	0.038	301.027	406.573
482	horim482	37.9167	139.375	50	50	30	0	0	5	44	10	0.1141	0.0023	0.000	406.573	0.000	406.573	406.573
483	horim483	37.9167	139.625	160	160	72	0	4	23	118	36	0.8435	0.0053	0.000	406.573	0.000	406.573	406.573
484	horim484	37.9167	139.875	44	44	69	0	1	7	35	13	0.1248	0.0028	0.000	406.573	0.000	406.573	406.573
485	horim485	37.9167	140.125	65	65	32	0	0	7	58	10	0.1619	0.0025	0.000	406.573	0.000	406.573	406.573
486	horim486	37.9167	140.375	59	59	76	0	1	12	46	18	0.1640	0.0028	0.000	406.573	0.000	406.573	406.573
487	horim487	37.9167	140.625	54	54	33	0	0	6	48	9	0.1074	0.0020	0.000	406.573	0.000	406.573	406.573
488	horim488	37.9167	140.875	123	123	34	0	0	14	108	17	0.2637	0.0021	112.914	293.654	0.005	293.659	406.573
489	horim489	37.7500	138.125	31	31	NA	0	0	0	30	0	0.0611	0.0020	397.348	0.000	10.129	10.129	407.477
490	horim490	37.7500	138.375	77	77	3	0	0	1	76	4	0.1415	0.0018	389.299	0.000	18.179	18.179	407.477
491	horim491	37.7500	138.875	131	131	22	0	0	10	121	15	0.2918	0.0022	97.979	309.498	0.000	309.498	407.477
492	horim492	37.7500	139.125	106	106	20	0	0	7	94	13	0.2134	0.0020	0.000	407.477	0.000	407.477	407.477
493	horim493	37.7500	139.375	103	103	53	0	1	14	80	22	0.2518	0.0024	0.000	407.477	0.000	407.477	407.477
494	horim494	37.7500	139.625	112	112	115	0	6	19	71	31	0.6723	0.0060	0.000	407.477	0.000	407.477	407.477
495	horim495	37.7500	139.875	159	159	54	0	3	18	127	30	0.5440	0.0034	0.000	407.477	0.000	407.477	407.477
496	horim496	37.7500	140.125	107	107	134	1	3	24	66	35	1.8444	0.0172	0.000	407.477	0.000	407.477	407.477
497	horim497	37.7500	140.375	113	113	55	0	1	16	86	23	0.4500	0.0040	0.000	407.477	0.000	407.477	407.477
498	horim498	37.7500	140.625	129	129	31	0	0	13	111	18	0.2888	0.0022	0.000	407.477	0.000	407.477	407.477
499	horim499	37.7500	140.875	153	153	38	0	0	19	131	23	0.3516	0.0023	8.965	398.512	0.000	398.512	407.477
500	horim500	37.7500	141.125	86	86	28	0	0	8	76	11	0.1961	0.0023	394.785	12.692	0.000	12.692	407.477
501	horim501	37.5833	136.875	23	23	NA	0	0	0	23	0	0.0496	0.0022	408.059	0.000	0.319	0.319	408.378
502	horim502	37.5833	137.125	87	87	3	0	0	1	83	2	0.1796	0.0021	403.237	5.105	0.036	5.141	408.378
503	horim503	37.5833	137.375	137	137	15	0	0	7	127	12	0.2808	0.0020	385.636	22.702	0.041	22.743	408.378
504	horim504	37.5833	138.625	77	77	4	0	0	1	73	5	0.1428	0.0019	359.669	48.694	0.015	48.709	408.378
505	horim505	37.5833	138.875	30	30	NA	0	0	1	29	3	0.0512	0.0017	9.645	398.733	0.000	398.733	408.378
506	horim506	37.5833	139.125	22	22	NA	0	0	2	19	3	0.0376	0.0017	0.000	408.378	0.000	408.378	408.378
507	horim507	37.5833	139.375	17	17	NA	0	0	3	14	4	0.0366	0.0022	0.000	408.378	0.000	408.378	408.378
508	horim508	37.5833	139.625	94	94	76	0	3	14	73	22	0.2703	0.0029	0.000	408.378	0.000	408.378	408.378
509	horim509	37.5833	139.875	132	132	28	0	0	12	116	17	0.3010	0.0023	0.000	408.378	0.000	408.378	408.378
510	horim510	37.5833	140.125	137	137	60	0	2	19	102	27	0.5471	0.0040	0.000	408.378	0.000	408.378	408.378
511	horim511	37.5833	140.375	68	68	63	0	1	9	47	13	0.3257	0.0048	0.000	408.378	0.000	408.378	408.378
512	horim512	37.5833	140.625	128	128	50	0	1	18	107	29	0.3753	0.0029	0.000	408.378	0.000	408.378	408.378
513	horim513	37.5833	140.875	173	173	38	0	1	19	151	29	0.4046	0.0023	0.000	408.378	0.000	408.378	408.378

514	horim514	37.5833	141.125	58	58	32	0	0	6	50	6	0.0998	0.0017	359.154	49.224	0.000	49.224	408.378
515	horim515	37.4167	136.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	408.512	0.763	0.000	0.763	409.275
516	horim516	37.4167	136.875	192	192	19	0	0	12	174	18	0.4574	0.0024	267.219	142.046	0.010	142.056	409.275
517	horim517	37.4167	137.125	180	180	25	0	0	15	162	22	0.4317	0.0024	65.953	343.286	0.036	343.322	409.275
518	horim518	37.4167	137.375	97	97	15	0	0	5	90	7	0.2010	0.0021	341.010	68.237	0.028	68.265	409.275
519	horim519	37.4167	138.375	15	15	NA	0	0	0	14	0	0.0294	0.0020	406.689	2.576	0.010	2.586	409.275
520	horim520	37.4167	138.625	107	107	2	0	0	1	103	5	0.2080	0.0019	132.939	276.328	0.008	276.336	409.275
521	horim521	37.4167	138.875	113	113	35	0	1	10	98	17	0.2507	0.0022	0.000	409.275	0.000	409.275	409.275
522	horim522	37.4167	139.125	120	120	57	0	2	16	96	28	0.3728	0.0031	0.000	409.275	0.000	409.275	409.275
523	horim523	37.4167	139.375	59	59	47	0	0	9	48	12	0.1297	0.0022	0.000	409.275	0.000	409.275	409.275
524	horim524	37.4167	139.625	67	67	28	0	0	6	57	8	0.1426	0.0021	0.000	409.275	0.000	409.275	409.275
525	horim525	37.4167	139.875	138	138	42	0	1	16	117	23	0.3238	0.0023	0.000	409.275	0.000	409.275	409.275
526	horim526	37.4167	140.125	43	43	27	0	1	1	41	3	0.0818	0.0019	0.000	409.275	0.000	409.275	409.275
527	horim527	37.4167	140.375	120	120	32	0	0	13	106	18	0.2400	0.0020	0.000	409.275	0.000	409.275	409.275
528	horim528	37.4167	140.625	197	197	41	0	0	26	160	36	0.5546	0.0028	0.000	409.275	0.000	409.275	409.275
529	horim529	37.4167	140.875	76	76	32	0	0	8	66	11	0.1402	0.0018	0.000	409.275	0.000	409.275	409.275
530	horim530	37.4167	141.125	71	71	21	0	0	5	65	7	0.1250	0.0018	344.919	64.318	0.038	64.356	409.275
531	horim531	37.2500	136.625	85	85	3	0	0	1	82	2	0.1794	0.0021	347.293	62.847	0.028	62.876	410.169
532	horim532	37.2500	136.875	148	148	22	0	0	11	134	15	0.3313	0.0022	39.874	370.280	0.015	370.295	410.169
533	horim533	37.2500	137.125	128	128	12	0	0	5	120	9	0.2500	0.0020	230.999	179.160	0.010	179.170	410.169
534	horim534	37.2500	137.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	407.290	2.879	0.000	2.879	410.169
535	horim535	37.2500	138.125	11	11	NA	0	0	0	11	0	0.0196	0.0018	407.780	2.384	0.005	2.389	410.169
536	horim536	37.2500	138.375	102	102	12	0	0	4	95	8	0.2131	0.0021	167.818	242.197	0.154	242.351	410.169
537	horim537	37.2500	138.625	15	15	NA	0	0	1	14	3	0.0216	0.0014	0.000	410.169	0.000	410.169	410.169
538	horim538	37.2500	138.875	100	100	25	0	0	8	88	14	0.1928	0.0019	0.000	410.169	0.000	410.169	410.169
539	horim539	37.2500	139.125	115	115	63	0	2	17	89	29	0.3475	0.0030	0.000	410.169	0.000	410.169	410.169
540	horim540	37.2500	139.375	41	41	81	0	1	7	29	11	0.1303	0.0032	0.000	410.169	0.000	410.169	410.169
541	horim541	37.2500	139.625	134	134	45	0	1	17	114	26	0.3844	0.0029	0.000	410.169	0.000	410.169	410.169
542	horim542	37.2500	139.875	179	179	50	0	1	27	149	39	0.5747	0.0032	0.000	410.169	0.000	410.169	410.169
543	horim543	37.2500	140.125	166	166	52	0	3	20	143	32	0.4613	0.0028	0.000	410.169	0.000	410.169	410.169
544	horim544	37.2500	140.375	104	104	26	0	0	9	93	9	0.2069	0.0020	0.000	410.169	0.000	410.169	410.169
545	horim545	37.2500	140.625	29	29	NA	0	0	5	24	6	0.0501	0.0017	0.000	410.169	0.000	410.169	410.169
546	horim546	37.2500	140.875	154	154	43	0	1	18	125	25	0.3752	0.0024	0.000	410.169	0.000	410.169	410.169
547	horim547	37.2500	141.125	46	46	32	0	0	5	41	6	0.1027	0.0022	380.225	29.831	0.113	29.944	410.169
548	horim548	37.0833	136.625	114	114	5	0	0	2	110	5	0.2321	0.0020	368.512	42.537	0.010	42.547	411.059
549	horim549	37.0833	136.875	87	87	13	0	0	4	82	7	0.1648	0.0019	88.659	292.732	29.668	322.400	411.059
550	horim550	37.0833	137.125	58	58	5	0	0	1	57	2	0.0997	0.0017	347.740	46.202	17.117	63.319	411.059
551	horim551	37.0833	137.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	410.352	0.707	0.000	0.707	411.059
552	horim552	37.0833	137.875	106	106	17	0	0	6	96	10	0.2223	0.0021	286.989	124.044	0.026	124.070	411.059
553	horim553	37.0833	138.125	144	144	33	0	1	12	121	19	0.3533	0.0025	39.235	371.819	0.005	371.824	411.059

554	horim554	37.0833	138.375	67	67	10	0	0	2	58	6	0.1363	0.0020	0.000	411.059	0.000	411.059	411.059
555	horim555	37.0833	138.625	95	95	38	0	0	12	81	20	0.2653	0.0028	0.000	411.059	0.000	411.059	411.059
556	horim556	37.0833	138.875	45	45	13	0	0	2	42	5	0.0700	0.0016	0.000	411.059	0.000	411.059	411.059
557	horim557	37.0833	139.125	94	94	103	0	3	20	61	31	0.5143	0.0055	0.000	411.059	0.000	411.059	411.059
558	horim558	37.0833	139.375	123	123	68	0	1	24	93	35	0.4850	0.0039	0.000	411.059	0.000	411.059	411.059
559	horim559	37.0833	139.625	166	166	54	0	1	27	136	37	0.4648	0.0028	0.000	411.059	0.000	411.059	411.059
560	horim560	37.0833	139.875	233	233	70	0	4	42	185	58	0.9633	0.0041	0.000	411.059	0.000	411.059	411.059
561	horim561	37.0833	140.125	207	207	45	0	1	28	174	38	0.6024	0.0029	0.000	411.059	0.000	411.059	411.059
562	horim562	37.0833	140.375	176	176	42	0	0	25	151	31	1.4374	0.0082	0.000	411.059	0.000	411.059	411.059
563	horim563	37.0833	140.625	145	145	37	0	0	18	127	25	0.3322	0.0023	0.000	411.059	0.000	411.059	411.059
564	horim564	37.0833	140.875	178	178	40	0	2	18	158	25	0.4822	0.0027	19.090	391.969	0.000	391.969	411.059
565	horim565	37.0833	141.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	408.962	2.090	0.008	2.097	411.059
566	horim566	36.9167	136.875	184	184	25	0	0	15	163	19	0.4598	0.0025	27.649	384.289	0.008	384.296	411.946
567	horim567	36.9167	137.125	102	102	3	0	0	1	98	3	0.2118	0.0021	367.879	44.062	0.005	44.067	411.946
568	horim568	36.9167	137.375	123	123	29	0	1	9	111	16	0.2574	0.0021	328.597	83.333	0.015	83.349	411.946
569	horim569	36.9167	137.625	130	130	25	0	0	11	118	18	0.2932	0.0023	60.501	351.442	0.003	351.444	411.946
570	horim570	36.9167	137.875	195	195	77	0	5	32	144	45	0.9316	0.0048	0.000	411.946	0.000	411.946	411.946
571	horim571	36.9167	138.125	150	150	65	0	2	24	112	32	0.7117	0.0047	0.000	411.946	0.000	411.946	411.946
572	horim572	36.9167	138.375	156	156	37	0	0	19	134	26	0.4358	0.0028	0.000	411.946	0.000	411.946	411.946
573	horim573	36.9167	138.625	164	164	77	0	4	27	120	40	0.7714	0.0047	0.000	411.946	0.000	411.946	411.946
574	horim574	36.9167	138.875	153	153	80	1	3	21	120	33	0.8529	0.0056	0.000	411.946	0.000	411.946	411.946
575	horim575	36.9167	139.125	197	197	88	1	4	32	143	47	1.3611	0.0069	0.000	411.946	0.000	411.946	411.946
576	horim576	36.9167	139.375	193	193	74	0	3	34	137	48	1.1060	0.0057	0.000	411.946	0.000	411.946	411.946
577	horim577	36.9167	139.625	187	187	64	0	2	34	151	47	0.6842	0.0037	0.000	411.946	0.000	411.946	411.946
578	horim578	36.9167	139.875	184	184	55	0	2	28	153	40	0.5658	0.0031	0.000	411.946	0.000	411.946	411.946
579	horim579	36.9167	140.125	161	161	33	0	1	15	144	20	0.3981	0.0025	0.000	411.946	0.000	411.946	411.946
580	horim580	36.9167	140.375	202	202	43	0	1	25	169	35	0.5404	0.0027	0.000	411.946	0.000	411.946	411.946
581	horim581	36.9167	140.625	213	213	44	0	1	28	178	37	0.5659	0.0027	0.000	411.946	0.000	411.946	411.946
582	horim582	36.9167	140.875	156	156	35	0	1	15	138	17	0.3830	0.0025	207.662	204.274	0.010	204.284	411.946
583	horim583	36.7500	136.625	81	81	11	0	0	3	76	5	0.1365	0.0017	336.645	76.184	0.000	76.184	412.829
584	horim584	36.7500	136.875	161	161	40	0	1	18	138	25	0.3858	0.0024	0.003	412.826	0.000	412.826	412.829
585	horim585	36.7500	137.125	144	144	25	0	0	12	131	16	0.3000	0.0021	132.615	280.167	0.046	280.213	412.829
586	horim586	36.7500	137.375	114	114	16	0	0	6	105	11	0.2144	0.0019	93.908	318.918	0.003	318.920	412.829
587	horim587	36.7500	137.625	182	182	86	0	6	30	131	43	1.1257	0.0062	0.000	412.829	0.000	412.829	412.829
588	horim588	36.7500	137.875	221	221	88	0	8	36	160	53	1.5165	0.0069	0.000	412.829	0.000	412.829	412.829
589	horim589	36.7500	138.125	190	190	60	0	3	27	148	39	0.8821	0.0046	0.000	412.829	0.000	412.829	412.829
590	horim590	36.7500	138.375	190	190	61	0	3	28	150	40	0.8964	0.0047	0.000	412.829	0.000	412.829	412.829
591	horim591	36.7500	138.625	114	114	91	0	3	25	84	36	0.6926	0.0061	0.000	412.829	0.000	412.829	412.829
592	horim592	36.7500	138.875	205	205	76	1	3	31	156	45	1.0934	0.0053	0.000	412.829	0.000	412.829	412.829
593	horim593	36.7500	139.125	128	128	59	0	0	24	98	30	0.3987	0.0031	0.000	412.829	0.000	412.829	412.829

594	horim594	36.7500	139.375	202	202	86	0	6	37	147	54	1.1663	0.0058	0.000	412.829	0.000	412.829	412.829
595	horim595	36.7500	139.625	244	244	71	0	5	41	189	56	1.0369	0.0042	0.000	412.829	0.000	412.829	412.829
596	horim596	36.7500	139.875	182	182	42	0	1	22	153	28	0.6593	0.0036	0.000	412.829	0.000	412.829	412.829
597	horim597	36.7500	140.125	117	117	28	0	1	8	106	12	0.2591	0.0022	0.000	412.829	0.000	412.829	412.829
598	horim598	36.7500	140.375	170	170	45	0	1	22	142	31	0.6392	0.0038	0.000	412.829	0.000	412.829	412.829
599	horim599	36.7500	140.625	199	199	31	0	1	17	175	20	0.5368	0.0027	20.764	392.065	0.000	392.065	412.829
600	horim600	36.7500	140.875	75	75	25	0	1	3	68	6	0.1860	0.0025	401.063	11.763	0.003	11.766	412.829
601	horim601	36.5833	136.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	413.677	0.031	0.000	0.031	413.708
602	horim602	36.5833	136.625	160	160	33	0	0	17	137	20	0.3638	0.0023	124.725	288.983	0.000	288.983	413.708
603	horim603	36.5833	136.875	33	33	NA	0	0	3	28	3	0.0658	0.0020	0.000	413.708	0.000	413.708	413.708
604	horim604	36.5833	137.125	120	120	28	0	1	8	107	13	0.2439	0.0020	0.000	413.708	0.000	413.708	413.708
605	horim605	36.5833	137.375	103	103	71	0	3	13	76	23	0.3639	0.0035	0.000	413.708	0.000	413.708	413.708
606	horim606	36.5833	137.625	143	143	124	0	8	29	91	46	1.4011	0.0098	0.000	413.708	0.000	413.708	413.708
607	horim607	36.5833	137.875	133	133	89	0	4	26	98	37	0.7778	0.0058	0.000	413.708	0.000	413.708	413.708
608	horim608	36.5833	138.125	101	101	39	0	1	10	88	13	0.2292	0.0023	0.000	413.708	0.000	413.708	413.708
609	horim609	36.5833	138.375	56	56	105	0	1	16	37	18	0.3868	0.0069	0.000	413.708	0.000	413.708	413.708
610	horim610	36.5833	138.625	188	188	62	0	2	31	146	43	0.7678	0.0041	0.000	413.708	0.000	413.708	413.708
611	horim611	36.5833	138.875	106	106	23	0	0	8	96	13	0.2264	0.0021	0.000	413.708	0.000	413.708	413.708
612	horim612	36.5833	139.125	201	201	57	0	1	34	158	42	0.6388	0.0032	0.000	413.708	0.000	413.708	413.708
613	horim613	36.5833	139.375	190	190	57	0	2	30	155	42	0.5781	0.0030	0.000	413.708	0.000	413.708	413.708
614	horim614	36.5833	139.625	196	196	51	0	1	30	163	40	0.7353	0.0038	0.000	413.708	0.000	413.708	413.708
615	horim615	36.5833	139.875	176	176	38	0	1	19	153	27	0.6241	0.0035	0.000	413.708	0.000	413.708	413.708
616	horim616	36.5833	140.125	142	142	29	0	1	11	129	19	0.3107	0.0022	0.000	413.708	0.000	413.708	413.708
617	horim617	36.5833	140.375	179	179	42	0	1	22	152	32	0.6506	0.0036	0.000	413.708	0.000	413.708	413.708
618	horim618	36.5833	140.625	158	158	40	0	1	18	137	22	0.4218	0.0027	133.028	280.675	0.005	280.680	413.708
619	horim619	36.4167	133.375	109	109	47	1	1	5	101	6	0.3818	0.0035	413.523	0.000	1.061	1.061	414.584
620	horim620	36.4167	136.375	43	43	6	0	0	1	42	1	0.0759	0.0018	264.348	150.236	0.000	150.236	414.584
621	horim621	36.4167	136.625	126	126	22	0	0	9	113	14	0.2653	0.0021	0.000	414.584	0.000	414.584	414.584
622	horim622	36.4167	136.875	101	101	45	0	1	12	85	19	0.2345	0.0023	0.000	414.584	0.000	414.584	414.584
623	horim623	36.4167	137.125	51	51	47	0	1	5	45	8	0.1066	0.0021	0.000	414.584	0.000	414.584	414.584
624	horim624	36.4167	137.375	142	142	80	0	4	24	106	36	0.6050	0.0043	0.000	414.584	0.000	414.584	414.584
625	horim625	36.4167	137.625	189	189	109	0	9	36	128	55	1.5357	0.0081	0.000	414.584	0.000	414.584	414.584
626	horim626	36.4167	137.875	142	142	64	0	2	24	113	33	0.4292	0.0030	0.000	414.584	0.000	414.584	414.584
627	horim627	36.4167	138.125	99	99	36	0	1	9	89	12	0.2167	0.0022	0.000	414.584	0.000	414.584	414.584
628	horim628	36.4167	138.375	150	150	55	0	2	21	122	25	0.5346	0.0036	0.000	414.584	0.000	414.584	414.584
629	horim629	36.4167	138.625	227	227	56	0	2	36	184	47	0.8783	0.0039	0.000	414.584	0.000	414.584	414.584
630	horim630	36.4167	138.875	153	153	66	0	2	26	116	33	0.4467	0.0029	0.000	414.584	0.000	414.584	414.584
631	horim631	36.4167	139.125	142	142	30	0	0	14	125	16	0.3144	0.0022	0.000	414.584	0.000	414.584	414.584
632	horim632	36.4167	139.375	151	151	32	0	0	16	134	21	0.3327	0.0022	0.000	414.584	0.000	414.584	414.584
633	horim633	36.4167	139.625	201	201	38	0	1	22	171	32	0.5009	0.0025	0.000	414.584	0.000	414.584	414.584

634	horim634	36.4167	139.875	117	117	23	0	0	9	107	11	0.2382	0.0020	0.000	414.584	0.000	414.584	414.584
635	horim635	36.4167	140.125	161	161	26	0	0	14	146	19	0.3706	0.0023	0.000	414.584	0.000	414.584	414.584
636	horim636	36.4167	140.375	150	150	20	0	0	10	139	10	0.3521	0.0023	0.000	414.584	0.000	414.584	414.584
637	horim637	36.4167	140.625	95	95	31	0	1	7	87	5	0.2441	0.0026	221.324	193.214	0.047	193.260	414.584
638	horim638	36.2500	133.125	58	58	123	2	1	2	51	4	0.4461	0.0077	344.607	0.000	70.850	70.850	415.457
639	horim639	36.2500	133.375	203	203	46	2	0	11	174	15	0.7986	0.0039	244.719	0.000	170.737	170.737	415.457
640	horim640	36.2500	136.125	115	115	7	0	0	3	110	5	0.2355	0.0020	298.203	117.067	0.187	117.254	415.457
641	horim641	36.2500	136.375	99	99	15	0	0	5	92	7	0.1725	0.0017	8.987	406.470	0.000	406.470	415.457
642	horim642	36.2500	136.625	113	113	65	0	2	18	90	27	0.3178	0.0028	0.000	415.457	0.000	415.457	415.457
643	horim643	36.2500	136.875	187	187	83	0	6	29	134	43	0.9676	0.0052	0.000	415.457	0.000	415.457	415.457
644	horim644	36.2500	137.125	37	37	NA	0	1	6	30	9	0.1021	0.0028	0.000	415.457	0.000	415.457	415.457
645	horim645	36.2500	137.375	137	137	40	0	0	18	115	27	0.3463	0.0025	0.000	415.457	0.000	415.457	415.457
646	horim646	36.2500	137.625	213	213	102	0	11	34	152	54	1.5574	0.0073	0.000	415.457	0.000	415.457	415.457
647	horim647	36.2500	137.875	164	164	61	0	2	27	133	35	0.5782	0.0035	0.000	415.457	0.000	415.457	415.457
648	horim648	36.2500	138.125	169	169	63	0	2	29	135	38	0.5562	0.0033	0.000	415.457	0.000	415.457	415.457
649	horim649	36.2500	138.375	112	112	41	0	1	12	95	14	0.3105	0.0028	0.000	415.457	0.000	415.457	415.457
650	horim650	36.2500	138.625	192	192	50	0	1	29	160	39	0.5988	0.0031	0.000	415.457	0.000	415.457	415.457
651	horim651	36.2500	138.875	137	137	36	0	0	16	117	21	0.3176	0.0023	0.000	415.457	0.000	415.457	415.457
652	horim652	36.2500	139.125	58	58	10	0	0	2	56	4	0.0964	0.0017	0.000	415.457	0.000	415.457	415.457
653	horim653	36.2500	139.375	80	80	11	0	0	3	77	3	0.1366	0.0017	0.000	415.457	0.000	415.457	415.457
654	horim654	36.2500	139.625	134	134	20	0	0	9	124	12	0.2840	0.0021	0.000	415.457	0.000	415.457	415.457
655	horim655	36.2500	139.875	90	90	23	0	0	7	81	8	0.1674	0.0019	0.000	415.457	0.000	415.457	415.457
656	horim656	36.2500	140.125	213	213	38	0	0	26	176	31	0.5782	0.0027	0.000	415.457	0.000	415.457	415.457
657	horim657	36.2500	140.375	107	107	11	0	0	4	102	6	0.2309	0.0022	0.000	415.457	0.000	415.457	415.457
658	horim658	36.2500	140.625	81	81	26	0	1	4	73	4	0.2198	0.0027	295.402	120.034	0.021	120.055	415.457
659	horim659	36.0833	132.875	102	102	44	1	1	3	97	3	0.3780	0.0037	396.757	0.000	19.569	19.569	416.326
660	horim660	36.0833	133.125	165	165	52	2	0	10	148	11	0.6505	0.0039	331.377	0.000	84.948	84.948	416.326
661	horim661	36.0833	133.375	85	85	52	1	1	3	80	4	0.3319	0.0039	415.094	0.000	1.232	1.232	416.326
662	horim662	36.0833	135.875	8	8	NA	0	0	0	8	0	0.0194	0.0024	414.651	1.667	0.008	1.675	416.326
663	horim663	36.0833	136.125	139	139	27	0	1	9	123	17	0.3763	0.0027	67.518	348.774	0.034	348.807	416.326
664	horim664	36.0833	136.375	114	114	23	0	0	8	93	11	0.3023	0.0027	0.000	416.326	0.000	416.326	416.326
665	horim665	36.0833	136.625	175	175	73	0	4	28	131	40	0.6088	0.0035	0.000	416.326	0.000	416.326	416.326
666	horim666	36.0833	136.875	190	190	88	0	7	32	141	48	1.0664	0.0056	0.000	416.326	0.000	416.326	416.326
667	horim667	36.0833	137.125	119	119	69	0	1	23	88	34	0.4641	0.0039	0.000	416.326	0.000	416.326	416.326
668	horim668	36.0833	137.375	160	160	67	0	3	26	127	36	0.5303	0.0033	0.000	416.326	0.000	416.326	416.326
669	horim669	36.0833	137.625	224	224	90	0	8	41	166	61	1.4659	0.0065	0.000	416.326	0.000	416.326	416.326
670	horim670	36.0833	137.875	133	133	55	0	2	18	110	28	0.3809	0.0029	0.000	416.326	0.000	416.326	416.326
671	horim671	36.0833	138.125	123	123	75	0	2	24	93	29	0.5743	0.0047	0.000	416.326	0.000	416.326	416.326
672	horim672	36.0833	138.375	150	150	121	1	5	29	96	39	1.1237	0.0075	0.000	416.326	0.000	416.326	416.326
673	horim673	36.0833	138.625	95	95	75	0	1	21	73	28	0.3244	0.0034	0.000	416.326	0.000	416.326	416.326

674	horim674	36.0833	138.875	156	156	57	0	1	26	125	33	0.4511	0.0029	0.000	416.326	0.000	416.326	416.326
675	horim675	36.0833	139.125	144	144	40	0	0	19	121	26	0.3423	0.0024	0.000	416.326	0.000	416.326	416.326
676	horim676	36.0833	139.375	103	103	21	0	0	7	92	9	0.2208	0.0021	0.000	416.326	0.000	416.326	416.326
677	horim677	36.0833	139.625	47	47	6	0	0	1	45	1	0.0902	0.0019	0.000	416.326	0.000	416.326	416.326
678	horim678	36.0833	139.875	49	49	18	0	0	3	46	3	0.0964	0.0020	0.000	416.326	0.000	416.326	416.326
679	horim679	36.0833	140.125	81	81	18	0	0	5	74	6	0.1566	0.0019	0.000	416.326	0.000	416.326	416.326
680	horim680	36.0833	140.375	90	90	13	0	0	4	83	5	0.1669	0.0019	0.000	416.326	0.000	416.326	416.326
681	horim681	36.0833	140.625	65	65	9	0	0	2	63	3	0.1227	0.0019	224.947	191.379	0.000	191.379	416.326
682	horim682	35.9167	133.125	1	1	NA	0	0	0	1	0	0.0025	0.0025	415.412	0.000	1.779	1.779	417.191
683	horim683	35.9167	135.875	13	13	NA	0	1	0	12	2	0.0888	0.0068	399.900	17.281	0.010	17.291	417.191
684	horim684	35.9167	136.125	138	138	33	0	1	12	120	18	0.3586	0.0026	13.841	403.347	0.003	403.350	417.191
685	horim685	35.9167	136.375	38	38	NA	0	2	4	32	8	0.1042	0.0027	0.000	417.191	0.000	417.191	417.191
686	horim686	35.9167	136.625	178	178	61	0	4	23	145	36	0.6151	0.0035	0.000	417.191	0.000	417.191	417.191
687	horim687	35.9167	136.875	194	194	75	0	5	33	152	48	0.6735	0.0035	0.000	417.191	0.000	417.191	417.191
688	horim688	35.9167	137.125	74	74	87	0	3	12	57	23	0.2312	0.0031	0.000	417.191	0.000	417.191	417.191
689	horim689	35.9167	137.375	167	167	124	1	9	28	116	47	1.2563	0.0075	0.000	417.191	0.000	417.191	417.191
690	horim690	35.9167	137.625	234	234	88	1	4	42	167	55	1.2648	0.0054	0.000	417.191	0.000	417.191	417.191
691	horim691	35.9167	137.875	201	201	69	0	3	35	153	44	0.7651	0.0038	0.000	417.191	0.000	417.191	417.191
692	horim692	35.9167	138.125	155	155	50	0	2	20	133	24	0.5771	0.0037	0.000	417.191	0.000	417.191	417.191
693	horim693	35.9167	138.375	185	185	126	3	5	29	132	42	2.4195	0.0131	0.000	417.191	0.000	417.191	417.191
694	horim694	35.9167	138.625	106	106	124	1	2	27	71	34	0.6812	0.0064	0.000	417.191	0.000	417.191	417.191
695	horim695	35.9167	138.875	172	172	87	0	4	34	119	46	0.6787	0.0039	0.000	417.191	0.000	417.191	417.191
696	horim696	35.9167	139.125	173	173	60	0	3	24	136	36	0.5735	0.0033	0.000	417.191	0.000	417.191	417.191
697	horim697	35.9167	139.375	89	89	30	0	0	9	79	13	0.1756	0.0020	0.000	417.191	0.000	417.191	417.191
698	horim698	35.9167	139.625	67	67	13	0	0	3	64	4	0.1280	0.0019	0.000	417.191	0.000	417.191	417.191
699	horim699	35.9167	139.875	87	87	10	0	0	3	84	3	0.1655	0.0019	0.000	417.191	0.000	417.191	417.191
700	horim700	35.9167	140.125	93	93	10	0	0	3	87	3	0.1811	0.0019	0.000	417.191	0.000	417.191	417.191
701	horim701	35.9167	140.375	120	120	12	0	0	5	111	5	0.2441	0.0020	0.000	417.191	0.000	417.191	417.191
702	horim702	35.9167	140.625	150	150	12	0	0	6	140	6	0.3499	0.0023	68.054	348.960	0.177	349.137	417.191
703	horim703	35.9167	140.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	414.892	2.299	0.000	2.299	417.191
704	horim704	35.7500	134.625	4	4	NA	0	0	1	3	1	0.0096	0.0024	418.045	0.008	0.000	0.008	418.053
705	horim705	35.7500	134.875	101	101	18	0	0	6	91	10	0.2087	0.0021	412.937	5.100	0.016	5.115	418.053
706	horim706	35.7500	135.125	100	100	31	0	1	7	87	11	0.2535	0.0025	247.555	170.461	0.037	170.498	418.053
707	horim707	35.7500	135.375	15	15	NA	0	1	1	13	2	0.0920	0.0061	383.956	33.661	0.437	34.097	418.053
708	horim708	35.7500	135.875	58	58	46	0	1	6	51	6	0.1925	0.0033	397.734	20.318	0.000	20.318	418.053
709	horim709	35.7500	136.125	188	188	48	0	3	20	157	27	0.5449	0.0029	118.194	299.846	0.013	299.859	418.053
710	horim710	35.7500	136.375	23	23	NA	0	2	2	19	6	0.0991	0.0043	0.000	418.053	0.000	418.053	418.053
711	horim711	35.7500	136.625	192	192	59	0	3	28	156	40	0.6050	0.0032	0.000	418.053	0.000	418.053	418.053
712	horim712	35.7500	136.875	166	166	50	0	2	21	139	30	0.4683	0.0028	0.000	418.053	0.000	418.053	418.053
713	horim713	35.7500	137.125	127	127	60	0	3	16	106	28	0.3206	0.0025	0.000	418.053	0.000	418.053	418.053

714	horim714	35.7500	137.375	152	152	78	0	4	28	120	39	0.5253	0.0035	0.000	418.053	0.000	418.053	418.053
715	horim715	35.7500	137.625	225	225	77	0	4	42	163	56	0.9666	0.0043	0.000	418.053	0.000	418.053	418.053
716	horim716	35.7500	137.875	237	237	111	2	9	37	172	55	3.1154	0.0131	0.000	418.053	0.000	418.053	418.053
717	horim717	35.7500	138.125	246	246	133	4	8	41	174	58	3.4524	0.0140	0.000	418.053	0.000	418.053	418.053
718	horim718	35.7500	138.375	241	241	75	1	2	40	177	52	1.0930	0.0045	0.000	418.053	0.000	418.053	418.053
719	horim719	35.7500	138.625	171	171	47	0	1	23	141	30	0.4911	0.0029	0.000	418.053	0.000	418.053	418.053
720	horim720	35.7500	138.875	162	162	61	0	1	28	122	36	0.5133	0.0032	0.000	418.053	0.000	418.053	418.053
721	horim721	35.7500	139.125	127	127	71	0	2	21	90	28	0.3775	0.0030	0.000	418.053	0.000	418.053	418.053
722	horim722	35.7500	139.375	130	130	28	0	0	12	113	19	0.2722	0.0021	0.000	418.053	0.000	418.053	418.053
723	horim723	35.7500	139.625	137	137	27	0	0	12	121	11	0.3352	0.0024	0.000	418.053	0.000	418.053	418.053
724	horim724	35.7500	139.875	99	99	15	0	0	5	91	4	0.2032	0.0021	3.803	412.754	1.496	414.250	418.053
725	horim725	35.7500	140.125	90	90	6	0	0	2	87	3	0.1835	0.0020	0.000	418.053	0.000	418.053	418.053
726	horim726	35.7500	140.375	131	131	11	0	0	5	121	8	0.2868	0.0022	0.000	418.053	0.000	418.053	418.053
727	horim727	35.7500	140.625	84	84	11	0	0	3	78	3	0.1809	0.0022	27.631	390.411	0.010	390.422	418.053
728	horim728	35.7500	140.875	84	84	3	0	0	1	83	2	0.1705	0.0020	319.376	98.646	0.031	98.677	418.053
729	horim729	35.5833	132.875	140	140	17	0	0	8	128	10	0.3061	0.0022	395.319	23.548	0.045	23.592	418.911
730	horim730	35.5833	133.125	147	147	19	0	0	9	132	13	0.3361	0.0023	251.958	166.000	0.953	166.953	418.911
731	horim731	35.5833	133.375	149	149	20	0	0	10	137	10	0.3420	0.0023	401.525	17.318	0.068	17.386	418.911
732	horim732	35.5833	133.625	109	109	33	1	0	3	103	5	0.3891	0.0036	386.209	32.691	0.010	32.702	418.911
733	horim733	35.5833	133.875	109	109	41	1	1	3	103	5	0.4010	0.0037	403.520	15.391	0.000	15.391	418.911
734	horim734	35.5833	134.125	218	218	37	1	1	14	192	22	0.7687	0.0035	349.602	69.280	0.029	69.309	418.911
735	horim735	35.5833	134.375	185	185	23	0	1	11	168	15	0.5064	0.0027	158.149	260.660	0.102	260.762	418.911
736	horim736	35.5833	134.625	110	110	26	0	1	6	96	11	0.3159	0.0029	29.571	389.047	0.293	389.340	418.911
737	horim737	35.5833	134.875	134	134	51	1	1	10	116	18	0.5126	0.0038	29.613	389.274	0.024	389.298	418.911
738	horim738	35.5833	135.125	132	132	28	0	0	12	116	17	0.2659	0.0020	22.205	396.706	0.000	396.706	418.911
739	horim739	35.5833	135.375	144	144	44	0	2	14	120	21	1.3950	0.0097	304.461	113.662	0.788	114.450	418.911
740	horim740	35.5833	135.625	97	97	40	0	1	10	85	12	0.2700	0.0028	382.472	36.355	0.084	36.439	418.911
741	horim741	35.5833	135.875	114	114	40	0	1	12	98	17	0.3235	0.0028	187.527	230.997	0.387	231.384	418.911
742	horim742	35.5833	136.125	171	171	53	0	3	20	139	30	0.5115	0.0030	3.521	415.390	0.000	415.390	418.911
743	horim743	35.5833	136.375	160	160	34	0	0	18	137	23	0.3831	0.0024	0.000	418.911	0.000	418.911	418.911
744	horim744	35.5833	136.625	226	226	45	0	2	27	189	38	0.6628	0.0029	0.000	418.911	0.000	418.911	418.911
745	horim745	35.5833	136.875	216	216	50	0	3	27	183	40	0.6709	0.0031	0.000	418.911	0.000	418.911	418.911
746	horim746	35.5833	137.125	171	171	50	0	2	22	143	32	0.4801	0.0028	0.000	418.911	0.000	418.911	418.911
747	horim747	35.5833	137.375	134	134	54	0	2	18	113	25	0.3315	0.0025	0.000	418.911	0.000	418.911	418.911
748	horim748	35.5833	137.625	269	269	80	1	6	42	207	59	1.2049	0.0045	0.000	418.911	0.000	418.911	418.911
749	horim749	35.5833	137.875	252	252	78	1	5	40	200	56	1.0838	0.0043	0.000	418.911	0.000	418.911	418.911
750	horim750	35.5833	138.125	256	256	115	3	7	42	181	56	2.0278	0.0079	0.000	418.911	0.000	418.911	418.911
751	horim751	35.5833	138.375	216	216	97	2	3	40	161	52	1.0681	0.0049	0.000	418.911	0.000	418.911	418.911
752	horim752	35.5833	138.625	57	57	36	0	0	7	50	7	0.1200	0.0021	0.000	418.911	0.000	418.911	418.911
753	horim753	35.5833	138.875	162	162	60	0	2	26	132	34	0.5210	0.0032	0.000	418.911	0.000	418.911	418.911

754	horim754	35.5833	139.125	225	225	52	0	1	35	183	41	0.6621	0.0029	0.000	418.911	0.000	418.911	418.911
755	horim755	35.5833	139.375	215	215	38	0	0	27	182	29	0.7358	0.0034	0.000	418.911	0.000	418.911	418.911
756	horim756	35.5833	139.625	144	144	16	0	0	8	134	9	0.3077	0.0021	0.873	417.302	0.736	418.038	418.911
757	horim757	35.5833	139.875	27	27	NA	0	0	0	27	0	0.0412	0.0015	308.277	80.765	29.870	110.635	418.911
758	horim758	35.5833	140.125	134	134	6	0	0	3	128	6	0.2683	0.0020	108.075	310.836	0.000	310.836	418.911
759	horim759	35.5833	140.375	145	145	19	0	0	9	130	10	0.3613	0.0025	24.901	394.010	0.000	394.010	418.911
760	horim760	35.5833	140.625	78	78	7	0	0	2	75	2	0.1494	0.0019	364.564	54.347	0.000	54.347	418.911
761	horim761	35.4167	132.625	177	177	23	0	0	13	154	12	0.4434	0.0025	322.769	96.949	0.047	96.996	419.766
762	horim762	35.4167	132.875	178	178	26	0	1	12	159	17	0.4136	0.0023	16.100	403.663	0.003	403.666	419.766
763	horim763	35.4167	133.125	183	183	23	0	0	14	162	18	0.4507	0.0025	0.000	419.766	0.000	419.766	419.766
764	horim764	35.4167	133.375	179	179	19	0	0	11	161	17	0.4123	0.0023	66.982	352.784	0.000	352.784	419.766
765	horim765	35.4167	133.625	195	195	45	0	2	22	159	33	0.5942	0.0030	0.223	419.543	0.000	419.543	419.766
766	horim766	35.4167	133.875	186	186	39	0	1	20	155	26	0.5176	0.0028	1.591	418.175	0.000	418.175	419.766
767	horim767	35.4167	134.125	154	154	44	0	1	19	127	27	0.4242	0.0028	0.000	419.766	0.000	419.766	419.766
768	horim768	35.4167	134.375	180	180	37	0	0	21	149	28	0.4664	0.0026	0.000	419.766	0.000	419.766	419.766
769	horim769	35.4167	134.625	217	217	42	0	1	26	176	34	0.6522	0.0030	0.000	419.766	0.000	419.766	419.766
770	horim770	35.4167	134.875	103	103	37	0	0	12	83	17	0.2405	0.0023	0.000	419.766	0.000	419.766	419.766
771	horim771	35.4167	135.125	154	154	38	0	0	19	130	25	0.4152	0.0027	0.000	419.766	0.000	419.766	419.766
772	horim772	35.4167	135.375	158	158	19	0	0	10	142	17	0.3293	0.0021	17.545	401.851	0.370	402.221	419.766
773	horim773	35.4167	135.625	114	114	56	0	3	12	96	20	0.3558	0.0031	28.390	391.318	0.058	391.376	419.766
774	horim774	35.4167	135.875	87	87	52	0	1	12	72	18	0.2357	0.0027	0.000	419.766	0.000	419.766	419.766
775	horim775	35.4167	136.125	169	169	33	0	0	18	144	22	0.3826	0.0023	0.000	419.766	0.000	419.766	419.766
776	horim776	35.4167	136.375	243	243	45	0	1	33	204	43	0.6873	0.0028	0.000	419.766	0.000	419.766	419.766
777	horim777	35.4167	136.625	175	175	35	0	1	17	152	23	0.4232	0.0024	0.000	419.766	0.000	419.766	419.766
778	horim778	35.4167	136.875	189	189	37	0	1	20	164	25	0.4810	0.0025	0.000	419.766	0.000	419.766	419.766
779	horim779	35.4167	137.125	195	195	40	0	1	23	167	27	0.4938	0.0025	0.000	419.766	0.000	419.766	419.766
780	horim780	35.4167	137.375	149	149	46	0	1	20	126	26	0.4147	0.0028	0.000	419.766	0.000	419.766	419.766
781	horim781	35.4167	137.625	283	283	75	1	5	44	219	60	1.2724	0.0045	0.000	419.766	0.000	419.766	419.766
782	horim782	35.4167	137.875	253	253	64	0	4	42	204	54	0.8607	0.0034	0.000	419.766	0.000	419.766	419.766
783	horim783	35.4167	138.125	250	250	110	2	8	42	177	61	1.6981	0.0068	0.000	419.766	0.000	419.766	419.766
784	horim784	35.4167	138.375	188	188	86	1	2	38	142	46	0.8043	0.0043	0.000	419.766	0.000	419.766	419.766
785	horim785	35.4167	138.625	156	156	101	0	5	32	102	44	1.3583	0.0087	0.000	419.766	0.000	419.766	419.766
786	horim786	35.4167	138.875	180	180	82	0	6	29	136	40	1.2862	0.0071	0.000	419.766	0.000	419.766	419.766
787	horim787	35.4167	139.125	252	252	61	0	3	40	196	49	0.8398	0.0033	0.000	419.766	0.000	419.766	419.766
788	horim788	35.4167	139.375	175	175	33	0	0	19	149	20	0.4245	0.0024	0.000	419.766	0.000	419.766	419.766
789	horim789	35.4167	139.625	150	150	24	0	0	12	135	10	0.3380	0.0023	128.239	277.297	14.229	291.527	419.766
790	horim790	35.4167	139.875	85	85	14	0	0	4	79	5	0.1670	0.0020	288.815	127.656	3.295	130.951	419.766
791	horim791	35.4167	140.125	133	133	14	0	0	6	122	8	0.2745	0.0021	6.970	412.777	0.018	412.796	419.766
792	horim792	35.4167	140.375	137	137	15	0	0	7	128	7	0.3257	0.0024	157.641	262.125	0.000	262.125	419.766
793	horim793	35.2500	132.375	118	118	21	0	0	8	106	8	0.2844	0.0024	390.120	30.452	0.045	30.497	420.617

794	horim794	35.2500	132.625	157	157	23	0	1	9	145	10	0.3777	0.0024	107.959	312.640	0.018	312.658	420.617
795	horim795	35.2500	132.875	156	156	21	0	1	8	143	13	0.3480	0.0022	0.000	420.617	0.000	420.617	420.617
796	horim796	35.2500	133.125	92	92	37	0	2	5	81	11	0.1941	0.0021	0.000	420.617	0.000	420.617	420.617
797	horim797	35.2500	133.375	157	157	47	0	2	18	132	22	0.3982	0.0025	0.000	420.617	0.000	420.617	420.617
798	horim798	35.2500	133.625	182	182	53	0	2	26	150	38	0.5166	0.0028	0.000	420.617	0.000	420.617	420.617
799	horim799	35.2500	133.875	161	161	42	0	1	19	137	28	0.4098	0.0025	0.000	420.617	0.000	420.617	420.617
800	horim800	35.2500	134.125	214	214	46	0	1	28	172	39	0.6221	0.0029	0.000	420.617	0.000	420.617	420.617
801	horim801	35.2500	134.375	195	195	61	1	1	26	158	38	0.5980	0.0031	0.000	420.617	0.000	420.617	420.617
802	horim802	35.2500	134.625	149	149	41	0	0	20	126	30	0.4226	0.0028	0.000	420.617	0.000	420.617	420.617
803	horim803	35.2500	134.875	123	123	23	0	0	9	106	15	0.2758	0.0022	0.000	420.617	0.000	420.617	420.617
804	horim804	35.2500	135.125	124	124	29	0	0	12	109	15	0.2720	0.0022	0.000	420.617	0.000	420.617	420.617
805	horim805	35.2500	135.375	51	51	12	0	0	2	46	4	0.0977	0.0019	0.000	420.617	0.000	420.617	420.617
806	horim806	35.2500	135.625	103	103	72	0	3	15	81	27	0.3379	0.0033	0.000	420.617	0.000	420.617	420.617
807	horim807	35.2500	135.875	142	142	65	0	2	24	111	32	0.3868	0.0027	0.000	420.617	0.000	420.617	420.617
808	horim808	35.2500	136.125	104	104	24	0	0	8	91	12	0.2296	0.0022	0.000	420.617	0.000	420.617	420.617
809	horim809	35.2500	136.375	207	207	41	0	0	27	170	32	0.6204	0.0030	0.000	420.617	0.000	420.617	420.617
810	horim810	35.2500	136.625	234	234	49	0	1	34	188	41	0.6818	0.0029	0.000	420.617	0.000	420.617	420.617
811	horim811	35.2500	136.875	114	114	23	0	0	9	104	11	0.2660	0.0023	0.000	420.617	0.000	420.617	420.617
812	horim812	35.2500	137.125	246	246	36	0	1	26	210	33	0.7029	0.0029	0.000	420.617	0.000	420.617	420.617
813	horim813	35.2500	137.375	135	135	43	0	1	16	115	22	0.3562	0.0026	0.000	420.617	0.000	420.617	420.617
814	horim814	35.2500	137.625	208	208	62	1	1	31	172	41	0.6899	0.0033	0.000	420.617	0.000	420.617	420.617
815	horim815	35.2500	137.875	248	248	80	2	2	42	200	52	0.9832	0.0040	0.000	420.617	0.000	420.617	420.617
816	horim816	35.2500	138.125	253	253	112	3	5	45	178	61	1.4891	0.0059	0.000	420.617	0.000	420.617	420.617
817	horim817	35.2500	138.375	172	172	61	0	1	31	133	35	0.4780	0.0028	0.000	420.617	0.000	420.617	420.617
818	horim818	35.2500	138.625	202	202	64	0	4	28	154	34	0.7591	0.0038	0.000	420.617	0.000	420.617	420.617
819	horim819	35.2500	138.875	248	248	57	0	3	38	205	46	0.7517	0.0030	0.000	420.617	0.000	420.617	420.617
820	horim820	35.2500	139.125	261	261	39	0	0	33	215	38	0.7534	0.0029	101.687	318.930	0.000	318.930	420.617
821	horim821	35.2500	139.375	151	151	20	0	0	10	137	10	0.3668	0.0024	354.223	66.368	0.026	66.394	420.617
822	horim822	35.2500	139.625	171	171	31	0	1	14	147	14	0.5323	0.0031	235.973	183.068	1.576	184.644	420.617
823	horim823	35.2500	139.875	160	160	32	0	1	14	141	15	0.4375	0.0027	158.307	262.250	0.060	262.310	420.617
824	horim824	35.2500	140.125	181	181	30	0	0	18	158	20	0.5039	0.0028	0.000	420.617	0.000	420.617	420.617
825	horim825	35.2500	140.375	106	106	25	0	1	6	97	5	0.2858	0.0027	167.101	253.489	0.026	253.515	420.617
826	horim826	35.0833	132.125	135	135	18	0	0	8	121	8	0.3325	0.0025	411.876	9.589	0.000	9.589	421.464
827	horim827	35.0833	132.375	164	164	24	0	2	7	150	12	0.4101	0.0025	134.279	287.011	0.174	287.185	421.464
828	horim828	35.0833	132.625	225	225	46	0	3	24	187	36	0.6241	0.0028	0.000	421.464	0.000	421.464	421.464
829	horim829	35.0833	132.875	202	202	41	0	1	24	172	33	0.5280	0.0026	0.000	421.464	0.000	421.464	421.464
830	horim830	35.0833	133.125	212	212	56	1	2	22	171	34	0.6724	0.0032	0.000	421.464	0.000	421.464	421.464
831	horim831	35.0833	133.375	181	181	50	0	3	20	149	31	0.4884	0.0027	0.000	421.464	0.000	421.464	421.464
832	horim832	35.0833	133.625	233	233	68	2	1	30	190	36	0.9788	0.0042	0.000	421.464	0.000	421.464	421.464
833	horim833	35.0833	133.875	80	80	20	0	0	5	70	7	0.2668	0.0033	0.000	421.464	0.000	421.464	421.464

834	horim834	35.0833	134.125	166	166	51	1	1	15	139	22	0.4896	0.0029	0.000	421.464	0.000	421.464	421.464
835	horim835	35.0833	134.375	139	139	57	1	0	17	117	23	0.6139	0.0044	0.000	421.464	0.000	421.464	421.464
836	horim836	35.0833	134.625	215	215	47	1	0	23	179	31	0.8677	0.0040	0.000	421.464	0.000	421.464	421.464
837	horim837	35.0833	134.875	208	208	33	0	0	22	176	27	0.5756	0.0028	0.000	421.464	0.000	421.464	421.464
838	horim838	35.0833	135.125	106	106	20	0	0	7	97	8	0.2188	0.0021	0.000	421.464	0.000	421.464	421.464
839	horim839	35.0833	135.375	77	77	29	0	0	7	64	11	0.1993	0.0026	0.000	421.464	0.000	421.464	421.464
840	horim840	35.0833	135.625	193	193	36	0	1	19	161	24	0.5310	0.0028	0.000	421.464	0.000	421.464	421.464
841	horim841	35.0833	135.875	211	211	35	0	1	20	174	24	0.6052	0.0029	0.000	421.464	0.000	421.464	421.464
842	horim842	35.0833	136.125	127	127	32	0	1	10	108	15	0.3177	0.0025	0.000	421.464	0.000	421.464	421.464
843	horim843	35.0833	136.375	203	203	63	0	3	31	155	40	0.6867	0.0034	0.000	421.464	0.000	421.464	421.464
844	horim844	35.0833	136.625	174	174	31	0	0	18	151	19	0.4560	0.0026	12.312	409.149	0.003	409.152	421.464
845	horim845	35.0833	136.875	96	96	21	0	0	7	89	10	0.2268	0.0024	49.670	362.854	8.941	371.795	421.464
846	horim846	35.0833	137.125	113	113	21	0	0	8	105	11	0.2718	0.0024	0.000	421.464	0.000	421.464	421.464
847	horim847	35.0833	137.375	159	159	74	1	1	26	126	34	0.5609	0.0035	0.000	421.464	0.000	421.464	421.464
848	horim848	35.0833	137.625	206	206	68	1	2	29	161	36	0.7230	0.0035	0.000	421.464	0.000	421.464	421.464
849	horim849	35.0833	137.875	182	182	87	1	3	33	138	42	0.7100	0.0039	0.000	421.464	0.000	421.464	421.464
850	horim850	35.0833	138.125	211	211	82	1	4	33	159	45	0.7733	0.0037	0.000	421.464	0.000	421.464	421.464
851	horim851	35.0833	138.375	191	191	41	0	1	23	163	27	0.5071	0.0027	0.274	421.190	0.000	421.190	421.464
852	horim852	35.0833	138.625	166	166	22	0	0	12	151	13	0.3845	0.0023	257.609	163.855	0.000	163.855	421.464
853	horim853	35.0833	138.875	166	166	25	0	0	14	150	13	0.4072	0.0025	126.905	294.380	0.179	294.559	421.464
854	horim854	35.0833	139.125	223	223	36	0	1	23	190	23	0.6851	0.0031	250.265	170.635	0.564	171.199	421.464
855	horim855	35.0833	139.625	70	70	30	0	1	4	65	5	0.2188	0.0031	402.848	17.648	0.969	18.617	421.464
856	horim856	35.0833	139.875	192	192	28	0	1	15	173	14	0.5567	0.0029	147.945	273.420	0.100	273.520	421.464
857	horim857	35.0833	140.125	223	223	35	0	2	19	191	21	0.7342	0.0033	220.238	201.021	0.205	201.227	421.464
858	horim858	35.0833	140.375	94	94	36	0	1	8	82	6	0.2702	0.0029	395.434	26.020	0.011	26.031	421.464
859	horim859	34.9167	131.875	2	2	NA	0	0	0	2	1	0.0024	0.0012	422.002	0.238	0.069	0.306	422.308
860	horim860	34.9167	132.125	204	204	22	0	0	15	184	16	0.5829	0.0029	152.505	269.204	0.599	269.803	422.308
861	horim861	34.9167	132.375	177	177	31	0	2	12	157	19	0.4505	0.0025	0.000	422.308	0.000	422.308	422.308
862	horim862	34.9167	132.625	219	219	41	0	2	23	184	35	0.5942	0.0027	0.000	422.308	0.000	422.308	422.308
863	horim863	34.9167	132.875	211	211	53	1	2	20	175	33	0.6129	0.0029	0.000	422.308	0.000	422.308	422.308
864	horim864	34.9167	133.125	223	223	78	3	1	25	182	37	1.0236	0.0046	0.000	422.308	0.000	422.308	422.308
865	horim865	34.9167	133.375	217	217	84	3	2	25	176	34	1.0914	0.0050	0.000	422.308	0.000	422.308	422.308
866	horim866	34.9167	133.625	126	126	119	3	3	12	103	19	0.8152	0.0065	0.000	422.308	0.000	422.308	422.308
867	horim867	34.9167	133.875	137	137	67	2	0	11	115	14	0.5805	0.0042	0.000	422.308	0.000	422.308	422.308
868	horim868	34.9167	134.125	168	168	50	1	1	15	145	19	0.5006	0.0030	0.000	422.308	0.000	422.308	422.308
869	horim869	34.9167	134.375	206	206	44	1	0	20	175	26	0.8163	0.0040	0.000	422.308	0.000	422.308	422.308
870	horim870	34.9167	134.625	167	167	44	1	0	15	146	16	0.6912	0.0041	0.000	422.308	0.000	422.308	422.308
871	horim871	34.9167	134.875	130	130	26	0	1	8	116	10	0.3138	0.0024	0.000	422.308	0.000	422.308	422.308
872	horim872	34.9167	135.125	144	144	33	0	0	16	126	19	0.3599	0.0025	0.000	422.308	0.000	422.308	422.308
873	horim873	34.9167	135.375	230	230	46	0	2	28	188	35	0.6588	0.0029	0.000	422.308	0.000	422.308	422.308

874	horim874	34.9167	135.625	80	80	44	0	1	8	66	12	0.2027	0.0025	0.000	422.308	0.000	422.308	422.308
875	horim875	34.9167	135.875	97	97	35	0	0	11	83	14	0.2496	0.0026	0.000	422.308	0.000	422.308	422.308
876	horim876	34.9167	136.125	128	128	38	0	1	13	112	19	0.3677	0.0029	0.000	422.308	0.000	422.308	422.308
877	horim877	34.9167	136.375	185	185	51	0	2	24	150	32	0.5455	0.0029	0.000	422.308	0.000	422.308	422.308
878	horim878	34.9167	136.625	96	96	22	0	0	7	87	8	0.3032	0.0032	180.351	238.484	3.473	241.957	422.308
879	horim879	34.9167	136.875	87	87	17	0	0	5	81	6	0.2437	0.0028	168.015	253.446	0.847	254.293	422.308
880	horim880	34.9167	137.125	156	156	39	1	0	11	140	12	0.4507	0.0029	0.000	422.308	0.000	422.308	422.308
881	horim881	34.9167	137.375	194	194	51	1	0	23	164	25	0.5739	0.0030	0.000	422.308	0.000	422.308	422.308
882	horim882	34.9167	137.625	228	228	59	1	2	27	183	33	0.7530	0.0033	0.000	422.308	0.000	422.308	422.308
883	horim883	34.9167	137.875	185	185	54	1	0	24	156	29	0.5463	0.0030	0.000	422.308	0.000	422.308	422.308
884	horim884	34.9167	138.125	197	197	50	1	1	20	170	26	0.5774	0.0029	0.000	422.308	0.000	422.308	422.308
885	horim885	34.9167	138.375	189	189	19	0	0	12	171	11	0.5011	0.0027	167.773	254.484	0.050	254.535	422.308
886	horim886	34.9167	138.625	28	28	NA	0	0	1	27	1	0.0521	0.0019	417.221	5.087	0.000	5.087	422.308
887	horim887	34.9167	138.875	247	247	40	0	1	29	205	34	0.7835	0.0032	40.085	382.218	0.005	382.223	422.308
888	horim888	34.9167	139.125	231	231	46	1	0	25	193	27	0.7581	0.0033	216.216	206.047	0.045	206.092	422.308
889	horim889	34.9167	139.875	121	121	32	0	1	10	108	9	0.4016	0.0033	275.266	146.963	0.079	147.042	422.308
890	horim890	34.7500	129.375	69	69	43	0	2	4	63	3	0.5667	0.0082	405.862	0.000	17.287	17.287	423.148
891	horim891	34.7500	131.125	101	101	64	1	2	6	89	4	0.4486	0.0044	415.431	0.000	7.718	7.718	423.148
892	horim892	34.7500	131.625	76	76	28	0	1	4	69	4	0.2152	0.0028	418.770	4.320	0.058	4.378	423.148
893	horim893	34.7500	131.875	186	186	19	0	0	12	170	11	0.5164	0.0028	231.649	191.143	0.357	191.499	423.148
894	horim894	34.7500	132.125	224	224	44	0	2	25	181	36	0.6859	0.0031	0.000	423.148	0.000	423.148	423.148
895	horim895	34.7500	132.375	205	205	41	0	2	21	173	33	0.5599	0.0027	0.000	423.148	0.000	423.148	423.148
896	horim896	34.7500	132.625	132	132	49	0	2	15	110	19	0.3077	0.0023	0.000	423.148	0.000	423.148	423.148
897	horim897	34.7500	132.875	178	178	53	1	2	15	150	19	0.4703	0.0026	0.000	423.148	0.000	423.148	423.148
898	horim898	34.7500	133.125	203	203	81	3	2	20	171	32	0.9074	0.0045	0.000	423.148	0.000	423.148	423.148
899	horim899	34.7500	133.375	238	238	63	2	2	24	199	32	1.0806	0.0045	0.000	423.148	0.000	423.148	423.148
900	horim900	34.7500	133.625	161	161	75	2	2	15	136	19	0.6777	0.0042	0.000	423.148	0.000	423.148	423.148
901	horim901	34.7500	133.875	158	158	41	1	1	9	142	13	0.8143	0.0052	0.000	423.148	0.000	423.148	423.148
902	horim902	34.7500	134.125	90	90	46	1	0	5	84	7	0.2212	0.0025	13.379	407.586	2.184	409.769	423.148
903	horim903	34.7500	134.375	187	187	45	1	1	16	166	17	0.9514	0.0051	167.531	239.442	16.175	255.617	423.148
904	horim904	34.7500	134.625	135	135	11	0	0	5	129	6	0.3341	0.0025	253.796	163.461	5.891	169.352	423.148
905	horim905	34.7500	134.875	87	87	20	0	0	6	80	5	0.2253	0.0026	79.549	338.881	4.719	343.600	423.148
906	horim906	34.7500	135.125	267	267	34	0	1	26	227	32	0.7704	0.0029	10.633	410.192	2.324	412.516	423.148
907	horim907	34.7500	135.375	187	187	27	0	0	16	159	20	0.5011	0.0027	49.316	361.555	12.277	373.832	423.148
908	horim908	34.7500	135.625	123	123	27	0	1	8	109	9	0.3123	0.0025	0.000	423.148	0.000	423.148	423.148
909	horim909	34.7500	135.875	232	232	33	0	1	22	198	28	0.6787	0.0029	0.000	423.148	0.000	423.148	423.148
910	horim910	34.7500	136.125	205	205	38	0	2	20	183	28	0.5753	0.0028	0.000	423.148	0.000	423.148	423.148
911	horim911	34.7500	136.375	186	186	41	0	2	19	158	25	0.5024	0.0027	0.000	423.148	0.000	423.148	423.148
912	horim912	34.7500	136.625	85	85	10	0	0	3	81	5	0.2184	0.0026	339.664	83.484	0.000	83.484	423.148
913	horim913	34.7500	136.875	93	93	22	0	1	4	87	3	0.2534	0.0027	319.253	103.859	0.037	103.896	423.148

914	horim914	34.7500	137.125	143	143	21	0	0	10	131	11	0.3633	0.0025	296.163	122.716	4.270	126.986	423.148
915	horim915	34.7500	137.375	215	215	41	1	0	20	189	19	0.7705	0.0036	75.870	344.915	2.363	347.278	423.148
916	horim916	34.7500	137.625	150	150	48	1	1	12	134	15	0.8181	0.0055	12.106	411.043	0.000	411.043	423.148
917	horim917	34.7500	137.875	114	114	39	1	0	6	106	6	0.3261	0.0029	0.000	423.148	0.000	423.148	423.148
918	horim918	34.7500	138.125	205	205	40	1	0	18	182	21	0.6521	0.0032	21.375	401.763	0.011	401.773	423.148
919	horim919	34.7500	138.375	66	66	18	0	0	4	62	2	0.1262	0.0019	367.359	55.784	0.005	55.790	423.148
920	horim920	34.7500	138.625	13	13	NA	0	0	0	13	0	0.0346	0.0027	420.897	2.210	0.042	2.252	423.148
921	horim921	34.7500	138.875	260	260	35	0	0	30	221	31	0.8068	0.0031	31.671	391.242	0.235	391.477	423.148
922	horim922	34.7500	139.125	137	137	24	0	0	11	122	9	0.3688	0.0027	370.824	52.324	0.000	52.324	423.148
923	horim923	34.7500	139.375	148	148	22	0	1	8	135	6	0.4598	0.0031	332.144	0.000	91.005	91.005	423.148
924	horim924	34.5833	129.375	181	181	30	0	2	11	157	8	0.9166	0.0051	179.794	0.000	244.191	244.191	423.985
925	horim925	34.5833	131.375	126	126	31	0	1	10	112	6	0.3996	0.0032	407.258	12.611	4.116	16.727	423.985
926	horim926	34.5833	131.625	179	179	32	0	2	13	160	15	0.5341	0.0030	95.421	328.373	0.191	328.564	423.985
927	horim927	34.5833	131.875	162	162	26	0	1	11	147	16	0.4166	0.0026	0.000	423.985	0.000	423.985	423.985
928	horim928	34.5833	132.125	259	259	53	1	1	31	208	43	0.9699	0.0037	0.000	423.985	0.000	423.985	423.985
929	horim929	34.5833	132.375	262	262	54	1	2	30	217	43	0.8007	0.0031	0.000	423.985	0.000	423.985	423.985
930	horim930	34.5833	132.625	229	229	52	1	2	23	190	31	0.7142	0.0031	0.000	423.985	0.000	423.985	423.985
931	horim931	34.5833	132.875	160	160	62	1	2	17	133	23	0.4520	0.0028	0.000	423.985	0.000	423.985	423.985
932	horim932	34.5833	133.125	192	192	53	1	2	18	164	25	0.5373	0.0028	0.000	423.985	0.000	423.985	423.985
933	horim933	34.5833	133.375	205	205	41	1	1	15	177	22	0.5835	0.0028	0.284	423.701	0.000	423.701	423.985
934	horim934	34.5833	133.625	132	132	18	0	1	5	123	7	0.3074	0.0023	11.553	412.427	0.005	412.432	423.985
935	horim935	34.5833	133.875	110	110	14	0	0	5	102	7	0.2307	0.0021	15.151	408.298	0.536	408.834	423.985
936	horim936	34.5833	134.125	125	125	14	0	0	6	118	7	0.3406	0.0027	252.976	148.621	22.388	171.009	423.985
937	horim937	34.5833	134.375	215	215	49	2	0	16	188	20	2.6417	0.0123	362.266	0.000	61.719	61.719	423.985
938	horim938	34.5833	134.625	92	92	20	0	0	6	84	6	0.2136	0.0023	415.677	0.000	8.308	8.308	423.985
939	horim939	34.5833	134.875	79	79	11	0	0	3	76	0	0.1994	0.0025	343.750	12.301	67.934	80.235	423.985
940	horim940	34.5833	135.125	112	112	26	0	0	10	102	8	0.2616	0.0023	347.072	59.777	17.135	76.913	423.985
941	horim941	34.5833	135.375	48	48	31	0	1	2	44	3	0.1315	0.0027	286.568	123.230	14.187	137.417	423.985
942	horim942	34.5833	135.625	99	99	25	0	1	5	90	6	0.2274	0.0023	0.000	423.985	0.000	423.985	423.985
943	horim943	34.5833	135.875	195	195	28	0	0	18	169	23	0.5212	0.0027	0.000	423.985	0.000	423.985	423.985
944	horim944	34.5833	136.125	240	240	53	0	2	34	190	44	0.8009	0.0033	0.000	423.985	0.000	423.985	423.985
945	horim945	34.5833	136.375	159	159	40	0	0	21	134	25	0.3804	0.0024	0.000	423.985	0.000	423.985	423.985
946	horim946	34.5833	136.625	112	112	16	0	0	6	102	7	0.2841	0.0025	191.950	232.035	0.000	232.035	423.985
947	horim947	34.5833	136.875	138	138	17	0	0	8	127	8	0.4164	0.0030	409.465	5.986	8.534	14.520	423.985
948	horim948	34.5833	137.125	184	184	22	0	1	11	171	13	0.5686	0.0031	296.853	126.769	0.363	127.132	423.985
949	horim949	34.5833	137.375	95	95	15	0	0	5	90	3	0.2673	0.0028	378.563	45.422	0.000	45.422	423.985
950	horim950	34.5833	137.625	2	2	NA	0	0	2	0	2	0.0196	0.0098	419.559	4.427	0.000	4.427	423.985
951	horim951	34.5833	137.875	45	45	13	0	0	2	43	2	0.0936	0.0021	395.442	28.543	0.000	28.543	423.985
952	horim952	34.5833	138.125	114	114	15	0	0	6	107	6	0.2748	0.0024	345.082	78.400	0.503	78.903	423.985
953	horim953	34.5833	138.875	137	137	26	0	0	12	124	11	0.3984	0.0029	348.415	75.114	0.456	75.570	423.985

954	horim954	34.5833	139.375	107	107	40	0	3	5	95	6	0.3901	0.0036	419.877	0.000	4.108	4.108	423.985
955	horim955	34.4167	129.125	4	4	NA	0	0	0	4	0	0.0106	0.0027	422.589	0.000	2.229	2.229	424.818
956	horim956	34.4167	129.375	101	101	33	0	1	8	91	6	0.3930	0.0039	253.954	0.000	170.864	170.864	424.818
957	horim957	34.4167	130.875	88	88	10	0	0	3	83	2	0.1963	0.0022	384.159	36.333	4.326	40.659	424.818
958	horim958	34.4167	131.125	122	122	24	0	0	10	111	9	0.3350	0.0027	257.939	153.470	13.409	166.879	424.818
959	horim959	34.4167	131.375	223	223	30	0	2	16	199	14	0.7671	0.0034	180.993	238.072	5.753	243.825	424.818
960	horim960	34.4167	131.625	203	203	43	0	2	22	170	28	0.6418	0.0032	0.000	424.818	0.000	424.818	424.818
961	horim961	34.4167	131.875	230	230	45	0	2	27	190	39	0.6652	0.0029	0.000	424.818	0.000	424.818	424.818
962	horim962	34.4167	132.125	245	245	51	0	3	30	195	42	0.8196	0.0033	0.000	424.818	0.000	424.818	424.818
963	horim963	34.4167	132.375	292	292	40	0	2	31	241	39	0.9881	0.0034	32.391	391.141	1.286	392.427	424.818
964	horim964	34.4167	132.625	232	232	50	1	2	22	196	29	0.7186	0.0031	2.519	422.296	0.003	422.299	424.818
965	horim965	34.4167	132.875	231	231	52	1	2	24	195	28	0.7329	0.0032	0.098	424.720	0.000	424.720	424.818
966	horim966	34.4167	133.125	205	205	50	1	2	18	177	21	0.6730	0.0033	66.922	319.314	38.582	357.896	424.818
967	horim967	34.4167	133.375	168	168	23	0	0	13	152	11	0.4447	0.0026	180.380	225.934	18.504	244.438	424.818
968	horim968	34.4167	133.625	109	109	16	0	0	6	100	6	0.2524	0.0023	341.909	50.781	32.128	82.909	424.818
969	horim969	34.4167	133.875	101	101	8	0	0	3	98	4	0.3350	0.0033	263.472	139.652	21.694	161.346	424.818
970	horim970	34.4167	134.125	185	185	15	0	0	9	171	9	0.7418	0.0040	307.423	57.420	59.975	117.395	424.818
971	horim971	34.4167	134.375	138	138	17	0	0	8	126	8	0.4160	0.0030	376.104	1.302	47.412	48.714	424.818
972	horim972	34.4167	134.625	18	18	NA	0	0	1	17	0	0.0515	0.0029	422.639	0.000	2.179	2.179	424.818
973	horim973	34.4167	134.875	130	130	24	0	0	10	114	9	0.3647	0.0028	209.867	0.000	214.951	214.951	424.818
974	horim974	34.4167	135.125	50	50	6	0	0	1	49	0	0.0909	0.0018	413.464	7.847	3.507	11.354	424.818
975	horim975	34.4167	135.375	239	239	40	0	1	27	197	33	0.7278	0.0030	101.325	319.726	3.766	323.493	424.818
976	horim976	34.4167	135.625	265	265	53	0	3	37	218	47	0.9050	0.0034	0.000	424.818	0.000	424.818	424.818
977	horim977	34.4167	135.875	231	231	42	0	2	25	194	32	0.6973	0.0030	0.000	424.818	0.000	424.818	424.818
978	horim978	34.4167	136.125	242	242	72	1	2	41	187	49	0.9026	0.0037	0.000	424.818	0.000	424.818	424.818
979	horim979	34.4167	136.375	121	121	50	0	1	16	95	20	0.3669	0.0030	0.000	424.818	0.000	424.818	424.818
980	horim980	34.4167	136.625	213	213	32	0	0	22	181	24	1.0482	0.0049	3.165	421.478	0.175	421.653	424.818
981	horim981	34.4167	136.875	218	218	37	0	2	20	186	23	0.7271	0.0033	184.479	233.902	6.437	240.339	424.818
982	horim982	34.4167	139.125	123	123	32	0	2	7	111	7	0.4155	0.0034	423.973	0.000	0.845	0.845	424.818
983	horim983	34.4167	139.375	3	3	NA	0	0	0	3	0	0.0087	0.0029	402.322	0.000	22.497	22.497	424.818
984	horim984	34.2500	129.125	105	105	46	1	0	7	95	8	1.5423	0.0147	337.512	0.000	88.136	88.136	425.648
985	horim985	34.2500	129.375	205	205	35	0	3	14	177	12	1.1790	0.0058	307.734	0.000	117.913	117.913	425.648
986	horim986	34.2500	130.125	41	41	43	0	1	3	37	1	0.1792	0.0044	424.706	0.000	0.942	0.942	425.648
987	horim987	34.2500	130.875	162	162	27	0	1	12	148	13	0.4560	0.0028	268.627	156.510	0.511	157.021	425.648
988	horim988	34.2500	131.125	158	158	17	0	0	9	145	11	0.3873	0.0025	0.000	425.648	0.000	425.648	425.648
989	horim989	34.2500	131.375	222	222	21	0	0	15	198	18	0.6355	0.0029	0.000	425.648	0.000	425.648	425.648
990	horim990	34.2500	131.625	242	242	39	0	3	21	202	31	0.8077	0.0033	0.000	425.648	0.000	425.648	425.648
991	horim991	34.2500	131.875	210	210	42	0	2	22	172	27	0.6341	0.0030	0.000	425.648	0.000	425.648	425.648
992	horim992	34.2500	132.125	223	223	36	0	2	20	190	24	0.7376	0.0033	10.740	414.907	0.000	414.907	425.648
993	horim993	34.2500	132.375	247	247	36	0	1	25	206	26	0.8355	0.0034	277.282	32.952	115.413	148.365	425.648

994	horim994	34.2500	132.625	247	247	36	0	2	23	212	28	0.7706	0.0031	114.318	277.185	34.145	311.330	425.648
995	horim995	34.2500	132.875	166	166	25	0	0	14	151	15	0.4245	0.0026	266.853	65.564	93.231	158.794	425.648
996	horim996	34.2500	133.125	84	84	10	0	0	3	81	2	0.3790	0.0045	251.355	2.267	172.025	174.292	425.648
997	horim997	34.2500	133.375	56	56	16	0	0	3	53	3	0.1203	0.0021	421.549	0.000	4.099	4.099	425.648
998	horim998	34.2500	133.625	159	159	13	0	0	7	147	7	0.4928	0.0031	320.861	95.929	8.858	104.787	425.648
999	horim999	34.2500	133.875	217	217	23	0	0	16	191	17	0.6394	0.0029	30.621	394.131	0.896	395.027	425.648
1000	horim1000	34.2500	134.125	175	175	28	0	1	13	156	16	0.4481	0.0026	2.459	423.189	0.000	423.189	425.648
1001	horim1001	34.2500	134.375	155	155	33	0	1	14	139	16	0.4333	0.0028	225.123	200.381	0.144	200.525	425.648
1002	horim1002	34.2500	134.625	175	175	19	0	0	11	162	9	0.5725	0.0033	265.344	62.662	97.641	160.303	425.648
1003	horim1003	34.2500	134.875	136	136	20	0	0	9	123	5	0.4127	0.0030	211.846	0.000	213.801	213.801	425.648
1004	horim1004	34.2500	135.125	105	105	27	0	0	9	90	7	0.3785	0.0036	198.206	224.758	2.683	227.441	425.648
1005	horim1005	34.2500	135.375	127	127	31	0	0	13	109	14	0.4052	0.0032	0.000	425.648	0.000	425.648	425.648
1006	horim1006	34.2500	135.625	254	254	67	1	3	36	199	48	0.8965	0.0035	0.000	425.648	0.000	425.648	425.648
1007	horim1007	34.2500	135.875	235	235	78	1	3	38	172	52	1.0797	0.0046	0.000	425.648	0.000	425.648	425.648
1008	horim1008	34.2500	136.125	260	260	78	1	3	44	190	57	1.1405	0.0044	0.000	425.648	0.000	425.648	425.648
1009	horim1009	34.2500	136.375	166	166	35	0	1	16	144	18	0.4817	0.0029	79.363	345.856	0.429	346.284	425.648
1010	horim1010	34.2500	136.625	101	101	30	0	0	10	90	10	0.3576	0.0035	294.963	130.264	0.420	130.684	425.648
1011	horim1011	34.2500	136.875	106	106	20	0	0	7	98	6	0.3064	0.0029	344.125	80.113	1.409	81.523	425.648
1012	horim1012	34.2500	139.125	145	145	47	1	2	7	128	7	1.5170	0.0105	403.125	0.000	22.522	22.522	425.648
1013	horim1013	34.2500	139.375	2	2	NA	0	0	1	1	1	0.0143	0.0072	424.957	0.000	0.691	0.691	425.648
1014	horim1014	34.0833	129.125	153	153	26	0	1	10	134	7	0.6589	0.0043	376.736	0.000	49.738	49.738	426.473
1015	horim1015	34.0833	129.375	45	45	20	0	0	3	42	3	0.1174	0.0026	409.285	0.000	17.188	17.188	426.473
1016	horim1016	34.0833	130.625	2	2	NA	0	0	0	2	0	0.0147	0.0073	425.257	0.000	1.216	1.216	426.473
1017	horim1017	34.0833	130.875	212	212	33	0	3	14	189	14	0.7355	0.0035	248.002	176.073	2.398	178.471	426.473
1018	horim1018	34.0833	131.125	183	183	23	0	1	11	166	13	0.5321	0.0029	37.273	389.201	0.000	389.201	426.473
1019	horim1019	34.0833	131.375	191	191	24	0	1	12	170	14	0.6048	0.0032	20.036	406.430	0.008	406.438	426.473
1020	horim1020	34.0833	131.625	173	173	21	0	0	12	157	13	0.5041	0.0029	67.441	348.055	10.977	359.033	426.473
1021	horim1021	34.0833	131.875	184	184	30	0	2	12	164	17	0.5019	0.0027	29.255	394.821	2.398	397.218	426.473
1022	horim1022	34.0833	132.125	198	198	33	0	2	15	173	17	0.6146	0.0031	48.458	378.016	0.000	378.016	426.473
1023	horim1023	34.0833	132.375	168	168	25	0	0	14	150	12	0.4196	0.0025	380.137	0.229	46.108	46.337	426.473
1024	horim1024	34.0833	132.625	128	128	28	0	0	12	114	9	0.3696	0.0029	379.195	0.000	47.278	47.278	426.473
1025	horim1025	34.0833	132.875	89	89	10	0	0	3	86	4	0.1790	0.0020	270.057	143.577	12.840	156.417	426.473
1026	horim1026	34.0833	133.125	55	55	5	0	0	1	53	1	0.1076	0.0020	367.864	25.930	32.679	58.609	426.473
1027	horim1027	34.0833	133.375	58	58	36	0	1	4	53	4	0.2858	0.0049	425.578	0.000	0.895	0.895	426.473
1028	horim1028	34.0833	133.625	212	212	32	0	1	19	182	22	0.6436	0.0030	210.771	214.672	1.031	215.703	426.473
1029	horim1029	34.0833	133.875	181	181	43	0	3	16	153	22	0.5874	0.0032	0.000	426.473	0.000	426.473	426.473
1030	horim1030	34.0833	134.125	236	236	54	0	3	32	189	40	0.8714	0.0037	0.000	426.473	0.000	426.473	426.473
1031	horim1031	34.0833	134.375	188	188	32	0	2	13	163	14	0.5888	0.0031	0.000	426.473	0.000	426.473	426.473
1032	horim1032	34.0833	134.625	189	189	17	0	0	11	173	11	0.5716	0.0030	242.822	183.630	0.021	183.651	426.473
1033	horim1033	34.0833	134.875	3	3	NA	0	0	0	3	0	0.0083	0.0028	424.444	0.000	2.029	2.029	426.473

1034	horim1034	34.0833	135.125	101	101	18	0	0	6	93	6	0.3097	0.0031	244.022	181.049	1.402	182.451	426.473
1035	horim1035	34.0833	135.375	206	206	36	0	1	21	177	26	0.5675	0.0028	0.000	426.473	0.000	426.473	426.473
1036	horim1036	34.0833	135.625	216	216	47	0	1	29	174	36	0.6605	0.0031	0.000	426.473	0.000	426.473	426.473
1037	horim1037	34.0833	135.875	223	223	75	1	2	36	163	46	0.8809	0.0040	0.000	426.473	0.000	426.473	426.473
1038	horim1038	34.0833	136.125	228	228	62	1	2	31	186	40	0.9076	0.0040	11.412	415.019	0.043	415.061	426.473
1039	horim1039	34.0833	136.375	179	179	20	0	0	12	163	14	0.6512	0.0036	386.177	39.313	0.983	40.297	426.473
1040	horim1040	34.0833	139.375	139	139	41	0	4	7	125	7	0.5020	0.0036	417.159	0.000	9.314	9.314	426.473
1041	horim1041	34.0833	139.625	6	6	NA	0	0	1	5	1	0.0249	0.0042	380.313	0.000	46.161	46.161	426.473
1042	horim1042	33.9167	129.625	68	68	60	0	3	4	58	5	0.5945	0.0087	414.012	0.000	13.284	13.284	427.296
1043	horim1043	33.9167	129.875	1	1	NA	0	0	0	1	0	0.0052	0.0052	425.066	0.000	2.229	2.229	427.296
1044	horim1044	33.9167	130.125	6	6	NA	0	0	0	6	0	0.0092	0.0015	426.836	0.000	0.460	0.460	427.296
1045	horim1045	33.9167	130.375	160	160	24	0	2	7	148	5	0.5201	0.0033	416.377	2.729	8.190	10.919	427.296
1046	horim1046	33.9167	130.625	107	107	25	0	0	9	98	4	0.3447	0.0032	271.229	155.185	0.881	156.066	427.296
1047	horim1047	33.9167	130.875	243	243	29	0	2	17	218	20	0.8525	0.0035	156.973	268.375	1.948	270.323	427.296
1048	horim1048	33.9167	131.125	199	199	19	0	1	10	186	12	0.6168	0.0031	361.456	65.741	0.099	65.839	427.296
1049	horim1049	33.9167	131.375	123	123	19	0	0	8	113	6	0.3326	0.0027	354.733	72.480	0.083	72.563	427.296
1050	horim1050	33.9167	131.625	115	115	13	0	0	5	107	5	0.2392	0.0021	420.045	0.798	6.452	7.250	427.296
1051	horim1051	33.9167	131.875	130	130	25	0	1	8	121	6	0.3816	0.0029	340.626	74.085	12.584	86.670	427.296
1052	horim1052	33.9167	132.125	195	195	26	0	1	14	175	14	0.5933	0.0030	176.929	185.701	64.666	250.366	427.296
1053	horim1053	33.9167	132.375	182	182	20	0	0	12	163	10	0.5466	0.0030	347.112	0.000	80.184	80.184	427.296
1054	horim1054	33.9167	132.625	168	168	16	0	0	9	156	6	0.4877	0.0029	353.347	29.303	44.645	73.948	427.296
1055	horim1055	33.9167	132.875	261	261	22	0	0	19	229	24	0.7932	0.0030	18.661	408.504	0.131	408.635	427.296
1056	horim1056	33.9167	133.125	171	171	32	0	2	12	154	15	0.6276	0.0037	111.360	315.936	0.000	315.936	427.296
1057	horim1057	33.9167	133.375	302	302	55	0	6	35	244	50	1.4559	0.0048	52.976	372.532	1.788	374.320	427.296
1058	horim1058	33.9167	133.625	235	235	52	0	4	25	183	32	1.0129	0.0043	13.540	413.756	0.000	413.756	427.296
1059	horim1059	33.9167	133.875	186	186	55	0	4	21	154	31	0.7640	0.0041	0.000	427.296	0.000	427.296	427.296
1060	horim1060	33.9167	134.125	217	217	87	2	3	29	159	41	1.4771	0.0068	0.000	427.296	0.000	427.296	427.296
1061	horim1061	33.9167	134.375	218	218	107	3	6	30	170	40	2.3908	0.0110	0.000	427.296	0.000	427.296	427.296
1062	horim1062	33.9167	134.625	230	230	76	3	2	22	188	28	2.2112	0.0096	125.258	300.101	1.937	302.038	427.296
1063	horim1063	33.9167	134.875	77	77	27	0	0	7	70	4	0.2282	0.0030	425.475	0.000	1.820	1.820	427.296
1064	horim1064	33.9167	135.125	146	146	16	0	0	8	138	8	0.5191	0.0036	187.948	238.573	0.774	239.348	427.296
1065	horim1065	33.9167	135.375	164	164	69	1	2	22	135	32	0.5837	0.0036	0.000	427.296	0.000	427.296	427.296
1066	horim1066	33.9167	135.625	204	204	73	1	3	29	158	40	0.7424	0.0036	0.000	427.296	0.000	427.296	427.296
1067	horim1067	33.9167	135.875	244	244	70	1	3	35	187	45	0.9871	0.0040	0.000	427.296	0.000	427.296	427.296
1068	horim1068	33.9167	136.125	225	225	63	1	3	27	182	35	0.8821	0.0039	147.364	279.833	0.099	279.932	427.296
1069	horim1069	33.9167	136.375	150	150	22	0	0	11	133	13	0.4982	0.0033	419.813	7.483	0.000	7.483	427.296
1070	horim1070	33.9167	138.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	427.290	0.000	0.005	0.005	427.296
1071	horim1071	33.9167	139.625	108	108	69	1	3	6	94	9	0.7603	0.0070	406.756	0.000	20.540	20.540	427.296
1072	horim1072	33.7500	129.625	136	136	34	0	2	9	118	5	0.9856	0.0072	331.727	0.000	96.387	96.387	428.114
1073	horim1073	33.7500	129.875	70	70	43	0	2	4	63	4	0.4494	0.0064	402.071	0.000	26.044	26.044	428.114

1074	horim1074	33.7500	130.125	8	8	NA	0	0	1	7	0	0.0178	0.0022	426.923	0.000	1.192	1.192	428.114
1075	horim1075	33.7500	130.375	177	177	22	0	1	10	160	7	0.5469	0.0031	337.537	85.532	5.044	90.577	428.114
1076	horim1076	33.7500	130.625	175	175	20	0	0	12	161	9	0.5370	0.0031	0.000	428.114	0.000	428.114	428.114
1077	horim1077	33.7500	130.875	194	194	25	0	0	16	173	16	0.6893	0.0036	10.251	417.791	0.072	417.863	428.114
1078	horim1078	33.7500	131.125	88	88	30	0	1	6	81	5	0.2214	0.0025	395.218	32.813	0.083	32.896	428.114
1079	horim1079	33.7500	131.625	152	152	18	0	0	9	139	6	0.3957	0.0026	406.514	14.858	6.742	21.600	428.114
1080	horim1080	33.7500	131.875	146	146	18	0	0	9	136	5	0.3735	0.0026	419.886	0.000	8.228	8.228	428.114
1081	horim1081	33.7500	132.125	155	155	15	0	0	8	143	7	0.3978	0.0026	398.286	0.944	28.884	29.828	428.114
1082	horim1082	33.7500	132.375	38	38	NA	0	0	1	37	2	0.0729	0.0019	423.243	0.000	4.871	4.871	428.114
1083	horim1083	33.7500	132.625	187	187	19	0	0	12	172	12	0.4869	0.0026	304.951	123.161	0.003	123.163	428.114
1084	horim1084	33.7500	132.875	241	241	37	0	1	26	202	33	0.7934	0.0033	0.000	428.114	0.000	428.114	428.114
1085	horim1085	33.7500	133.125	261	261	95	2	8	34	195	53	2.5249	0.0097	0.000	428.114	0.000	428.114	428.114
1086	horim1086	33.7500	133.375	209	209	104	2	8	29	164	47	2.0577	0.0098	0.000	428.114	0.000	428.114	428.114
1087	horim1087	33.7500	133.625	251	251	64	1	4	29	197	40	1.2579	0.0050	0.000	428.114	0.000	428.114	428.114
1088	horim1088	33.7500	133.875	245	245	78	1	5	36	188	47	1.5542	0.0063	0.000	428.114	0.000	428.114	428.114
1089	horim1089	33.7500	134.125	192	192	129	3	6	31	136	45	1.6923	0.0088	0.000	428.114	0.000	428.114	428.114
1090	horim1090	33.7500	134.375	208	208	89	3	4	20	171	32	1.6924	0.0081	6.114	421.992	0.008	422.000	428.114
1091	horim1091	33.7500	134.625	160	160	45	1	0	15	144	14	0.6611	0.0041	266.357	161.551	0.206	161.757	428.114
1092	horim1092	33.7500	134.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	428.042	0.072	0.000	0.072	428.114
1093	horim1093	33.7500	135.125	110	110	19	0	0	7	103	5	0.3419	0.0031	406.698	21.416	0.000	21.416	428.114
1094	horim1094	33.7500	135.375	220	220	38	0	2	21	185	24	0.9231	0.0042	116.335	311.501	0.278	311.780	428.114
1095	horim1095	33.7500	135.625	232	232	55	1	2	26	194	32	0.8270	0.0036	0.000	428.114	0.000	428.114	428.114
1096	horim1096	33.7500	135.875	270	270	58	1	3	32	219	42	1.1390	0.0042	4.322	423.698	0.094	423.792	428.114
1097	horim1097	33.7500	136.125	101	101	24	0	0	8	91	8	0.2835	0.0028	381.322	46.792	0.000	46.792	428.114
1098	horim1098	33.5833	129.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	427.344	0.000	1.585	1.585	428.929
1099	horim1099	33.5833	129.875	132	132	25	0	2	5	125	4	0.4348	0.0033	373.574	43.190	12.165	55.355	428.929
1100	horim1100	33.5833	130.125	105	105	26	0	1	6	96	6	0.2687	0.0026	273.340	154.734	0.855	155.589	428.929
1101	horim1101	33.5833	130.375	174	174	22	0	1	10	159	11	0.5605	0.0032	115.411	307.538	5.980	313.518	428.929
1102	horim1102	33.5833	130.625	221	221	32	0	2	17	194	20	0.6737	0.0030	0.000	428.929	0.000	428.929	428.929
1103	horim1103	33.5833	130.875	195	195	40	0	1	22	163	25	0.7059	0.0036	0.000	428.929	0.000	428.929	428.929
1104	horim1104	33.5833	131.125	118	118	39	0	0	15	99	17	0.3602	0.0031	91.034	337.857	0.038	337.895	428.929
1105	horim1105	33.5833	131.375	156	156	17	0	0	9	143	7	0.4776	0.0031	202.132	226.794	0.003	226.797	428.929
1106	horim1106	33.5833	131.625	194	194	23	0	0	15	178	11	0.5599	0.0029	56.886	372.043	0.000	372.043	428.929
1107	horim1107	33.5833	132.375	143	143	19	0	0	9	127	12	0.3924	0.0027	340.193	88.733	0.003	88.736	428.929
1108	horim1108	33.5833	132.625	191	191	23	0	1	11	170	15	0.5759	0.0030	29.546	399.380	0.003	399.383	428.929
1109	horim1109	33.5833	132.875	231	231	52	0	4	26	186	37	0.8269	0.0036	0.000	428.929	0.000	428.929	428.929
1110	horim1110	33.5833	133.125	237	237	66	1	5	26	192	34	1.4688	0.0062	0.000	428.929	0.000	428.929	428.929
1111	horim1111	33.5833	133.375	231	231	83	3	3	26	192	33	1.8018	0.0078	0.000	428.929	0.000	428.929	428.929
1112	horim1112	33.5833	133.625	295	295	92	5	3	32	239	43	4.0893	0.0139	51.214	377.675	0.040	377.715	428.929
1113	horim1113	33.5833	133.875	224	224	56	1	2	26	190	31	0.9212	0.0041	13.941	414.980	0.008	414.988	428.929

1114	horim1114	33.5833	134.125	204	204	88	2	4	26	158	36	1.2293	0.0060	0.000	428.929	0.000	428.929	428.929
1115	horim1115	33.5833	134.375	201	201	42	1	0	18	173	19	0.9577	0.0048	262.051	164.246	2.632	166.878	428.929
1116	horim1116	33.5833	134.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	428.567	0.000	0.362	0.362	428.929
1117	horim1117	33.5833	135.375	183	183	25	0	0	15	163	15	0.6922	0.0038	302.087	126.727	0.115	126.842	428.929
1118	horim1118	33.5833	135.625	153	153	49	1	1	13	136	17	0.6087	0.0040	16.927	411.862	0.140	412.002	428.929
1119	horim1119	33.5833	135.875	191	191	35	0	1	19	166	21	0.7848	0.0041	131.044	297.391	0.493	297.885	428.929
1120	horim1120	33.5833	139.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	428.918	0.000	0.011	0.011	428.929
1121	horim1121	33.4167	129.375	125	125	34	0	1	11	109	11	0.4557	0.0036	403.581	0.000	26.159	26.159	429.740
1122	horim1122	33.4167	129.625	139	139	34	0	2	10	126	8	0.5709	0.0041	321.245	54.365	54.131	108.495	429.740
1123	horim1123	33.4167	129.875	135	135	31	0	2	8	123	8	0.4588	0.0034	131.945	268.195	29.600	297.796	429.740
1124	horim1124	33.4167	130.125	224	224	27	0	1	17	202	22	0.6601	0.0029	27.265	402.472	0.003	402.475	429.740
1125	horim1125	33.4167	130.375	268	268	33	0	2	22	226	30	0.8763	0.0033	0.000	429.740	0.000	429.740	429.740
1126	horim1126	33.4167	130.625	220	220	29	0	0	21	192	23	0.6855	0.0031	0.000	429.740	0.000	429.740	429.740
1127	horim1127	33.4167	130.875	237	237	36	0	0	27	195	33	0.7752	0.0033	0.000	429.740	0.000	429.740	429.740
1128	horim1128	33.4167	131.125	203	203	33	0	1	18	170	20	0.6961	0.0034	0.000	429.740	0.000	429.740	429.740
1129	horim1129	33.4167	131.375	103	103	37	0	1	9	87	9	0.3443	0.0033	0.167	429.574	0.000	429.574	429.740
1130	horim1130	33.4167	131.625	91	91	16	0	0	5	86	5	0.2641	0.0029	145.204	284.496	0.040	284.536	429.740
1131	horim1131	33.4167	132.125	180	180	20	0	0	12	166	10	0.6367	0.0035	369.521	60.198	0.021	60.219	429.740
1132	horim1132	33.4167	132.375	169	169	27	0	0	15	150	12	0.4712	0.0028	217.893	209.163	2.684	211.847	429.740
1133	horim1133	33.4167	132.625	159	159	28	0	1	12	143	13	0.4317	0.0027	0.000	429.740	0.000	429.740	429.740
1134	horim1134	33.4167	132.875	231	231	60	1	4	23	192	34	1.2373	0.0054	0.000	429.740	0.000	429.740	429.740
1135	horim1135	33.4167	133.125	248	248	96	3	6	31	196	47	1.9674	0.0079	0.000	429.740	0.000	429.740	429.740
1136	horim1136	33.4167	133.375	239	239	31	0	1	21	209	22	1.3479	0.0056	181.520	247.619	0.602	248.221	429.740
1137	horim1137	33.4167	133.625	123	123	15	0	0	6	114	3	0.6887	0.0056	413.845	15.872	0.024	15.896	429.740
1138	horim1138	33.4167	133.875	127	127	61	2	0	7	113	8	1.0619	0.0084	387.944	41.769	0.027	41.796	429.740
1139	horim1139	33.4167	134.125	211	211	58	2	0	22	180	25	1.0510	0.0050	82.983	346.747	0.011	346.758	429.740
1140	horim1140	33.4167	134.375	122	122	53	1	0	12	105	12	0.5376	0.0044	425.674	4.063	0.003	4.066	429.740
1141	horim1141	33.4167	135.625	112	112	24	0	0	9	102	11	0.3680	0.0033	412.788	16.853	0.099	16.952	429.740
1142	horim1142	33.4167	135.875	174	174	24	0	0	14	156	13	0.6165	0.0035	399.153	20.381	10.206	30.587	429.740
1143	horim1143	33.2500	128.875	3	3	NA	0	0	0	3	0	0.0097	0.0032	429.428	0.000	1.120	1.120	430.548
1144	horim1144	33.2500	129.125	163	163	30	0	2	10	148	7	0.6711	0.0041	379.834	0.000	50.714	50.714	430.548
1145	horim1145	33.2500	129.375	207	207	33	0	2	16	179	12	1.0208	0.0049	315.098	0.000	115.449	115.449	430.548
1146	horim1146	33.2500	129.625	160	160	26	0	1	11	145	10	0.5413	0.0034	138.517	272.695	19.336	292.031	430.548
1147	horim1147	33.2500	129.875	211	211	59	2	2	17	185	21	2.7745	0.0131	10.807	419.709	0.032	419.741	430.548
1148	horim1148	33.2500	130.125	169	169	27	0	1	12	153	14	0.5233	0.0031	5.483	425.065	0.000	425.065	430.548
1149	horim1149	33.2500	130.375	149	149	12	0	0	6	139	6	0.4614	0.0031	4.040	426.508	0.000	426.508	430.548
1150	horim1150	33.2500	130.625	190	190	23	0	1	11	170	13	0.5764	0.0030	0.000	430.548	0.000	430.548	430.548
1151	horim1151	33.2500	130.875	166	166	33	0	0	18	141	21	0.4555	0.0027	0.000	430.548	0.000	430.548	430.548
1152	horim1152	33.2500	131.125	136	136	18	0	0	8	121	10	0.3221	0.0024	0.000	430.548	0.000	430.548	430.548
1153	horim1153	33.2500	131.375	237	237	29	0	0	22	200	26	1.2387	0.0052	0.105	430.443	0.000	430.443	430.548

1154	horim1154	33.2500	131.625	168	168	18	0	0	10	149	8	0.4347	0.0026	189.290	241.220	0.038	241.257	430.548
1155	horim1155	33.2500	131.875	167	167	25	0	0	14	152	11	0.5162	0.0031	333.358	95.919	1.270	97.189	430.548
1156	horim1156	33.2500	132.375	137	137	19	0	0	9	127	7	0.5030	0.0037	378.448	45.805	6.295	52.100	430.548
1157	horim1157	33.2500	132.625	272	272	37	0	1	29	228	30	0.9697	0.0036	25.734	401.398	3.416	404.814	430.548
1158	horim1158	33.2500	132.875	211	211	53	0	4	23	171	29	0.8173	0.0039	0.000	430.548	0.000	430.548	430.548
1159	horim1159	33.2500	133.125	230	230	41	0	3	22	197	28	0.8394	0.0036	13.947	416.592	0.008	416.600	430.548
1160	horim1160	33.2500	133.375	120	120	22	0	0	9	111	9	0.4478	0.0037	424.844	5.647	0.056	5.704	430.548
1161	horim1161	33.2500	134.125	165	165	33	1	0	9	153	8	0.8384	0.0051	379.220	51.250	0.078	51.328	430.548
1162	horim1162	33.0833	128.875	12	12	NA	0	1	1	10	0	0.2371	0.0198	430.851	0.000	0.501	0.501	431.352
1163	horim1163	33.0833	129.125	155	155	28	0	0	14	135	11	0.6646	0.0043	387.570	0.000	43.782	43.782	431.352
1164	horim1164	33.0833	129.375	122	122	37	0	2	9	108	7	0.4653	0.0038	427.412	0.000	3.939	3.939	431.352
1165	horim1165	33.0833	129.625	179	179	29	0	1	14	159	12	0.7687	0.0043	301.852	98.137	31.363	129.499	431.352
1166	horim1166	33.0833	129.875	143	143	29	0	1	11	129	11	0.4232	0.0030	106.124	294.922	30.306	325.228	431.352
1167	horim1167	33.0833	130.125	200	200	23	0	0	15	179	13	0.6265	0.0031	137.916	293.433	0.003	293.436	431.352
1168	horim1168	33.0833	130.375	154	154	16	0	1	5	143	6	0.4491	0.0029	236.740	194.588	0.024	194.612	431.352
1169	horim1169	33.0833	130.625	217	217	23	0	1	13	193	13	0.6925	0.0032	0.000	431.352	0.000	431.352	431.352
1170	horim1170	33.0833	130.875	192	192	32	0	1	17	167	21	1.5468	0.0081	0.000	431.352	0.000	431.352	431.352
1171	horim1171	33.0833	131.125	190	190	33	0	0	20	161	27	0.7651	0.0040	0.000	431.352	0.000	431.352	431.352
1172	horim1172	33.0833	131.375	196	196	37	0	1	21	168	30	0.8349	0.0043	0.000	431.352	0.000	431.352	431.352
1173	horim1173	33.0833	131.625	97	97	26	0	0	8	84	7	0.2540	0.0026	0.000	431.352	0.000	431.352	431.352
1174	horim1174	33.0833	131.875	247	247	32	0	1	23	215	25	0.9026	0.0037	183.591	244.379	3.382	247.760	431.352
1175	horim1175	33.0833	132.125	141	141	23	0	0	11	128	7	0.4831	0.0034	428.434	2.084	0.833	2.917	431.352
1176	horim1176	33.0833	132.375	203	203	25	0	1	14	183	11	0.9317	0.0046	371.204	55.662	4.486	60.148	431.352
1177	horim1177	33.0833	132.625	244	244	46	0	2	30	198	33	0.8772	0.0036	0.812	430.540	0.000	430.540	431.352
1178	horim1178	33.0833	132.875	205	205	48	0	3	22	168	26	0.7894	0.0039	0.000	431.352	0.000	431.352	431.352
1179	horim1179	33.0833	133.125	181	181	38	0	2	17	160	20	0.6710	0.0037	224.963	206.276	0.113	206.389	431.352
1180	horim1180	33.0833	139.625	128	128	61	1	3	7	111	10	0.8435	0.0066	426.189	0.000	5.163	5.163	431.352
1181	horim1181	33.0833	139.875	128	128	61	1	3	7	111	10	0.8435	0.0066	363.897	0.000	67.455	67.455	431.352
1182	horim1182	32.9167	128.875	58	58	25	0	0	5	53	5	0.2896	0.0050	390.362	0.000	41.790	41.790	432.152
1183	horim1183	32.9167	129.125	197	197	34	0	2	16	173	13	0.8479	0.0043	276.328	0.000	155.824	155.824	432.152
1184	horim1184	32.9167	129.375	89	89	43	0	2	7	80	5	0.3388	0.0038	431.264	0.000	0.888	0.888	432.152
1185	horim1185	32.9167	129.625	95	95	28	0	0	9	86	6	0.4539	0.0048	267.031	155.628	9.493	165.121	432.152
1186	horim1186	32.9167	129.875	153	153	48	1	1	12	136	10	0.5497	0.0036	211.184	216.641	4.327	220.968	432.152
1187	horim1187	32.9167	130.125	276	276	35	0	3	22	240	30	1.1245	0.0041	123.803	307.757	0.591	308.349	432.152
1188	horim1188	32.9167	130.375	157	157	23	0	1	9	142	9	0.4796	0.0031	332.400	99.744	0.008	99.752	432.152
1189	horim1189	32.9167	130.625	213	213	23	0	1	13	189	13	0.9864	0.0046	19.363	412.789	0.000	412.789	432.152
1190	horim1190	32.9167	130.875	159	159	35	0	2	12	140	18	0.5045	0.0032	0.000	432.152	0.000	432.152	432.152
1191	horim1191	32.9167	131.125	175	175	33	0	1	16	152	22	0.6717	0.0038	0.000	432.152	0.000	432.152	432.152
1192	horim1192	32.9167	131.375	202	202	49	0	2	25	162	35	0.7404	0.0037	0.000	432.152	0.000	432.152	432.152
1193	horim1193	32.9167	131.625	101	101	22	0	0	7	85	9	0.2586	0.0026	0.000	432.152	0.000	432.152	432.152

1194	horim1194	32.9167	131.875	163	163	32	0	1	14	144	14	0.6016	0.0037	56.371	371.889	3.892	375.781	432.152
1195	horim1195	32.9167	132.125	161	161	30	0	1	13	145	10	0.5903	0.0037	416.729	13.293	2.130	15.423	432.152
1196	horim1196	32.9167	132.375	171	171	21	0	0	12	153	9	0.6272	0.0037	417.445	13.108	1.599	14.707	432.152
1197	horim1197	32.9167	132.625	206	206	29	0	0	20	183	18	0.7956	0.0039	192.327	238.197	1.629	239.825	432.152
1198	horim1198	32.9167	132.875	193	193	38	0	2	18	168	20	0.7305	0.0038	13.881	418.271	0.000	418.271	432.152
1199	horim1199	32.9167	133.125	18	18	NA	0	0	3	15	1	0.0767	0.0043	425.613	6.512	0.027	6.539	432.152
1200	horim1200	32.7500	128.625	203	203	21	0	0	14	180	10	0.9335	0.0046	335.544	0.000	97.405	97.405	432.949
1201	horim1201	32.7500	128.875	174	174	26	0	0	15	157	11	0.7951	0.0046	275.889	0.000	157.060	157.060	432.949
1202	horim1202	32.7500	129.125	51	51	35	0	0	6	45	6	0.2211	0.0043	426.712	0.000	6.236	6.236	432.949
1203	horim1203	32.7500	129.625	89	89	23	0	1	4	83	4	0.3473	0.0039	425.832	7.103	0.014	7.116	432.949
1204	horim1204	32.7500	129.875	250	250	37	1	1	18	219	18	1.0845	0.0043	156.571	271.730	4.647	276.377	432.949
1205	horim1205	32.7500	130.125	93	93	35	0	1	8	83	7	0.3247	0.0035	219.357	213.326	0.265	213.591	432.949
1206	horim1206	32.7500	130.375	234	234	37	0	2	22	198	27	1.3212	0.0056	233.060	199.743	0.146	199.889	432.949
1207	horim1207	32.7500	130.625	198	198	20	0	1	10	177	9	0.6151	0.0031	162.189	270.080	0.679	270.759	432.949
1208	horim1208	32.7500	130.875	158	158	15	0	0	8	143	10	0.4490	0.0028	0.000	432.949	0.000	432.949	432.949
1209	horim1209	32.7500	131.125	128	128	33	0	2	8	116	12	0.4206	0.0033	0.000	432.949	0.000	432.949	432.949
1210	horim1210	32.7500	131.375	253	253	55	1	2	29	205	40	1.4700	0.0058	0.000	432.949	0.000	432.949	432.949
1211	horim1211	32.7500	131.625	145	145	71	2	0	15	121	28	1.6419	0.0113	0.000	432.949	0.000	432.949	432.949
1212	horim1212	32.7500	131.875	187	187	29	0	1	15	168	12	1.7612	0.0094	191.043	239.304	2.601	241.905	432.949
1213	horim1213	32.7500	132.125	2	2	NA	0	0	0	2	0	0.0276	0.0138	431.356	1.592	0.000	1.592	432.949
1214	horim1214	32.7500	132.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	431.215	0.000	1.734	1.734	432.949
1215	horim1215	32.7500	132.625	137	137	24	0	0	11	125	10	0.5105	0.0037	365.234	56.674	11.040	67.715	432.949
1216	horim1216	32.7500	132.875	217	217	21	0	0	15	195	14	0.8694	0.0040	267.525	165.358	0.065	165.423	432.949
1217	horim1217	32.7500	133.125	161	161	23	0	0	12	143	9	0.6929	0.0043	421.924	11.011	0.014	11.025	432.949
1218	horim1218	32.5833	128.625	180	180	26	0	1	13	166	8	0.8954	0.0050	352.929	0.000	80.813	80.813	433.741
1219	horim1219	32.5833	128.875	106	106	25	0	0	9	95	7	0.4368	0.0041	370.224	0.000	63.517	63.517	433.741
1220	horim1220	32.5833	129.625	84	84	32	0	1	6	77	7	0.3277	0.0039	432.063	1.442	0.236	1.678	433.741
1221	horim1221	32.5833	129.875	96	96	25	0	1	5	89	6	0.3799	0.0040	380.868	49.076	3.798	52.874	433.741
1222	horim1222	32.5833	130.125	192	192	41	1	1	14	172	13	1.3871	0.0072	309.708	66.976	57.058	124.034	433.741
1223	horim1223	32.5833	130.375	149	149	44	1	1	10	135	10	0.5350	0.0036	335.118	29.503	69.120	98.623	433.741
1224	horim1224	32.5833	130.625	187	187	26	0	1	13	166	13	0.5603	0.0030	113.182	317.952	2.608	320.559	433.741
1225	horim1225	32.5833	130.875	192	192	35	0	0	21	156	23	0.6686	0.0035	0.000	433.741	0.000	433.741	433.741
1226	horim1226	32.5833	131.125	197	197	64	1	2	25	158	36	1.4459	0.0073	0.000	433.741	0.000	433.741	433.741
1227	horim1227	32.5833	131.375	173	173	37	0	2	15	152	21	0.6689	0.0039	0.000	433.741	0.000	433.741	433.741
1228	horim1228	32.5833	131.625	192	192	31	0	2	14	173	16	0.6627	0.0035	50.558	383.132	0.052	383.183	433.741
1229	horim1229	32.5833	131.875	154	154	27	0	0	14	137	10	0.5513	0.0036	418.340	12.734	2.668	15.401	433.741
1230	horim1230	32.4167	129.875	135	135	36	0	1	13	117	12	0.4385	0.0032	426.215	0.000	8.316	8.316	434.531
1231	horim1231	32.4167	130.125	233	233	26	0	1	17	211	15	0.9295	0.0040	78.611	0.000	355.920	355.920	434.531
1232	horim1232	32.4167	130.375	159	159	43	1	1	11	145	11	0.5789	0.0036	233.619	2.438	198.474	200.912	434.531
1233	horim1233	32.4167	130.625	207	207	28	0	1	16	186	18	0.6588	0.0032	66.408	367.867	0.255	368.122	434.531

1234	horim1234	32.4167	130.875	154	154	52	0	3	15	120	25	0.6690	0.0043	0.000	434.531	0.000	434.531	434.531
1235	horim1235	32.4167	131.125	21	21	NA	1	3	2	11	7	0.7540	0.0359	0.000	434.531	0.000	434.531	434.531
1236	horim1236	32.4167	131.375	71	71	68	0	3	7	60	12	0.3678	0.0052	0.000	434.531	0.000	434.531	434.531
1237	horim1237	32.4167	131.625	185	185	34	1	0	12	170	13	0.7868	0.0043	154.853	279.107	0.570	279.677	434.531
1238	horim1238	32.4167	139.875	50	50	36	0	1	3	46	3	0.1985	0.0040	428.566	0.000	5.964	5.964	434.531
1239	horim1239	32.2500	129.875	145	145	50	1	1	12	130	9	0.5670	0.0039	423.230	0.000	12.086	12.086	435.316
1240	horim1240	32.2500	130.125	167	167	47	1	1	14	147	12	0.7393	0.0044	206.874	0.000	228.442	228.442	435.316
1241	horim1241	32.2500	130.375	119	119	28	0	1	8	106	8	0.4224	0.0035	298.861	122.280	14.175	136.455	435.316
1242	horim1242	32.2500	130.625	200	200	28	0	1	15	174	16	0.6836	0.0034	0.000	435.316	0.000	435.316	435.316
1243	horim1243	32.2500	130.875	188	188	38	0	2	17	162	23	0.6942	0.0037	0.000	435.316	0.000	435.316	435.316
1244	horim1244	32.2500	131.125	222	222	80	2	5	22	175	37	1.7306	0.0078	0.000	435.316	0.000	435.316	435.316
1245	horim1245	32.2500	131.375	236	236	57	2	0	24	194	29	1.1468	0.0049	0.000	435.316	0.000	435.316	435.316
1246	horim1246	32.2500	131.625	105	105	37	1	0	4	99	6	0.4640	0.0044	299.050	136.217	0.049	136.266	435.316
1247	horim1247	32.0833	128.375	22	22	NA	1	0	3	18	2	0.1350	0.0061	432.400	0.000	3.698	3.698	436.098
1248	horim1248	32.0833	129.875	1	1	NA	0	0	1	0	0	0.0019	0.0019	436.005	0.000	0.093	0.093	436.098
1249	horim1249	32.0833	130.125	129	129	53	1	1	11	115	10	0.7487	0.0058	310.992	73.035	52.070	125.106	436.098
1250	horim1250	32.0833	130.375	225	225	25	0	1	15	197	17	0.9163	0.0041	57.524	378.375	0.199	378.574	436.098
1251	horim1251	32.0833	130.625	138	138	18	0	0	8	121	6	0.6533	0.0047	0.000	436.098	0.000	436.098	436.098
1252	horim1252	32.0833	130.875	206	206	62	2	1	19	170	27	1.0373	0.0050	0.000	436.098	0.000	436.098	436.098
1253	horim1253	32.0833	131.125	89	89	40	0	1	9	78	8	0.2589	0.0029	0.000	436.098	0.000	436.098	436.098
1254	horim1254	32.0833	131.375	139	139	37	1	1	5	130	8	0.7540	0.0054	0.647	435.452	0.000	435.452	436.098
1255	horim1255	32.0833	131.625	116	116	13	0	0	5	109	4	0.3322	0.0029	395.207	40.891	0.000	40.891	436.098
1256	horim1256	31.9167	128.375	71	71	67	1	1	4	65	2	0.3876	0.0055	436.006	0.000	0.870	0.870	436.876
1257	horim1257	31.9167	129.875	166	166	87	3	3	11	144	12	0.8410	0.0051	407.424	0.000	29.452	29.452	436.876
1258	horim1258	31.9167	130.125	93	93	54	1	1	5	86	7	0.4198	0.0045	368.006	68.741	0.128	68.870	436.876
1259	horim1259	31.9167	130.375	231	231	33	0	2	18	198	23	1.0719	0.0046	0.000	436.876	0.000	436.876	436.876
1260	horim1260	31.9167	130.625	114	114	21	0	0	8	102	8	0.6028	0.0053	0.000	436.876	0.000	436.876	436.876
1261	horim1261	31.9167	130.875	246	246	79	3	3	25	200	34	3.5572	0.0145	0.000	436.876	0.000	436.876	436.876
1262	horim1262	31.9167	131.125	125	125	45	1	0	9	108	8	0.5540	0.0044	0.000	436.876	0.000	436.876	436.876
1263	horim1263	31.9167	131.375	166	166	31	1	1	5	156	7	0.7181	0.0043	52.127	384.678	0.071	384.749	436.876
1264	horim1264	31.9167	139.875	0	0	NA	0	0	0	0	0	0.0000	0.0000	436.871	0.000	0.005	0.005	436.876
1265	horim1265	31.7500	129.625	197	197	63	2	2	16	170	14	1.9047	0.0097	408.497	0.000	29.153	29.153	437.651
1266	horim1266	31.7500	129.875	143	143	96	3	3	9	125	11	0.8503	0.0059	402.871	0.000	34.779	34.779	437.651
1267	horim1267	31.7500	130.125	167	167	40	1	1	10	153	9	0.9429	0.0056	372.836	64.721	0.093	64.814	437.651
1268	horim1268	31.7500	130.375	214	214	25	0	1	14	189	14	0.9623	0.0045	17.783	419.777	0.090	419.867	437.651
1269	horim1269	31.7500	130.625	223	223	41	1	3	12	199	14	0.9940	0.0045	71.449	365.945	0.257	366.202	437.651
1270	horim1270	31.7500	130.875	184	184	21	0	1	10	167	14	0.5700	0.0031	21.370	416.278	0.003	416.281	437.651
1271	horim1271	31.7500	131.125	102	102	16	0	0	5	88	6	0.2693	0.0026	0.000	437.651	0.000	437.651	437.651
1272	horim1272	31.7500	131.375	213	213	39	0	2	20	176	18	1.4251	0.0067	55.301	382.286	0.063	382.349	437.651
1273	horim1273	31.5833	129.625	187	187	66	2	3	13	162	11	1.0269	0.0055	413.478	0.000	24.943	24.943	438.421

1274	horim1274	31.5833	130.125	4	4	NA	1	0	0	3	1	0.0824	0.0206	438.410	0.000	0.011	0.011	438.421
1275	horim1275	31.5833	130.375	241	241	39	1	1	19	213	18	1.1059	0.0046	139.747	298.675	0.000	298.675	438.421
1276	horim1276	31.5833	130.625	242	242	54	1	4	21	206	21	1.2425	0.0051	204.489	233.516	0.417	233.932	438.421
1277	horim1277	31.5833	130.875	176	176	33	0	2	13	155	15	0.5327	0.0030	56.958	381.464	0.000	381.464	438.421
1278	horim1278	31.5833	131.125	87	87	54	1	0	6	76	5	0.9432	0.0108	0.000	438.421	0.000	438.421	438.421
1279	horim1279	31.5833	131.375	142	142	30	0	1	10	118	8	0.6471	0.0046	139.362	296.624	2.435	299.059	438.421
1280	horim1280	31.4167	129.625	5	5	NA	1	0	1	2	2	0.0849	0.0170	439.142	0.000	0.047	0.047	439.188
1281	horim1281	31.4167	130.125	214	214	61	2	3	15	184	15	1.2045	0.0056	370.936	67.533	0.720	68.252	439.188
1282	horim1282	31.4167	130.375	217	217	63	3	1	15	192	18	2.1073	0.0097	42.357	396.831	0.000	396.831	439.188
1283	horim1283	31.4167	130.625	159	159	26	0	1	11	144	11	0.6291	0.0040	348.431	90.738	0.019	90.758	439.188
1284	horim1284	31.4167	130.875	256	256	65	2	4	22	212	30	1.3933	0.0054	27.983	411.197	0.008	411.206	439.188
1285	horim1285	31.4167	131.125	166	166	55	1	3	12	146	12	1.4370	0.0087	260.398	176.382	2.408	178.790	439.188
1286	horim1286	31.4167	131.375	168	168	48	1	2	11	148	11	1.2013	0.0072	286.265	152.073	0.851	152.924	439.188
1287	horim1287	31.4167	140.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	439.161	0.000	0.027	0.027	439.188
1288	horim1288	31.2500	129.375	35	35	NA	1	0	3	31	2	0.1840	0.0053	437.654	0.000	2.297	2.297	439.952
1289	horim1289	31.2500	129.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	439.946	0.000	0.005	0.005	439.952
1290	horim1290	31.2500	130.125	127	127	82	2	3	7	112	9	0.6113	0.0048	406.152	33.670	0.129	33.799	439.952
1291	horim1291	31.2500	130.375	125	125	72	2	1	9	112	9	1.4798	0.0118	216.388	223.514	0.049	223.563	439.952
1292	horim1292	31.2500	130.625	243	243	58	2	3	18	207	20	1.1968	0.0049	230.333	209.005	0.613	209.619	439.952
1293	horim1293	31.2500	130.875	238	238	85	4	3	19	198	22	1.4760	0.0062	58.092	381.859	0.000	381.859	439.952
1294	horim1294	31.2500	131.125	231	231	55	2	2	17	199	18	1.0308	0.0045	323.871	116.061	0.019	116.081	439.952
1295	horim1295	31.0833	129.375	31	31	NA	1	0	2	28	2	0.2210	0.0071	440.692	0.000	0.019	0.019	440.711
1296	horim1296	31.0833	130.625	224	224	87	4	4	15	192	17	1.3225	0.0059	374.507	66.171	0.033	66.204	440.711
1297	horim1297	31.0833	130.875	241	241	97	5	4	17	201	24	1.5618	0.0065	271.075	169.636	0.000	169.636	440.711
1298	horim1298	30.9167	129.375	14	14	NA	0	0	1	13	0	0.0624	0.0045	440.898	0.000	0.569	0.569	441.467
1299	horim1299	30.9167	129.875	91	91	83	1	2	8	72	8	0.4925	0.0054	437.430	0.000	4.037	4.037	441.467
1300	horim1300	30.9167	130.625	24	24	NA	3	1	3	15	6	0.3250	0.0135	440.576	0.769	0.121	0.890	441.467
1301	horim1301	30.9167	131.125	1	1	NA	0	0	0	1	0	0.0012	0.0012	441.406	0.000	0.061	0.061	441.467
1302	horim1302	30.7500	129.375	14	14	NA	0	0	0	14	0	0.0486	0.0035	442.125	0.000	0.094	0.094	442.219
1303	horim1303	30.7500	129.875	97	97	168	4	4	6	82	12	0.5779	0.0060	430.873	0.000	11.346	11.346	442.219
1304	horim1304	30.7500	130.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	442.208	0.000	0.011	0.011	442.219
1305	horim1305	30.7500	130.375	67	67	94	2	0	3	62	4	0.3260	0.0049	426.295	0.000	15.924	15.924	442.219
1306	horim1306	30.7500	130.875	160	160	87	3	3	10	142	10	1.9170	0.0120	412.872	0.000	29.347	29.347	442.219
1307	horim1307	30.7500	131.125	218	218	78	4	3	11	196	12	1.4548	0.0067	331.548	0.000	110.671	110.671	442.219
1308	horim1308	30.5833	130.875	203	203	70	3	3	11	183	13	1.1995	0.0059	343.155	0.000	99.812	99.812	442.967
1309	horim1309	30.5833	131.125	203	203	93	5	3	8	182	11	1.2898	0.0064	382.025	0.000	60.942	60.942	442.967
1310	horim1310	30.4167	130.125	147	147	65	2	2	8	134	8	0.7144	0.0049	410.631	0.000	33.081	33.081	443.712
1311	horim1311	30.4167	130.375	268	268	253	20	5	17	209	38	8.7850	0.0328	334.060	0.000	109.652	109.652	443.712
1312	horim1312	30.4167	130.625	271	271	214	17	3	20	214	35	6.8486	0.0253	287.470	0.000	156.242	156.242	443.712
1313	horim1313	30.4167	130.875	206	206	93	5	3	8	184	13	1.7045	0.0083	291.030	0.000	152.682	152.682	443.712

1314	horim1314	30.4167	140.375	21	21	NA	0	1	0	20	1	0.1371	0.0065	438.923	0.000	4.789	4.789	443.712
1315	horim1315	30.2500	130.375	266	266	163	11	6	19	214	26	4.4705	0.0168	350.946	0.000	93.506	93.506	444.453
1316	horim1316	30.2500	130.625	302	302	261	23	6	20	232	40	10.6672	0.0353	296.550	0.000	147.903	147.903	444.453
1317	horim1317	30.0833	129.875	37	37	NA	2	0	3	32	3	0.7700	0.0208	444.998	0.000	0.192	0.192	445.190
1318	horim1318	30.0833	130.125	1	1	NA	0	0	0	1	0	0.0090	0.0090	445.181	0.000	0.008	0.008	445.190
1319	horim1319	29.9167	129.625	96	96	189	5	3	6	81	9	0.6364	0.0066	441.463	0.000	4.460	4.460	445.923
1320	horim1320	29.9167	129.875	154	154	113	4	3	11	130	13	1.6475	0.0107	408.666	0.000	37.257	37.257	445.923
1321	horim1321	29.7500	129.625	16	16	NA	0	0	1	15	1	0.0800	0.0050	444.395	0.000	2.257	2.257	446.652
1322	horim1322	29.7500	129.875	106	106	120	3	3	5	91	8	0.7647	0.0072	436.295	0.000	10.358	10.358	446.652
1323	horim1323	29.7500	140.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	446.647	0.000	0.006	0.006	446.652
1324	horim1324	29.5833	129.625	123	123	146	5	2	8	106	10	0.7951	0.0065	419.840	0.000	27.539	27.539	447.378
1325	horim1325	29.4167	129.625	127	127	172	6	4	6	109	11	1.0256	0.0081	440.597	0.000	7.503	7.503	448.100
1326	horim1326	29.2500	129.375	76	76	173	4	1	5	66	6	0.6378	0.0084	447.530	0.000	1.288	1.288	448.818
1327	horim1327	29.0833	129.125	145	145	125	5	2	8	126	9	1.2775	0.0088	442.381	0.000	7.152	7.152	449.533
1328	horim1328	28.7500	128.875	48	48	162	2	1	5	40	6	0.2766	0.0058	448.795	0.000	2.155	2.155	450.950
1329	horim1329	28.7500	129.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	449.880	0.000	1.070	1.070	450.950
1330	horim1330	28.5833	129.625	141	141	229	10	3	6	118	14	1.5323	0.0109	445.566	0.000	6.087	6.087	451.653
1331	horim1331	28.4167	129.375	237	237	201	13	8	12	195	24	3.3452	0.0141	369.273	0.000	83.079	83.079	452.352
1332	horim1332	28.4167	129.625	249	249	230	17	7	13	206	27	4.1737	0.0168	268.440	0.000	183.912	183.912	452.352
1333	horim1333	28.4167	129.875	191	191	158	8	6	10	165	16	2.1821	0.0114	447.444	0.000	4.909	4.909	452.352
1334	horim1334	28.4167	130.125	191	191	158	8	6	10	165	16	2.1821	0.0114	439.291	0.000	13.061	13.061	452.352
1335	horim1335	28.2500	129.125	210	210	249	15	8	13	171	26	3.5672	0.0170	390.027	0.000	63.021	63.021	453.047
1336	horim1336	28.2500	129.375	282	282	248	20	10	14	226	31	9.8414	0.0349	106.432	0.000	346.615	346.615	453.047
1337	horim1337	28.2500	129.625	203	203	207	12	6	11	169	20	2.9517	0.0145	436.207	0.000	16.840	16.840	453.047
1338	horim1338	28.2500	129.875	191	191	158	8	6	10	165	16	2.1821	0.0114	413.782	0.000	39.265	39.265	453.047
1339	horim1339	28.2500	130.125	191	191	158	8	6	10	165	16	2.1821	0.0114	451.870	0.000	1.177	1.177	453.047
1340	horim1340	28.0833	129.125	215	215	200	12	8	10	182	21	3.0365	0.0141	407.288	0.000	46.451	46.451	453.739
1341	horim1341	28.0833	129.375	212	212	198	11	9	12	177	24	3.2297	0.0152	380.227	0.000	73.512	73.512	453.739
1342	horim1342	27.9167	128.125	6	6	NA	1	0	0	5	1	0.0593	0.0099	451.929	0.000	2.498	2.498	454.427
1343	horim1343	27.9167	128.875	247	247	251	18	9	11	201	28	5.2597	0.0213	408.253	0.000	46.173	46.173	454.427
1344	horim1344	27.9167	129.375	0	0	NA	0	0	0	0	0	0.0000	0.0000	454.322	0.000	0.105	0.105	454.427
1345	horim1345	27.7500	128.875	280	280	250	20	10	12	224	30	5.8651	0.0209	282.421	0.000	172.689	172.689	455.111
1346	horim1346	27.7500	129.125	190	190	204	11	7	8	162	18	2.5773	0.0136	429.240	0.000	25.871	25.871	455.111
1347	horim1347	27.7500	142.125	6	6	NA	3	0	0	3	3	0.7570	0.1262	452.139	0.000	2.971	2.971	455.111
1348	horim1348	27.5833	128.875	68	68	264	6	1	2	58	8	0.9964	0.0147	452.745	0.000	3.046	3.046	455.791
1349	horim1349	27.5833	142.125	13	13	NA	3	0	0	10	2	0.7745	0.0596	454.196	0.000	1.595	1.595	455.791
1350	horim1350	27.4167	128.625	238	238	196	13	9	9	203	22	3.2299	0.0136	365.635	0.000	90.831	90.831	456.467
1351	horim1351	27.4167	142.125	7	7	NA	2	0	0	5	0	0.6392	0.0913	455.711	0.000	0.756	0.756	456.467
1352	horim1352	27.2500	128.625	8	8	NA	2	1	0	5	3	0.1547	0.0193	454.475	0.000	2.664	2.664	457.139
1353	horim1353	27.2500	140.875	1	1	NA	1	0	0	0	1	0.1250	0.1250	456.828	0.000	0.311	0.311	457.139

1354	horim1354	27.2500	142.125	0	0	NA	0	0	0	0	0	0.0000	0.0000	455.306	0.000	1.833	1.833	457.139
1355	horim1355	27.0833	127.875	169	169	140	6	5	8	146	12	1.7504	0.0104	439.632	0.000	18.176	18.176	457.807
1356	horim1356	27.0833	128.125	102	102	151	4	3	5	87	7	1.1047	0.0108	455.513	0.000	2.295	2.295	457.807
1357	horim1357	27.0833	128.375	152	152	197	9	3	8	129	13	1.6980	0.0112	437.316	0.000	20.492	20.492	457.807
1358	horim1358	27.0833	142.125	35	35	NA	8	2	0	25	7	3.7917	0.1083	421.287	0.000	36.521	36.521	457.807
1359	horim1359	27.0833	142.375	1	1	NA	0	0	0	1	0	0.0227	0.0227	457.767	0.000	0.040	0.040	457.807
1360	horim1360	26.9167	127.875	112	112	152	5	2	5	98	8	1.2486	0.0111	441.970	0.000	16.503	16.503	458.472
1361	horim1361	26.9167	128.125	2	2	NA	1	0	0	1	1	0.0576	0.0288	458.036	0.000	0.436	0.436	458.472
1362	horim1362	26.9167	128.375	115	115	182	5	5	8	94	11	2.7679	0.0241	446.636	0.000	11.836	11.836	458.472
1363	horim1363	26.7500	127.875	223	223	150	8	9	11	191	17	3.2302	0.0145	395.952	0.000	63.180	63.180	459.133
1364	horim1364	26.7500	128.125	214	214	218	13	8	7	175	19	4.2603	0.0199	329.300	0.000	129.833	129.833	459.133
1365	horim1365	26.7500	128.375	169	169	195	9	6	7	141	17	2.5530	0.0151	348.692	0.000	110.441	110.441	459.133
1366	horim1366	26.7500	142.125	10	10	NA	4	0	0	6	4	1.1073	0.1107	449.784	0.000	9.348	9.348	459.133
1367	horim1367	26.5833	126.875	1	1	NA	0	0	0	1	0	0.0020	0.0020	459.750	0.000	0.040	0.040	459.790
1368	horim1368	26.5833	127.125	106	106	253	8	4	4	88	8	1.3931	0.0131	452.169	0.000	7.621	7.621	459.790
1369	horim1369	26.5833	127.875	232	232	178	11	9	9	198	20	3.4024	0.0147	323.844	0.000	135.946	135.946	459.790
1370	horim1370	26.5833	128.125	189	189	190	10	6	9	159	18	3.2824	0.0174	230.067	0.000	229.723	229.723	459.790
1371	horim1371	26.5833	128.375	127	127	162	6	3	4	111	10	1.6350	0.0129	456.743	0.000	3.047	3.047	459.790
1372	horim1372	26.5833	142.125	25	25	NA	6	2	0	17	5	3.4627	0.1385	443.099	0.000	16.691	16.691	459.790
1373	horim1373	26.4167	126.625	188	188	196	11	5	7	162	17	2.7681	0.0147	449.197	0.000	11.246	11.246	460.443
1374	horim1374	26.4167	126.875	242	242	173	11	10	9	208	20	3.8496	0.0159	426.908	0.000	33.535	33.535	460.443
1375	horim1375	26.4167	127.125	128	128	204	8	3	5	110	13	1.6888	0.0132	456.720	0.000	3.723	3.723	460.443
1376	horim1376	26.4167	127.625	117	117	253	9	4	4	98	12	2.6891	0.0230	439.610	0.000	20.833	20.833	460.443
1377	horim1377	26.4167	127.875	233	233	206	13	10	9	195	22	3.8573	0.0166	231.428	0.000	229.015	229.015	460.443
1378	horim1378	26.4167	128.125	41	41	95	1	1	1	38	1	0.4864	0.0119	459.364	0.000	1.079	1.079	460.443
1379	horim1379	26.2500	126.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	461.069	0.000	0.023	0.023	461.092
1380	horim1380	26.2500	126.875	215	215	178	11	6	8	185	18	3.4214	0.0159	445.334	0.000	15.758	15.758	461.092
1381	horim1381	26.2500	127.125	62	62	120	2	1	3	54	3	0.6164	0.0099	459.163	0.000	1.929	1.929	461.092
1382	horim1382	26.2500	127.375	182	182	171	10	2	6	160	14	2.2762	0.0125	432.661	0.000	28.431	28.431	461.092
1383	horim1383	26.2500	127.625	135	135	186	7	5	4	116	11	1.8074	0.0134	366.662	0.000	94.430	94.430	461.092
1384	horim1384	26.2500	127.875	132	132	160	6	4	3	116	11	1.9285	0.0146	347.020	0.000	114.072	114.072	461.092
1385	horim1385	26.0833	127.125	61	61	122	2	1	3	53	3	0.5819	0.0095	461.028	0.000	0.709	0.709	461.737
1386	horim1386	26.0833	127.375	105	105	194	6	2	6	88	11	1.3211	0.0126	457.682	0.000	4.055	4.055	461.737
1387	horim1387	26.0833	127.625	150	150	200	8	7	5	127	12	2.1939	0.0146	382.225	0.000	79.512	79.512	461.737
1388	horim1388	26.0833	127.875	151	151	143	6	4	5	133	10	2.0157	0.0133	432.294	0.000	29.443	29.443	461.737
1389	horim1389	25.9167	123.625	28	28	NA	0	1	1	26	1	0.2697	0.0096	461.483	0.000	0.896	0.896	462.379
1390	horim1390	25.9167	124.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	462.321	0.000	0.058	0.058	462.379
1391	horim1391	25.9167	131.125	78	78	165	3	4	3	66	6	1.2989	0.0167	448.297	0.000	14.081	14.081	462.379
1392	horim1392	25.9167	131.375	78	78	165	3	4	3	66	6	1.2989	0.0167	443.978	0.000	18.401	18.401	462.379
1393	horim1393	25.7500	123.375	73	73	95	2	1	2	67	3	0.8587	0.0118	459.193	0.000	3.823	3.823	463.016

1394	horim1394	25.7500	123.625	64	64	85	1	2	3	57	1	0.6687	0.0104	462.275	0.000	0.741	0.741	463.016
1395	horim1395	25.7500	131.125	78	78	165	3	4	3	66	6	1.2989	0.0167	455.100	0.000	7.916	7.916	463.016
1396	horim1396	25.7500	131.375	78	78	165	3	4	3	66	6	1.2989	0.0167	460.925	0.000	2.091	2.091	463.016
1397	horim1397	25.4167	141.375	15	15	NA	1	0	0	14	1	0.3406	0.0227	458.712	0.000	5.568	5.568	464.279
1398	horim1398	24.9167	125.125	90	90	139	4	1	2	81	5	1.5033	0.0167	451.522	0.000	14.623	14.623	466.145
1399	horim1399	24.9167	125.375	123	123	104	3	4	3	111	5	2.5188	0.0205	453.155	0.000	12.990	12.990	466.145
1400	horim1400	24.7500	124.625	75	75	98	2	2	0	69	3	1.1556	0.0154	461.594	0.000	5.165	5.165	466.759
1401	horim1401	24.7500	125.125	87	87	155	4	2	2	77	6	1.4089	0.0162	438.158	0.000	28.601	28.601	466.759
1402	horim1402	24.7500	125.375	120	120	89	3	2	2	110	5	2.0592	0.0172	319.449	0.000	147.311	147.311	466.759
1403	horim1403	24.7500	141.375	20	20	NA	2	0	0	18	2	0.7128	0.0356	443.448	0.000	23.311	23.311	466.759
1404	horim1404	24.5833	124.125	18	18	NA	1	1	0	15	1	0.5279	0.0293	467.139	0.000	0.231	0.231	467.369
1405	horim1405	24.5833	124.375	152	152	169	6	8	5	128	10	2.7920	0.0184	436.653	0.000	30.716	30.716	467.369
1406	horim1406	24.5833	124.625	0	0	NA	0	0	0	0	0	0.0000	0.0000	450.664	0.000	16.705	16.705	467.369
1407	horim1407	24.4167	122.875	194	194	153	7	8	10	164	12	4.2185	0.0217	449.811	0.000	18.165	18.165	467.976
1408	horim1408	24.4167	123.125	194	194	153	7	8	10	164	12	4.2185	0.0217	457.285	0.000	10.690	10.690	467.976
1409	horim1409	24.4167	123.625	187	187	158	8	6	6	162	11	4.2433	0.0227	462.515	0.000	5.460	5.460	467.976
1410	horim1410	24.4167	123.875	232	232	161	10	7	10	198	16	6.8956	0.0297	330.886	0.000	137.090	137.090	467.976
1411	horim1411	24.4167	124.125	244	244	191	12	11	10	204	19	7.7460	0.0317	290.760	0.000	177.216	177.216	467.976
1412	horim1412	24.4167	124.375	148	148	103	3	6	5	131	5	2.6419	0.0179	455.763	0.000	12.212	12.212	467.976
1413	horim1413	24.4167	131.125	1	1	NA	0	0	0	1	0	0.0139	0.0139	466.821	0.000	1.155	1.155	467.976
1414	horim1414	24.2500	123.625	144	144	144	5	6	4	124	7	2.9480	0.0205	432.629	0.000	35.949	35.949	468.578
1415	horim1415	24.2500	123.875	229	229	186	11	10	10	192	20	9.7618	0.0426	340.496	0.000	128.082	128.082	468.578
1416	horim1416	24.2500	124.125	88	88	102	2	3	2	78	4	1.5046	0.0171	451.136	0.000	17.442	17.442	468.578
1417	horim1417	24.2500	141.375	8	8	NA	2	1	0	5	2	0.2692	0.0337	465.034	0.000	3.544	3.544	468.578
1418	horim1418	24.0833	123.875	91	91	117	3	2	2	82	6	1.9725	0.0217	456.415	0.000	12.761	12.761	469.176

Appendix E: Classification and ordination results

E1. RBS 2010

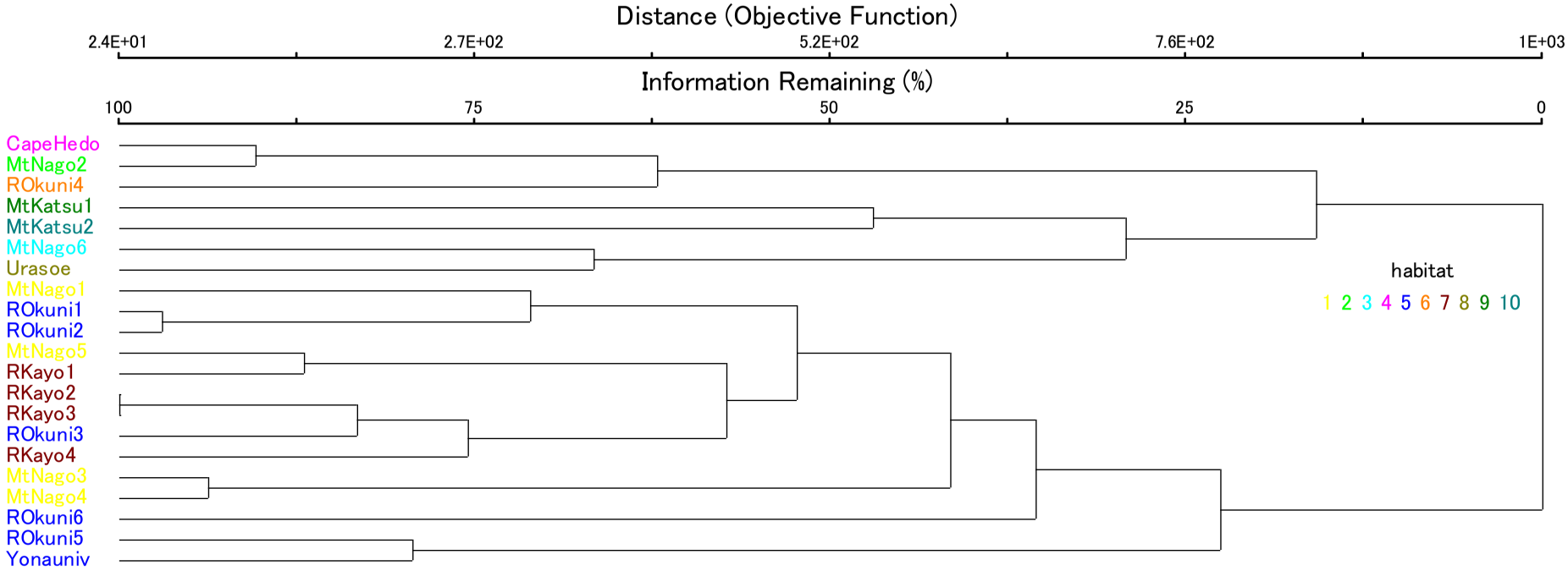


Figure E1. Dendogram produced for 21 RBS samples in Okinawa-jima island by similarity analysis using Ward's method with Euclidean distance measure. Habitat refers to landscape unit: 1. Mt. Nago forest; 2. Mt. Nago river; 3. Mt. Nago Utaki; 4. Cape Hedo coast grassland; 5. Mt. Yonaha forest; 6. Mt. Yonaha river; 7. Mt. Tano forest; 8. Urasoe Utaki; 9. Mt. Katsuu rocky summit; 10. Mt. Katsuu forest.

Table E1. Pearson's product-moment correlation coefficient (r, r2) and Kendall tau rank correlation (τ) for DCA axes on 21 RBS samples in Okinawa-jima island. DCA graph is shown in Figure 4.12. spcount = the number of species per sample. GHI = GHI calculated regardless of the number of species per sample; GHI40 = score for samples with over 40 species.

Axis	1			2			3		
	r	r^2	τ	r	r^2	τ	r	r^2	τ
Latitude	0.405	0.164	0.076	-0.511	0.261	-0.229	0.203	0.041	0.162
Longitude	0.226	0.051	-0.229	-0.574	0.329	-0.419	-0.09	0.008	-0.162
Altitude	-0.368	0.136	-0.081	-0.346	0.120	-0.072	0.319	0.102	0.263
spcount	-0.596	0.355	-0.192	-0.039	0.002	0.019	-0.093	0.009	-0.010
GHI	-0.276	0.076	0.038	-0.154	0.024	-0.095	0.139	0.019	0.124
GHI40	-0.562	0.315	0.019	-0.165	0.027	-0.095	0.116	0.013	0.143
Black	-0.340	0.116	-0.081	-0.194	0.038	-0.142	0.100	0.010	0.081
Gold	-0.413	0.170	-0.061	0.084	0.007	0.133	-0.118	0.014	0.041
Blue	-0.241	0.058	-0.192	-0.218	0.048	-0.060	-0.087	0.008	-0.082
Green	-0.628	0.394	-0.235	-0.032	0.001	-0.053	-0.127	0.016	0.014

Table E2. Pearson's product-moment correlation coefficient (r, r2) and Kendall tau rank correlation (τ) for NMS axes on 20 RBS samples (excluding Capte Hedo plot) in Okinawa-jima island. NMS graph is shown in Figure 4.13. spcount = the number of species per sample. GHI = GHI calculated regardless of the number of species per sample; GHI40 = score for samples with over 40 species.

Axis	1			2		
	r	r^2	τ	r	r^2	τ
Latitude	-0.429	0.184	-0.042	0.332	0.11	0.284
Longitude	-0.632	0.399	-0.295	0.414	0.172	0.389
Altitude	0.028	0.001	0.121	-0.209	0.044	0.026
spcount	-0.230	0.053	0.149	-0.221	0.049	0.011
GHI	-0.003	0.000	0.084	-0.354	0.125	-0.011
GHI40	-0.003	0.000	0.084	-0.354	0.125	-0.011
Black	-0.149	0.022	0.073	-0.144	0.021	0.073
Gold	0.062	0.004	0.091	-0.266	0.071	-0.217
Blue	-0.227	0.052	-0.018	-0.250	0.062	-0.102
Green	-0.282	0.080	0.111	-0.119	0.014	0.111

Table E3. Pearson's product-moment correlation coefficient (r, r2) and Kendall tau rank correlation (τ) for NMS axes on 14 RBS samples in Okinawa-jima island. NMS graph is shown in Figure 4.14. spcount = the number of species per sample. GHI40 = score for samples with over 40 species.

Axis	1			2			3		
	r	r^2	τ	r	r^2	τ	r	r^2	τ
Latitude	0.302	0.091	0.275	0.202	0.041	0.099	0.531	0.282	0.473
Longitude	0.193	0.037	0.253	-0.006	0.000	-0.055	0.522	0.273	0.451
Altitude	0.784	0.614	0.626	-0.038	0.001	0.011	-0.223	0.050	-0.099
spcount	0.570	0.325	0.483	0.362	0.131	0.326	-0.293	0.086	-0.191
GHI40	0.778	0.605	0.560	0.241	0.058	0.121	0.131	0.017	0.099

E2. The *Utaki* sacred groves

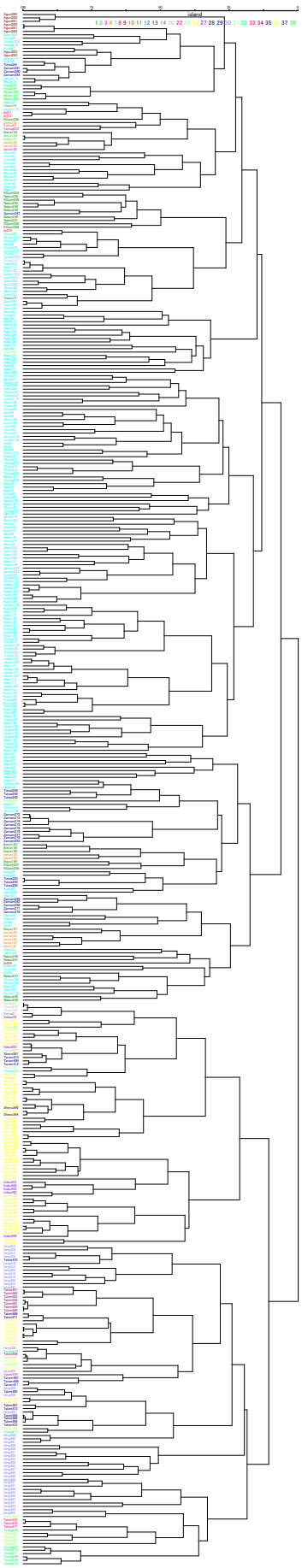


Figure E2. Dendogram produced for 460 Utaki sites with over 2 species by similarity analysis using Ward's method with Euclidean distance measure. 28 island or island groups for Kerama and Daito is colour coded. Sites in pale blue are Okinawa-jima island which were further analysed y ordination.

colour	island	ID
	Iheya-jima island	1
	Noho-jima island	2
	Gushikawa-jima island	3
	Izena-jima island	4
	Okinawa-jima island	7
	Ie-jima island	8
	Aguni-jima island	9
	Ikei-jima island	10
	Kume-jima island	11
	Miyagi-jima island	12
	Henza-jima island	13
	Tsuken-jima island	14
	Kudaka-jima island	20
	Ou-jima island	22
	Ikema-jima island	25
	Miyako-jima island	26
	Irabu-jima island	27
	Kurima-jima island	28
	Tarama-jima island	29
	Ishigaki-jima island	30
	Iriomote-jima island	31
	Yonaguni-jima island	32
	Kohama-jima island	33
	Taketomi-jima island	34
	Kuro-shima island	35
	Hateruma-jima island	36
	Kerama	37
	Daito	38

Appendix F: Beetle sampling data

F1. Beetle collected for 2009 survey site

Table F1. Summary of Flight Intercept Trap (FIT) locations and sampling dates for 2009 survey site. Site = studied forest patch ID; Mgt = management (Yes, Y; No, N); Trap = replicate number; Coll. = collection date (set up = 5/07/2009 – 13/07/2009, 1 = 19/07/2009 – 24/07/2009, 2 = 04/08/2009 – 07/08/2009, 3 = 25/08/2009 – 26/08/2009); lat = latitude (°N); long = longitude (°E); alt = altitude (m).

sampleID	site	site name	Mgt	Trap	Coll.	lat	long	alt
funaapY1.1	1	Chiba Funabashi Kanehori-cho	Y	1	1	35.763128	140.060528	34
funaapY1.2	1	Chiba Funabashi Kanehori-cho	Y	1	2	35.763128	140.060528	34
funaapY1.3	1	Chiba Funabashi Kanehori-cho	Y	1	3	35.763128	140.060528	34
funaapY2.1	1	Chiba Funabashi Kanehori-cho	Y	2	1	35.762778	140.059528	67
funaapY2.2	1	Chiba Funabashi Kanehori-cho	Y	2	2	35.762778	140.059528	67
funaapY2.3	1	Chiba Funabashi Kanehori-cho	Y	2	3	35.762778	140.059528	67
funaskY1.1	2	Chiba Funabashi Ojinbo-cho	Y	1	1	35.760389	140.067861	32
funaskY1.2	2	Chiba Funabashi Ojinbo-cho	Y	1	2	35.760389	140.067861	32
funaskY1.3	2	Chiba Funabashi Ojinbo-cho	Y	1	3	35.760389	140.067861	32
funaskY2.1	2	Chiba Funabashi Ojinbo-cho	Y	2	1	35.777361	140.067417	33
funaskY2.2	2	Chiba Funabashi Ojinbo-cho	Y	2	2	35.777361	140.067417	33
funaskY2.3	2	Chiba Funabashi Ojinbo-cho	Y	2	3	35.777361	140.067417	33
funatmY1.1	3	Chiba Funabashi Toyotomi-cho	Y	1	1	35.761889	140.075472	40
funatmY1.2	3	Chiba Funabashi Toyotomi-cho	Y	1	2	35.761889	140.075472	40
funatmY1.3	3	Chiba Funabashi Toyotomi-cho	Y	1	3	35.761889	140.075472	40
funatmY2.1	3	Chiba Funabashi Toyotomi-cho	Y	2	1	35.762361	140.075000	40
funatmY2.2	3	Chiba Funabashi Toyotomi-cho	Y	2	2	35.762361	140.075000	40
funatmY2.3	3	Chiba Funabashi Toyotomi-cho	Y	2	3	35.762361	140.075000	40
funatmN3.1	3	Chiba Funabashi Toyotomi-cho	N	3	1	35.761111	140.073667	37
funatmN3.2	3	Chiba Funabashi Toyotomi-cho	N	3	2	35.761111	140.073667	37
funatmN3.3	3	Chiba Funabashi Toyotomi-cho	N	3	3	35.761111	140.073667	37
funatmN4.1	3	Chiba Funabashi Toyotomi-cho	N	4	1	35.761028	140.073972	32
funatmN4.2	3	Chiba Funabashi Toyotomi-cho	N	4	2	35.761028	140.073972	32
funatmN4.3	3	Chiba Funabashi Toyotomi-cho	N	4	3	35.761028	140.073972	32
ushinsY1.1	4	Ibaraki Ushiku Kessoku-cho	Y	1	1	35.962556	140.173222	29
ushinsY1.2	4	Ibaraki Ushiku Kessoku-cho	Y	1	2	35.962556	140.173222	29
ushinsY1.3	4	Ibaraki Ushiku Kessoku-cho	Y	1	3	35.962556	140.173222	29
ushinsY3.1	4	Ibaraki Ushiku Kessoku-cho	Y	3	1	35.963611	140.172778	31
ushinsY3.2	4	Ibaraki Ushiku Kessoku-cho	Y	3	2	35.963611	140.172778	31
ushinsY3.3	4	Ibaraki Ushiku Kessoku-cho	Y	3	3	35.963611	140.172778	31
ushinsN2.1	4	Ibaraki Ushiku Kessoku-cho	N	2	1	35.962306	140.172722	35
ushinsN2.2	4	Ibaraki Ushiku Kessoku-cho	N	2	2	35.962306	140.172722	35
ushinsN2.3	4	Ibaraki Ushiku Kessoku-cho	N	2	3	35.962306	140.172722	35
ushinsN4.1	4	Ibaraki Ushiku Kessoku-cho	N	4	1	35.962556	140.172722	34
ushinsN4.2	4	Ibaraki Ushiku Kessoku-cho	N	4	2	35.962556	140.172722	34
ushinsN4.3	4	Ibaraki Ushiku Kessoku-cho	N	4	3	35.962556	140.172722	34
ushikhY1.1	5	Ibaraki Ushiku Sakuradai	Y	1	1	35.955694	140.150500	26
ushikhY1.2	5	Ibaraki Ushiku Sakuradai	Y	1	2	35.955694	140.150500	26
ushikhY1.3	5	Ibaraki Ushiku Sakuradai	Y	1	3	35.955694	140.150500	26
ushikhY2.1	5	Ibaraki Ushiku Sakuradai	Y	2	1	35.955694	140.150722	25
ushikhY2.2	5	Ibaraki Ushiku Sakuradai	Y	2	2	35.955694	140.150722	25
ushikhY2.3	5	Ibaraki Ushiku Sakuradai	Y	2	3	35.955694	140.150722	25
ushikhN3.1	5	Ibaraki Ushiku Sakuradai	N	3	1	35.956389	140.151028	30
ushikhN3.2	5	Ibaraki Ushiku Sakuradai	N	3	2	35.956389	140.151028	30
ushikhN3.3	5	Ibaraki Ushiku Sakuradai	N	3	3	35.956389	140.151028	30
ushikhN4.1	5	Ibaraki Ushiku Sakuradai	N	4	1	35.956028	140.150750	28
ushikhN4.2	5	Ibaraki Ushiku Sakuradai	N	4	2	35.956028	140.150750	28
ushikhN4.3	5	Ibaraki Ushiku Sakuradai	N	4	3	35.956028	140.150750	28
moriccY1.1	6	Ibaraki Moriya Okashiwa	Y	1	1	35.948694	139.976194	42

moriccY1.2	6	Ibaraki Moriya Okashiwa	Y	1	2	35.948694	139.976194	42
moriccY1.3	6	Ibaraki Moriya Okashiwa	Y	1	3	35.948694	139.976194	42
moriccY2.1	6	Ibaraki Moriya Okashiwa	Y	2	1	35.948250	139.975667	37
moriccY2.2	6	Ibaraki Moriya Okashiwa	Y	2	2	35.948250	139.975667	37
moriccY2.3	6	Ibaraki Moriya Okashiwa	Y	2	3	35.948250	139.975667	37
moritzN3.1	6.1	Ibaraki Moriya Tatsuzawa	N	3	1	35.956194	139.966667	73
moritzN3.2	6.1	Ibaraki Moriya Tatsuzawa	N	3	2	35.956194	139.966667	73
moritzN3.3	6.1	Ibaraki Moriya Tatsuzawa	N	3	3	35.956194	139.966667	73
moritzN4.1	6.1	Ibaraki Moriya Tatsuzawa	N	4	1	35.955694	139.966778	19
moritzN4.2	6.1	Ibaraki Moriya Tatsuzawa	N	4	2	35.955694	139.966778	19
moritzN4.3	6.1	Ibaraki Moriya Tatsuzawa	N	4	3	35.622417	139.967889	32
yukikmY1.1	7	Ibaraki Yuki Tama	Y	1	1	36.253861	139.849444	40
yukikmY1.2	7	Ibaraki Yuki Tama	Y	1	2	36.253861	139.849444	40
yukikmY1.3	7	Ibaraki Yuki Tama	Y	1	3	36.253861	139.849444	40
yukikmY2.1	7	Ibaraki Yuki Tama	Y	2	1	36.254111	139.849833	40
yukikmY2.2	7	Ibaraki Yuki Tama	Y	2	2	36.254111	139.849833	40
yukikmY2.3	7	Ibaraki Yuki Tama	Y	2	3	36.254111	139.849833	40
yukikmN3.1	7	Ibaraki Yuki Tama	N	3	1	36.252694	139.848500	42
yukikmN3.2	7	Ibaraki Yuki Tama	N	3	2	36.252694	139.848500	42
yukikmN3.3	7	Ibaraki Yuki Tama	N	3	3	36.252694	139.848500	42
yukikmN4.1	7	Ibaraki Yuki Tama	N	4	1	36.253306	139.848000	42
yukikmN4.2	7	Ibaraki Yuki Tama	N	4	2	36.253306	139.848000	42
yukikmN4.3	7	Ibaraki Yuki Tama	N	4	3	36.253306	139.848000	42
sjgoroY3.1	8	Ibaraki Sekijo Ueno	Y	3	1	36.245167	139.938750	39
sjgoroY3.2	8	Ibaraki Sekijo Ueno	Y	3	2	36.245167	139.938750	39
sjgoroY3.3	8	Ibaraki Sekijo Ueno	Y	3	3	36.245167	139.938750	39
sjgoroY4.1	8	Ibaraki Sekijo Ueno	Y	4	1	36.245556	36.245556	40
sjgoroY4.2	8	Ibaraki Sekijo Ueno	Y	4	2	36.245556	36.245556	40
sjgoroY4.3	8	Ibaraki Sekijo Ueno	Y	4	3	36.245556	36.245556	40
sjgoroN1.1	8	Ibaraki Sekijo Ueno	N	1	1	36.246833	139.938417	38
sjgoroN1.2	8	Ibaraki Sekijo Ueno	N	1	2	36.246833	139.938417	38
sjgoroN1.3	8	Ibaraki Sekijo Ueno	N	1	3	36.246833	139.938417	38
sjgoroN2.1	8	Ibaraki Sekijo Ueno	N	2	1	36.246556	139.938528	39
sjgoroN2.2	8	Ibaraki Sekijo Ueno	N	2	2	36.246556	139.938528	39
sjgoroN2.3	8	Ibaraki Sekijo Ueno	N	2	3	36.246556	139.938528	39
sdkageY1.1	9	Ibaraki Shimodate Kagesawa	Y	1	1	36.262194	139.964972	52
sdkageY1.2	9	Ibaraki Shimodate Kagesawa	Y	1	2	36.262194	139.964972	52
sdkageY1.3	9	Ibaraki Shimodate Kagesawa	Y	1	3	36.262194	139.964972	52
sdkageY2.1	9	Ibaraki Shimodate Kagesawa	Y	2	1	36.261417	139.964972	50
sdkageY2.2	9	Ibaraki Shimodate Kagesawa	Y	2	2	36.261417	139.964972	50
sdkageY2.3	9	Ibaraki Shimodate Kagesawa	Y	2	3	36.261417	139.964972	50
sdkageN3.1	9	Ibaraki Shimodate Kagesawa	N	3	1	36.261472	139.962806	50
sdkageN3.2	9	Ibaraki Shimodate Kagesawa	N	3	2	36.261472	139.962806	50
sdkageN3.3	9	Ibaraki Shimodate Kagesawa	N	3	3	36.261472	139.962806	50
sdkageN4.1	9	Ibaraki Shimodate Kagesawa	N	4	1	36.262111	139.962861	43
sdkageN4.2	9	Ibaraki Shimodate Kagesawa	N	4	2	36.262111	139.962861	43
sdkageN4.3	9	Ibaraki Shimodate Kagesawa	N	4	3	36.262111	139.962861	43
kogaswY1.1	10	Ibaraki Koga Inamiya	Y	1	1	36.184111	139.780417	27
kogaswY1.2	10	Ibaraki Koga Inamiya	Y	1	2	36.184111	139.780417	27
kogaswY1.3	10	Ibaraki Koga Inamiya	Y	1	3	36.184111	139.780417	27
kogaswY2.1	10	Ibaraki Koga Inamiya	Y	2	1	36.183806	139.780194	28
kogaswY2.2	10	Ibaraki Koga Inamiya	Y	2	2	36.183806	139.780194	28
kogaswY2.3	10	Ibaraki Koga Inamiya	Y	2	3	36.183806	139.780194	28
kogaswN3.1	10	Ibaraki Koga Inamiya	N	3	1	36.183472	139.780528	29
kogaswN3.2	10	Ibaraki Koga Inamiya	N	3	2	36.183472	139.780528	29
kogaswN3.3	10	Ibaraki Koga Inamiya	N	3	3	36.183472	139.780528	29
kogaswN4.1	10	Ibaraki Koga Inamiya	N	4	1	36.183111	139.779917	26

kogaswN4.2	10	Ibaraki Koga Inamiya	N	4	2	36.183111	139.779917	26
kogaswN4.3	10	Ibaraki Koga Inamiya	N	4	3	36.183111	139.779917	26
kashikY1.1	11	Chiba Kashiwa Kashiwanoha	Y	1	1	35.903222	139.944694	24
kashikY1.2	11	Chiba Kashiwa Kashiwanoha	Y	1	2	35.903222	139.944694	24
kashikY1.3	11	Chiba Kashiwa Kashiwanoha	Y	1	3	35.903222	139.944694	24
kashikY2.1	11	Chiba Kashiwa Kashiwanoha	Y	2	1	35.902167	139.944694	21
kashikY2.2	11	Chiba Kashiwa Kashiwanoha	Y	2	2	35.902528	139.944500	41
kashikY2.3	11	Chiba Kashiwa Kashiwanoha	Y	2	3	35.902528	139.944500	41

List of beetle species sampled in 2009 FITs

Alleculidae
Allecula cryptomeriae
Allecula melanoria
Allecula simiola
Borboresthes acicularis
Borboresthes cruralis
Anthribidae
Exechesops leucopis
Lilocerus laxus
Ozotomerus japonicus
Phloeobius gibbosus
Platystanos sellatus
Apionidae
Phyllobius intrusus
Phyllobius picipes
Attelabidae
Cycnotrachelus roelofsi
Mechoris ursulus
Biphyllidae
Biphyllus aequalis
Biphyllus rufopictus
Biphyllus throscoides
Buprestidae
Agrilus cyaneaoniger
Trachys variolaris
Carabidae
Amara chalcites
Amara macros
Anisodactylus punctatipennis
Calleida onoha
Carabus insulicola insulicola
Chlaenius micans
Chlaenius naeviger
Chlaenius pallipes
Chlaenius sericimicans
Chlaernius posticalis
Colpodes aurelius aurelius
Panagaues robustus
Synuchus arcuaticollis
Synuchus nitidus
Cerambycidae
Acalolepta fraudatrix
Acalolepta sejuncta
Aredolpona succedauea
Leptuna achracefasciata
Megopis sinica
Mesosa hirsuta
Mesosa longipennis
Pterolophia granulata
Spondylis buprestoides
Uraecha binaculata
Chrysomelidae
Acrothinium gaschkevitchii
gaschkevitchii
Demotina fasciculata
Demotina modesta
Hyperaxis fasciata
Longitarsus scutellaris
Longitarsus succineus
Pagria signata
Phyllotreta striolata
Psylliodes brettinghami
Xanthonia placida
Cicindelidae
Cicindela kaleea yedoensis
Coccinellidae
Chilocorus kuwanae
Harmonia axyridis
Propylea japonica
Pseudoscymnus nakanei
Rodolia cardinalis
Colydiidae
Microprius opacus
Penthelispa vilis
Protosilvanus lateritius
Sympanotus pictus
Cucujidae
Cryptolestes ferrugineus
Psammoecus quadrimaculatus
Cupedidae
Tenomerga mucida
Curculionodae
Choerorhinus sp.
Cossoninae sp.
Cryptorhynchinae sp
Curculio sp
Cyrtepistomus castaneus
Demimaea fascicularis
Lissorhoptrus oryzophilus
Myllocerus griseus
Myosides seriechispidus
Pseudocossonus brevitarsis
Rhadinomerus annulipes
Shirahoshizo insidiosus
Shirahoshizo pini
Simulatacalles simulator
Tanusphyrus major
Trachyphloesoma advena
Disteniidae
Distenia gracilis
Elateridae
Agrilus vidnus subviduus
Agrypnus binodulus binodulus
Agrypnus cordicollis
Agrypnus fuliginosus
Ampedus hypogastricus
hypogastricus
Aulonothroscus longulus
Cardiopohrus niponicus
Elater kometsuki
Elater sieboldi
Harminathous suturalis
Haterumelater bicarinatus
Hemicrepidius secessus
secessus
Melanotus annosus
Melanotus cete
Melanotus legatus
Melanotus lewisi
Melanotus senilis
Neotrichophorus junior
Paracardiophorus pullatus
Stenagostus umbratilis
Tetrigus lewisi
Erotylidae
Aulacochilus sibiricus
Dacne japonica
Eucnemidae
Eucnemidae sp.
Prozylobius helleri
Histeridae
Acritus komai
Bacanius niponicus
Eulomalus tardipes
Margarinotus niponicus

Margarinotus sutus
Merohister jekeli
Platylomalus niponensis
Saprinus niponicus
Hydrophilidae
Cercyon olibrus
Enohrus japonicus
Peratogonus reversus
Leiodidae
Colenius sp.
Lucanidae
Macrodorcas recius
Prosopocoilus inclinatus inclinatus
Melandryidae
Holostrophus dux
Holostrophus lewisi
Holostrophus orientalis
Pholoetrya rugicollis
Serropalpus niponicus
Synchroa melanotoides
Mordellidae
Higehananomia palpalis
Mordellistenoda ohsumiana
Pentaria elongata
Variimorda flavimana
Mycetophagidae
Pseudotriphyllus lewisianus
Nitidulidae
Carpophilus marginellus
Epuraea bickhaldti
Ipidia sibirica
Lasiodactylus pictus
Lbrodor japonicus
Nitidulidae sp.
Soronia fracta
Stelidota multiguttata
Oedemeridae
Xanthochroa waterhousei
Phalacridae
Heterolitus thoracicus
Ptilodactylidae
Pseudoepilichas niponicus
Rhynchophoridae
Diocalandra elongata
Diocalandra sasa
Myosides seriehispidus
Orchlesis takaosanus
Phyndiphoridae sp.
Sipalinus gigas
Saplingidae
Lissodema japonum
Scaphidiidae
Cyparium mikado
Scaphidium japonum
Scaphisoma gentile
Scarabadaeidae
Adoretus tenuimaculatus
Allomyrica dichotoma
Aphodius hibernalis
Blitopertha orientalis
Bolbelasimus nigroplagiaium
Eophilerurus chiuensis
Geotrupidae laevistriatus
Holotrichia kiotoensis
Maladera castanea
Maladera japonica
Maladera kamiyai
Maladera renardi
Maladera secreta
Melolontha japonica
Miridiba castanea
Ochodaeus maculatus
Onthophagus atripennis apicetinctus
Onthophagus nitidus
Panelus parvulus
Phomborrhira japonica
Scolytidae
Ambrosiodmus rubricollis
Bostrychidae sp.
Coccotrypes cardamomi
Coccotrypes graniceps
Coccotrypes nubilus
Cryphalus sp.1
Dryocoetiops coffeae
Euwallacea interjectus
Euwallacea sp.1
Hypothenemus erditus
Sueus niisimai
Xyleborinus saxeseni
Xyleborus atratus
Xyleborus ganshoensis
Xyleborus japonicus
Xyleborus sp.1
Xyleborus sp.2
Xyleborus sp.3
Xyleborus sp.4
Xylosandrus compactus
Xylosandrus crassiusculus
Xylosandrus germanus
Scydmaenidae
Cephennium japonicum
Silphidae
Eusilpha brunneicollis
Eusilpha japonica
Nicrophorus concolor
Nicrophorus quadripunctatus
Ptomascopus morio
Silvanidae
Silvanus bidentatus
Sphindidae
Aspidophorus japonicus
Staphilinidae
Aleochara curtula
Aleochara lata
Aleochara sp
Atheta sp.
Bledis sp.
Carpelimus sp.
Carpelimus sp.2
Erichsonia sp
Ocypus lewisius
Ontholestes gracilis
Osoriinae sp. (Mimigonus sp.)
Philonthus japonicus
Philonthus wusthoffi
Platydracus inornatus
Sepedophilus armatus
Staphylinus paganus
Stenus cicindeloides
Tenebrionidae
Ceropria induta
Plesiophthalmus nigrocyaneus
Promethis striatipennis
Strongylium cultellatum (uedai)
Uloma latimanus
Uloma marseuli
Tetratomidae
Tetratomidae insignis

Table F1. Summary of family foraging behaviours and habitats for the order Coleoptera sampled in 2009 FITs. CWD= Coarse Wood Debris.

Family	Family foraging behaviour	Family habitat
Cupedidae	saproxylic (feed on decaying logs colonised by wood-decay fungi)	dead tree
Cicindelidae	predaceous	underground
Carabidae	predaceous	soil, ground surface
Hydrophilidae	omnivorous	aquatic, some terrestrial
Silphidae	scavenger	aboveground, some inside woods
Scaphidiidae	fungivorous	fungus, decaying tree
Scydmaenidae	predaceous	
Histeridae	predaceous	forest, inside ant nests, tree bark
Staphylinidae	phytophagous, fungivorous, some predaceous and parasitic	soil, underground, forests, tree canopy, ant nests, coastal areas
Leiodidae	fungivorous	dead trees/CWD affected by fungus, lead litter
Lucanidae	larvae phytophagous, adult tree saptree bark/ shoots	decaying treees (CWD), soil
Scarabaeidae	scavenger	dung, decomposing organic matter
Scarabaeidae	phytophagous (plant roots), adult on leaves, flowers, fruits, tree sap, pollen and nectar	dung, decomposing organic matter
Scarabaeidae	phytophagous (plant roots), adult on leaves, flowers, fruits, tree sap, pollen and nectar	soil
Ptilodactylidae	fungivorous	leaf litter or CWD on stream bank
Buprestidae	phytophagous, saproxylic	larvae on CWD, inside plant leaves. Adults on new logged or fallen trees
Buprestidae	phytophagous	larvae on CWD, inside plant leaves. Adults on new logged or fallen trees
Elateridae	predaceous, some species also on plant roots	larvae on CWD, soil and humus. Adults on tree canopy, leaves, flowers, CWD, rocks, aboveground
Eucnemidae	Saproxylic	CWD in forests
Sphindidae	fungivorous	
Colydiidae	predaceous	CWD and its tree bark
Silvanidae	Saproxylic, dead woods, tree bark, straw	CWD, tree bark, straw and stored cereal
Biphyllidae	fungivorous	
Cucujidae	predaceous, some on cereal	tree bark of decaying woods
Tetratomidae	fungivorous	
Mycetophagidae	fungivorous	fungus, CWD and tree barks
Nitidulidae	tree sap, fruits, saproxylic, fungivorous, tree bark, grain and some predaceous	tree sap, fruits, fungus, CWD, tree bark, rotten meat
Lathrididae	fungivorous	fallen leaves and branches
Coccinellidae	feed on Aphididea, Coccoidea, Tetranychidae and some phytophagous	plant leaves
Erotylidae	fungivorous and some saproxylic	fungus
Tenebrionidae	fungivorous, predaceous and phytophagous	CWD, fungus, sand dune, stored cereal
Tenebrionidae	fungivorous	CWD, tree bark of dead trees, fungus
Phalacridae	Phytophagous	
Salpingidae	fungivorous	
Melandryidae	larvae fungivorous and saproxylic, adult unknown	CWD, dead trees, fungus, leaf litter
Mordellidae	phytophagous	CWD
Oedemeridae	larvae phytophagous, adult nectar and pollen	CWD

Cerambycidae	saproxylic	dead trees
Cerambycidae	larvae tree and bamboo, adult tree bark, pollen, nectar etc.	trees both alive and dead
Chrysomelidae	phytophagous, some larvae also saproxylic and plant roots	plant
Anthribidae	dead tree, saproxylic, fungivorous and beans. Adult often fungivorous	dead trees, CWD, fungus and legumes
Attelabidae	tree after death, some larve also potatos	plant
Apionidae	fruit and plant stem	plant stem incl, trees
Curculionidae	any parrt of plant body	on host trees and herbs
Rhynchophoridae	any parrt of plant body	on host trees and herbs
Scolytidae	tree bark of dying or dead trees and Ambrosiella spp.	dying trees or recently fallen trees

Table F2. Ecological information on species sampled in 2009 FITs. FG (Foraging type): SAP=saproxylic; PRE=predaceous; OMN=omnivorous; SCA=scavenger; PHY=phytophagous; FNG=fungivorous. Notes = Habitats, distribution or abundance information of species or genera. Body size (B): minimum (min), maximum (max), mean (avg) from Nakane and Nihon Seibutsuchiri Gakkai. (1969). Star; GD = GOLD; BU = BLUE; GN = GREEN. Stars were assigned using the Draft Keys (Appendix F3).

Family	*Species*	Foraging behaviour	FG	Notes	B min.	B max	B avg.	Star
Cupedidae	*Tenomerga mucida*	-	SAP	-	9	17	13	GN
Cicindelidae	*Cicindela kaleea yedoensis*	-	PRE	Tokyo and Kyushu	9	9	9	GD
Carabidae	*Carabus insulicola insulicola*	-	PRE	mountain and plains, most widespread sp in *Synuchus* spp.	25	32	28.5	BU
Carabidae	*Synuchus arcuaticollis*	-	PRE	-	7.7	11	9.1	BU
Carabidae	*Synuchus nitidus*	-	PRE	-	12.3	16	14.2	GN
Carabidae	*Colpodes aurelius aurelius*	-	PRE	-	7	7	7	GN
Carabidae	*Amara macros*	-	PRE	-	10	10	10	BU
Carabidae	*Amara chalcites*	-	PRE	-	8.5	8.5	8.5	GN
Carabidae	*Anisodactylus punctatipennis*	-	PRE	widespread	11	11	11	GN
Carabidae	*Chlaenius sericimicans*	omnivorous	PRE	wetland on plains	14.5	15	14.5	GN
Carabidae	*Chlaenius pallipes*	omnivorous	PRE	-	14	14	14	GN
Carabidae	*Chlaenius micans*	omnivorous	PRE	-	15	18	16.3	GN
Carabidae	*Chlaenius naeviger*	omnivorous	PRE	-	14	16	14.8	GN
Carabidae	*Chlaernius posticalis*	omnivorous	PRE	-	13	13	13	GN
Carabidae	*Calleida onoha*	predaceous	PRE	on trees	8	8	8	GN
Carabidae	*Panagaues robustus*	predaceous, organic matter	PRE	-	5	5.5	5.25	GN
Hydrophilidae	*Cercyon olibrus*	predaceous	OMN	organic matter	2.5	2.5	2.5	GN
Hydrophilidae	*Peratogonus reversus*	predaceous	OMN	leaf litter	2	2	2	GN
Hydrophilidae	*Enohrus japonicus*	-	OMN	under leaf litter in vicinity of stagnant water	5.5	6	5.75	GN
Silphidae	*Nicrophorus concolor*	predaceous	SCA	-	25	45	35	GN
Silphidae	*Nicrophorus quadripunctatus*	feed on larvae of Lepidoptera	SCA	on plant	14	18	16	GN
Silphidae	*Ptomascopus morio*	-	SCA	plains, widespread	14	14	14	GN

Silphidae	*Eusilpha brunneicollis*	-	SCA	-	20	20	20	BU
Silphidae	*Eusilpha japonica*	-	SCA	-	23	23	23	GN
Scaphidiidae	*Cyparium mikado*	fungivorous	FNG	-	5	5	5	GN
Scaphidiidae	*Scaphidium femorale*	fungivorous	FNG	-	5	5	5	BU
Scaphidiidae	*Scaphidium japonum*	fungivorous	FNG	-	5	7	6	GN
Scaphidiidae	*Scaphisoma gentile*		FNG	-	x	x	-	BU
Scydmaenidae	*Cephennium japonicum*		PRE	leaf litter	1.2	1.2	1.2	BU
Histeridae	*Merohister jekeli*	-	PRE	-	6	12	9	-
Histeridae	*Saprinus niponicus*	-	PRE	-	x	x	-	-
Histeridae	*Bacanius niponicus*	-	PRE	leaf litter	1	1	1	BU
Histeridae	*Acritus komai*	-	PRE	-	x	x	-	GN
Histeridae	*Platylomalus niponensis*	-	PRE	-	3	3.5	3.25	GN
Histeridae	*Margarinotus niponicus*	-	PRE	-	3	5	4	GN
Histeridae	*Eulomalus tardipes*	-	PRE	-	x	x	-	GN
Histeridae	*Margarinotus sutus*	-	PRE	-	x	x	-	GN
Staphylinidae	*Bledius sp.*	-	PHY+FNG	-	x	x	-	-
Leiodidae	*Colenins sp.*	-	FNG	-	x	x	-	-
Staphylinidae	*Carpelimus sp.*		PHY+FNG	-	x	x	-	-
Staphylinidae	*Carpelimus sp. 2*		PHY+FNG	-	x	x	-	-
Staphylinidae	*Atheta sp.*		PHY+FNG	-	x	x	-	-
Staphylinidae	*Osoriinae sp.*		PHY+FNG	-	x	x	-	-
Staphylinidae	*Sepedophilus armatus*		PHY+FNG	-	3	3	3	BU
Staphylinidae	*Stenus cicindeloides*		PHY+FNG	-	5	5	5	GN
Staphylinidae	*Philonthus japonicus*		PHY+FNG	-	11	11	11	GN
Staphylinidae	*Philonthus wusthoffi*		PHY+FNG	-	x	x	-	GN
Staphylinidae	*Staphylinus paganus*		PHY+FNG	plains, lowland	16	16	16	GN
Staphylinidae	*Ocypus lewisius*		PHY+FNG	-	20	20	20	BU
Staphylinidae	*Platydracus inornatus*		PHY+FNG	-	20	20	20	GN
Staphylinidae	*Ontholestes gracilis*		PHY+FNG	-	13	13	13	GN
Staphylinidae	*Erichsonia sp.*		PHY+FNG	-	x	x	-	-
Staphylinidae	*Aleochara lata*		PHY+FNG	-	x	x	-	GN
Staphylinidae	*Aleochara curtula*		PHY+FNG	-	7	8	7.5	GN
Staphylinidae	*Aleochara sp*		PHY+FNG	-	x	x	-	-
Lucanidae	*Macrodorcas recius*	saproxylic, May-Oct	PHY	overwinter inside decaying wood and under rocks	m16.5 f20	m45 f28	-	GN
Lucanidae	*Prosopocoilus inclinatus inclinatus*	saproxylic, Jun-Sept	PHY	larvae on coarse wood debris	m36 f24	m71 f30	-	GN
Scarabaeidae	*Geotrupidae laevistriatus*	large animal dung (e.g. cattle, deer, monkey, sheep, fox, racoon dog, boar)	SCA	forest	14	20	17	GN
Scarabaeidae	*Ochodaeus maculatus*	Apr-Oct	SCA	adults fly daytime on sun patches in forests, logged area, forest	7	11	8.75	BU

				edges.				
Scarabaeidae	*Bolbelasimus nigroplagiaium*	old cattle dung, May-Nov	SCA	lawn area, golf course, grazing land. Adults dig holes underground. Active just after sunset when warm, no wind	9	14	11.5	GN
Scarabaeidae	*Panelus parvulus*	omnivorous (dung of cattle, horse, deer, fox, racoon dog, marten, dog, human) , year round	SCA	dung in forests, leaf litter, inside tree bark	2.5	3	2.75	GN
Scarabaeidae	*Onthophagus atripennis apicetinctus*	scavenger (dog, human, cattle, horse, racoon dog, bear, marten), litter, Mar-Nov	SCA	from in forests to open area, lowland, plain and human settlement	6	10	8	GN
Scarabaeidae	*Onthophagus nitidus*	scavenger, May-Nov	SCA	in forests	5.5	8	6.75	GN
Scarabaeidae	*Aphodius hibernalis*	monkey, fox, deer, dog, human, spring-autumn/year round	SCA	lowland to plains, inside tree cavity	7.5	8	7.75	BU
Scarabaeidae	*Blitopertha orientalis*	omnivorous, plants	PHY	diurnal, but also on street lamps at night	8	14	10.8	GN
Scarabaeidae	*Melolontha japonica*	-	PHY	-	25	31	28	BU
Scarabaeidae	*Maladera secreta*	phytophagous, larve roots	PHY	-	9	12	10.3	BU
Scarabaeidae	*Maladera japonica*	phytophagous, larve roots	PHY	-	8	8.5	8.25	GN
Scarabaeidae	*Maladera castanea*	phytophagous, larve roots	PHY	-	8	10	9	GN
Scarabaeidae	*Maladera kamiyai*	phytophagous, larve roots	PHY	-	8	9	8.5	GN
Scarabaeidae	*Maladera renardi*	?	PHY	-	8	9.5	8.75	-
Scarabaeidae	*Miridiba castanea*	phytophagous, larve roots	PHY	-	18	22	20	GN
Scarabaeidae	*Holotrichia kiotoensis*	phytophagous, larve roots	PHY	-	15	20	17.5	GN
Scarabaeidae	*Adoretus tenuimaculatus*	-	PHY	-	9.5	11	10.3	GN
Scarabaeidae	*Phomborrhira japonica*	tree sap, rotten fruits, Jun-Sept	PHY	-	23	29	26	BU
Scarabaeidae	*Trypoxylus (Allomyrica) dichotoma*	larvae saproxylic, adult tree sap of Q. acutissima and rotten fruits, Jun-Aug	PHY	larvae on CWD or humus.	30	53	41.5	GN
Scarabaeidae	*Eophilerurus chiuensis*	larvae predaceous, adult tree sap, Apr-Oct	PHY	CWD and humus	20	24	22	-
Ptilodactylidae	*Pseudoepilichas niponicus*	-	FNG	common	5	6	5.5	GN
Buprestidae	*Agrilus viduus subviduus*	Japanese zelcova (*Zelcova serrata*) and Japanese elm (*Ulmus davidiana* var. *japonica*)	PHY		6	10	8	BU
Buprestidae	*Agrilus cyaneaoniger*		PHY	*Quercus crispula* and *Q. acutissima* etc	10	15	12.5	GN
Buprestidae	*Trachys variolaris*		PHY	*Quercus* spp. *Q. acutissima* and *Q. dentata* etc	3	4.1	3.55	GN
Elateridae	*Aulonothroscus longulus*		PRE	-	x	x	-	GN
Eucnemidae	*Eucnemidae sp.*		SAP	-	x	x	-	-
Eucnemidae	*Prozylobius helleri*		SAP	-	x	x	-	GN

Elateridae	*Agrypnus cordicollis*	predaceous	PRE	common	14	14	14	GN
Elateridae	*Agrypnus fuliginosus*	predaceous	PRE	common	10	10	10	GN
Elateridae	*Agrypnus binodulus binodulus*	predaceous	PRE	common	16	16	16	GN
Elateridae	*Tetrigus lewisi*	predaceous	PRE	-	25	33	29	GN
Elateridae	*Haterumelater bicarinatus*	predaceous	PRE	decaying coniferous woods	9.5	9.5	9.5	GN
Elateridae	*Elater sieboldi*	predaceous	PRE	plains, lowland	24	24	24	GN
Elateridae	*Elater kometsuki*	predaceous	PRE	plains, lowland	x	x	-	BU
Elateridae	*Harminathous suturalis*	predaceous	PRE	low abundance	x	x	-	BU
Elateridae	*Melanotus senilis*	predaceous	PRE	-	13	13	13	GN
Elateridae	*Hemicrepidius secessus secessus*	predaceous	PRE	common	x	x	-	GN
Elateridae	*Melanotus legatus*	predaceous	PRE	2 sub spp. in Ryukyu and Izu Isls.	16	16	16	GN
Elateridae	*Melanotus cete*	predaceous	PRE	common	17	17	17	GN
Elateridae	*Melanotus lewisi*	predaceous	PRE	-	x	x	-	BU
Elateridae	*Melanotus annosus*	predaceous	PRE	-	x	x	-	GN
Elateridae	*Neotrichophorus junior*	predaceous	PRE	-	11	11	11	GN
Elateridae	*Ampedus hypogastricus hypogastricus*	larvae on decaying *Pinus* trees	PRE	larvae on decaying *Pinus* trees	x	x	-	GN
Elateridae	*Stenagostus umbratilis*	predaceous	PRE	-	22	22	22	GN
Elateridae	*Cardiopohrus niponicus*	predaceous	PRE	-	7	8.5	7.75	BU
Elateridae	*Paracardiophorus pullatus*	predaceous	PRE	-	6	6	6	GN
Sphindidae	*Aspidophorus japonicus*		FNG	-	1.5	1.5	1.5	GN
Colydiidae	*Sympanotus pictus*	predaceous	PRE	-	5	5	5	BU
Colydiidae	*Protosilvanus lateritius*		PRE	-	4	4	4	GN
Colydiidae	*Microprius opacus*		PRE	-	2.2	3	2.6	GN
Colydiidae	*Penthelispa vilis*		PRE	-	3.5	3.5	3.5	BU
Silvanidae	*Silvanus bidentatus*		SAP	-	3.5	3.5	3.5	GN
Biphyllidae	*Biphyllus throscoides*		FNG	rare	2	2	2	BU
Biphyllidae	*Biphyllus rufopictus*		FNG	very common	2	2	2	BU
Biphyllidae	*Biphyllus aequalis*		FNG	rare	2.5	2.5	2.5	BU
Cucujidae	*Cryptolestes ferrugineus*		PRE	across the world	x	x	-	GN
Cucujidae	*Psammoecus quadrimaculatus*		PRE	-	2.5	3	2.75	GN
Tetratomidae	*Tetratomidae insignis*	often on *Trametes versicolor*	FNG		2.5	3	2.75	BU
Mycetophagidae	*Pseudotriphyllus lewisianus*	mushrooms e.g. *Trametes versicolor*	FNG		x	x	-	GD
Nitidulidae	*Ipidia sibirica*	-	SAP+FNG	-	3.5	3.5	3.5	GN
Nitidulidae	*Epuraea bickhaldti*	-	SAP+FNG	-	x	x	-	GN
Nitidulidae	*Soronia fracta*	Soronia spp. on tree saps	SAP+FNG		8.5	8.5	8.5	GN
Nitidulidae	*Nitidulidae sp.*	-	SAP+FNG		x	x	-	-
Nitidulidae	*Lasiodactylus pictus*	-	SAP+FNG		7.5	7.5	7.5	GN
Nitidulidae	*Stelidota multiguttata*	rotten fruits	SAP+FNG	leaf litter	3	3	3	GN
Nitidulidae	*Lbrodor japonicus*	tree sap	SAP+FNG		7.5	14	10.5	GN
Nitidulidae	*Carpophilus marginellus*	-	SAP+FNG		3	3	3	GN
Lathrididae	*unspecified latin name*	-	FNG		x	x	-	-

Coccinellidae	*Pseudoscymnus nakanei*	-	PRE+PHY	rare	x	x	-	BU
Coccinellidae	*Chilocorus kuwanae*	-	PRE+PHY		3.5	4.8	4.15	GN
Coccinellidae	*Rodolia cardinalis*	-	PRE+PHY		3.5	4	3.75	GN
Coccinellidae	*Harmonia axyridis*		PRE+PHY	introduced across the world	4	8	6	GN
Coccinellidae	*Propylea japonica*		PRE+PHY	plains, lowland. concentrated patches but across many areas	3.5	5	4.25	GN
Erotylidae	*Dacne japonica*	-	FNG		3	4.5	3.75	GN
Erotylidae	*Aulacochilus sibiricus*	-	FNG		5.5	8	6.75	GN
Tenebrionidae	*Uloma latimanus*	saproxylic	FNG+PRE+SAP		10	10	10	GN
Tenebrionidae	*Uloma marseuli*	saproxylic	FNG+PRE+SAP		7	9	8	BU
Tenebrionidae	*Ceropria induta*	-	FNG+PRE+SAP		10	10	10	GN
Tenebrionidae	*Promethis striatipennis*	-	FNG+PRE+SAP		x	x	-	-
Tenebrionidae	*Plesiophthalmus nigrocyaneus*	-	FNG+PRE+SAP	2 sub sp	16	22	19	-
Tenebrionidae	*Strongylium cultellatum*	-	FNG+PRE+SAP		9	12	10.5	BU
Tenebrionidae	*Allecula melanoria*	-	FNG	decaying trees of *Pinus* spp	10	11	10.5	GN
Tenebrionidae	*Allecula cryptomeriae*		FNG	CDW, nocturnal	16	18	16.8	BU
Tenebrionidae	*Allecula simiola*		FNG	on tree leaves	6	6	6	GN
Tenebrionidae	*Borboresthes acicularis*		FNG	on tree leaves	7	7	7	BU
Tenebrionidae	*Borboresthes cruralis*		FNG	on tree leaves	8	8	8	BU
Phalacridae	*Heterolitus thoracicus*		PHY	common	1.5	2	1.75	GN
Salpingidae	*Lissodema japonum*		FNG	-	x	x	-	BU
Melandryidae	*Holostrophus orientalis*	fungivorous	FNG+SAP		4.5	6.8	5.63	GN
Melandryidae	*Holostrophus dux*	fungivorous	FNG+SAP	-	8.7	13	10.9	BU
Melandryidae	*Synchroa melanotoides*	fungivorous	FNG+SAP	decaying woods, relatively common	3.5	5	4.25	GN
Melandryidae	*Holostrophus lewisi*	fungivorous	FNG+SAP	-	5.3	13	9.15	BU
Melandryidae	*Pholoetrya rugicollis*	fungivorous	FNG+SAP	common	8.5	19	13.5	GN
Melandryidae	*Serropalpus niponicus*	fungivorous	FNG+SAP		5	6	5.5	GN
Mordellidae	*Pseudoepilichas niponicus*		PHY		8	15	11.5	GN
Mordellidae	*Higehananomia palpalis*		PHY		3.5	4	3.75	GN
Mordellidae	*Mordellistenoda ohsumiana*		PHY		3.5	4	3.75	BU
Mordellidae	*Pentaria elongata*		PHY		2.7	3.3	3	GN
Mordellidae	*Variimorda flavimana*		PHY		5.7	7.9	6.8	BU
Oedemeridae	*Xanthochroa waterhousei*		PHY		11	15	13	GN
Cerambycidae	*Distenia gracilis*		SAP	standing dead trees or dead branches, nocturnal	20	30	25	GN
Cerambycidae	*Megopis sinica*		PHY	many BL trees and *Pinus* spp.	30	55	42.5	GN
Cerambycidae	*Spondylis buprestoides*		PHY	coniferous trees	12	25	18.5	GN
Cerambycidae	*Aredolpona succedauea*		PHY	flowers and decaying woods	12	22	17	GN
Cerambycidae	*Leptuna achracefasciata*		PHY	-	13	20	16.5	GN
Cerambycidae	*Mesosa longipennis*		PHY	many BL trees and *Pinus* spp.	13	21	17	GN

Cerambycidae	*Mesosa hirsuta*		PHY	many BL trees and *Pinus* spp.	10	18	14	GN
Cerambycidae	*Pterolophia granulata*		PHY	adults on tree barks of BL trees, also fungivorous. Common	7	10	8.5	GN
Cerambycidae	*Acalolepta fraudatrix*		PHY	inside fallen leaves during day, on newly fallen trees at night	17	26	21.5	GN
Cerambycidae	*Acalolepta sejuncta*		PHY	adult on fallen leaves of BL trees, inside fallen leaves attached to branches during day	15	20	17.5	GN
Cerambycidae	*Uraecha binaculata*	larave on the range of BL trees such as EG *Quercus* spp. *Rhus javanica*, particularly on relatively slim dead branches.	PHY	high number of individuals along the coast, mainly in plains but also on mountains. dead leaves and branches.	15	25	20	GN
Chrysomelidae	*Demotrina modesta*		PHY		7	7	7	-
Chrysomelidae	*Acrothinium gaschkevitchii gaschkevitchii*	feed on *Vitis* spp.	PHY		7	7	7	GN
Chrysomelidae	*Xanthonia placida*	feed on *Morus* spp.	PHY		2.5	2.5	2.5	BU
Chrysomelidae	*Hyperaxis fasciata*	feed on *Q. dentata* and alike	PHY		4	4	4	GN
Chrysomelidae	*Pagria signata*	feed on *Glycine max*	PHY		2.5	2.5	2.5	GN
Chrysomelidae	*Demotina fasciculata*	evergreen *Quercus* spp. and *Camellia sinensis*	PHY		4	4	4	GN
Chrysomelidae	*Phyllotreta striolata*	*Brassicaceae* spp.	PHY		3	3	3	GN
Chrysomelidae	*Longitarsus scutellaris*	larvae live underground, adult feed on *Plantago asiatica*	PHY		2	2	2	GN
Chrysomelidae	*Longitarsus succineus*	*Artemisia* spp.	PHY		2	2	2	GN
Chrysomelidae	*Psylliodes brettinghami*	aubergine, potato, Chinese lantern plant etc.	PHY		3	3	3	GN
Anthribidae	*Platystanos sellatus*		SAP+FNG		10	12	11	GN
Anthribidae	*Lilocerus laxus*		SAP+FNG		7	9	8	GN
Anthribidae	*Exechesops leucopis*		SAP+FNG		8	9	8.5	GN
Anthribidae	*Ozotomerus japonicus*		SAP+FNG		6	10	8	GN
Anthribidae	*Phloeobius gibbosus*		SAP+FNG		10	10	10	BU
Attelabidae	*Mechoris ursulus*		SAP		9	9	9	GN
Attelabidae	*Cycnotrachelus roelofsi*		SAP		5	8	6.5	GN
Apionidae	*Phyllobius picipes*		PHY		5	5	5	GN
Apionidae	*Phyllobius intrusus*		PHY		5.5	6	5.75	-
Curculionidae	*Myllocerus griseus*		PHY		5	5	5	GN
Curculionidae	*Cyrtepistomus castaneus*		PHY		6	6	6	GN
Curculionidae	*Myosides seriechispidus*		PHY		3.5	3.5	3.5	GN
Curculionidae	*Trachyphloesoma advena*		PHY		2.2	2.2	2.2	GN
Curculionidae	*Lissorhoptrus oryzophilus*		PHY		4	4	4	GN
Curculionidae	*Tanusphyrus major*		PHY		3	3	3	GN

Curculionidae	*Demimaea fascicularis*		PHY	3.5	3.5	3.5	GN
Curculionidae	*Curculio sp*		PHY	x	x	-	-
Curculionidae	*Simulatacalles simulator*		PHY	3	5	4	GN
Curculionidae	*Rhadinomerus annulipes*		PHY	x	x	-	GN
Curculionidae	*Cryptorhynchinae Genus ? Sp*		PHY	x	x	-	-
Curculionidae	*Shirahoshizo insidiosus*		PHY	4.5	6.2	5.35	BU
Curculionidae	*Shirahoshizo pini*		PHY	x	x	-	BU
Curculionidae	*Shirahoshizo sp.*		PHY	x	x	-	-
Curculionidae	*Pseudocossonus brevitarsis*	bamboo shoots	PHY	4.6	6.6	5.6	BU
Curculionidae	*Choerorhinus sp.*		PHY	x	x	-	-
Curculionidae	*Cossoninae genus? Sp.*		PHY	x	x	-	-
Rhynchophoridae	*Phyndiphoridae genus? Sp.*		PHY	x	x	-	-
Rhynchophoridae	*Sipalinus gigas*		PHY	12	24	18	GN
Rhynchophoridae	*Diocalandra sasa*		PHY	2.7	4.5	3.6	BU
Rhynchophoridae	*Diocalandra elongata*		PHY	2.1	2.3	2.2	BU
Rhynchophoridae	*Myosides seriehispidus*		PHY	3.5	3.5	3.5	-
Rhynchophoridae	*Orchlesis takaosanus*		PHY	4	4	4	-
Scolytidae	*Dryocoetiops coffeae*		SAP	x	x	-	GN
Scolytidae	*Ambrosiodmus rubricollis*		SAP	x	x	-	GN
Scolytidae	*Sueus niisimai*		SAP	x	x	-	GN
Scolytidae	*Xyleborinus saxeseni*		SAP	x	x	-	GN
Scolytidae	*Xylosandrus compactus*		SAP	x	x	-	GN
Scolytidae	*Xyleborus atratus*		SAP	2.7	2.7	2.7	GN
Scolytidae	*Coccotrypes cardamomi*		SAP	x	x	-	-
Scolytidae	*Xylosandrus crassiusculus*		SAP	2.7	2.7	2.7	GN
Scolytidae	*Scolytidae? sp.*		SAP	x	x	-	-
Scolytidae	*Euwallacea interjectus*		SAP	x	x	-	GN
Scolytidae	*Coccotrypes graniceps*		SAP	x	x	-	-
Scolytidae	*Xylosandrus germanus*		SAP	2.2	2.2	2.2	GN
Scolytidae	*Xyleborus sp.1*		SAP	x	x	-	-
Scolytidae	*Hypothenemus erditus*		SAP	x	x	-	GN
Scolytidae	*Xyleborus sp.2*		SAP	x	x	-	-
Scolytidae	*Xyleborus sp.3*		SAP	x	x	-	-
Scolytidae	*Xyleborus sp.4*		SAP	x	x	-	-
Scolytidae	*Euwallacea sp.1*		SAP	x	x	-	-
Scolytidae	*Xyleborus ganshoensis*		SAP	x	x	-	BU
Scolytidae	*Xyleborus japonicus*		SAP	x	x	-	-
Scolytidae	*Coccotrypes nubilus*		SAP	x	x	-	GN
Scolytidae	*Cryphalus sp.1*		SAP	x	x	-	-

F2. Beetle collected and partially identified for 2010 survey site

Table F2. Summary of Flight Intercept Trap (FIT) locations and sampling dates for 2010 survey site. TrapID & GPSname = ID for trap; lat = latitude (°N); long = longitude (°E); alt = altitude (m; .set up = date and time recorded at trap set up; collection 1 & 2 = subsequent trap collection date.

TrapID	lat	long	alt	GPSname	set up	collection1	collection2
Kayo1	26.588141	128.064441	316.157	Kayp?a	08/06/2010 16:03	24/06/2010	06/07/2010
Kayo2	26.584346	128.077576	227.716	Kayo!2	08/06/2010 17:16	24/06/2010	06/07/2010
Kayo3	26.575535	128.103168	160.425	Kayo!!3	08/06/2010 17:48	24/06/2010	06/07/2010
Kayo4	26.575333	128.093769	161.146	Kayo!!4	08/06/2010 18:43	24/06/2010	06/07/2010
Okuni1	26.705801	128.186610	312.071	Okuni1	09/06/2010 14:21	24/06/2010	06/07/2010
Okuni2	26.705105	128.188920	322.646	Okuni2	09/06/2010 14:38	24/06/2010	06/07/2010
Okuni3	26.704960	128.189859	307.024	Okuni3	09/06/2010 14:52	24/06/2010	06/07/2010
Okuni4	26.707886	128.195703	186.140	Okuni4	09/06/2010 15:14	24/06/2010	06/07/2010
Okuni5	26.709087	128.197253	188.303	Okuni5	09/06/2010 15:28	24/06/2010	06/07/2010
Okuni6	26.716465	128.197888	275.782	Okuni6	09/06/2010 15:46	24/06/2010	06/07/2010
Okuni7	26.717976	128.200384	273.000	Okuni7	09/06/2010 16:01	24/06/2010	06/07/2010
Okuni8	26.719548	128.199970	262.083	Okuni8	09/06/2010 16:18	24/06/2010	06/07/2010
Okuni9	26.719530	128.201348	265.207	Okuni9	09/06/2010 16:32	24/06/2010	06/07/2010
Okuni10	26.718345	128.204414	279.146	Okuni10	09/06/2010 16:50	24/06/2010	06/07/2010
Nago1	26.586439	128.004679	242.000	Nago1	10/06/2010 11:10	24/06/2010	06/07/2010
Nago2	26.586011	128.004805	253.000	Nago2	10/06/2010 11:24	24/06/2010	06/07/2010
Nago3	26.585555	128.005515	287.000	Nago3	10/06/2010 11:38	24/06/2010	06/07/2010
Nago4	26.584449	128.007474	299.000	Nago4	10/06/2010 11:57	24/06/2010	06/07/2010
Nago5	26.589696	128.005873	208.000	Nago5	10/06/2010 14:28	24/06/2010	06/07/2010
Nago6	26.591064	128.004044	214.000	Nago6	10/06/2010 14:57	24/06/2010	06/07/2010

List of beetle species sampled in 2010 FITs for those identified as of August 2011

Alleclidae
Allecula simiola
Bolbostetha sauteri oshimana
Anthribidae
Xanthoderopygus flavicollis (Morimoto, 1978)
Cerambycidae
Acalolepta oshimana omoro
Ceresium elongatum
Glenea (Glenea) lineata ihai
Mimectatina meridiana ohirai
Mimostrangalia longicornis
Pterolophia(Pseudale) obovata
Sciades (Miaenia) longicolllis
Uraecha oshimana
Chelonariidae
Pseudochelonarium yakushimanum
Chrysomelidae
Basilepta davidi (Lefevre, 1877)
Linaeidea formosana
Nodina kraussi
Zipangia loochooana
Cicindelidae
Cicindela kaleea humerula
Therates alboobliquatus yakushimanus
Colydiidae
Pseudotarphius lewisii
Erotylidae
Tritoma sasajii
Ptilodactylidae
Ptilodactyla amamioshimana
Scaphidiidae
Episcaphium sp.
Scarabaeidae
Maladera okinawaensis
Maladera oshimana okinawana
Ochodaeus interruptus kurosawai
Onthophagus (Parascatonomus) itoi
Onthophagus (Parascatonomus) murasakianus carnarius
Onthophagus sp.
Sophrops kawadai okinawaensis
Sphindidae
Aspidiphorus sp.
Tenebrionidae
Derispia japonica
Pseudonautes purpurivittatus
Stenochinus carinatus carinatus
Tetragonomenes palpaloides

F3. Keys to Stars for Coloeptera

Keys to assign Stars for beetles were drafted in 2010. Stars were only assigned for species sampled in 2009 FITs, species identification for 2010 samples is incomplete, hence left un-examined.

Keys to stars for the Japanese Coleoptera

(Working draft as of September 2010)

1. Endemic to Japan

    2. Endemic to any (or all) of the following small island groups

        Ryukyu Islands, Ogasawara Islands, Izu Islands = **BLACK**

    2a. Not only in the small island groups

        3. Not so widespread in Japan (≤ 2 districts AND ≤ 14 prefectures)

            Only in ≤ 7 prefectures = **BLACK**

            In > 7 prefectures = **GOLD**

        3a. Widespread in Japan (> 2 districts OR > 14 prefectures)

            4. Occur in ≤ 10 prefectures

                In ≤ 5 prefectures and rare (e.g. mountain tops, along the coast line) = **BLACK**

                In > 5 prefectures = **GOLD**

            4a. Occur in > 10 prefectures

                Not in all districts = **BLUE**

                In almost all districts = **GREEN**

1a. Not endemic to Japan

    2. Apart from Japan, only in one of Taiwan OR Korea OR the Kuriles & Sakhalin, use the table:

Distribution outside Japan		**Distribution within Japan**			
Regions	Distribution in the regions	Islands or ≤ 1 district	≤ 2 districts	≤ 3 districts	> 3 districts
Taiwan	< ½ island	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	≥ ½ island	**GOLD**	**BLUE**	**GREEN**	**GREEN**
Korea	Islands or sparse distribution	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	Not only in islands nor restricted	**GOLD**	**BLUE**	**GREEN**	**GREEN**
Kuriles & Sakhalin	Only in the south Kuriles	**BLACK**	**GOLD**	**BLUE**	**GREEN**
	Not only in the south Kuriles	**GOLD**	**BLUE**	**GREEN**	**GREEN**
China	≤ 2 provinces	**GOLD**	**BLUE**	**GREEN**	**GREEN**
	>2 provinces	**GREEN**	**GREEN**	**GREEN**	**GREEN**

    2a. Not only in one of Taiwan OR Korea OR the Kuriles & Sakhalin, and beyond = **GREEN**

Additional consideration on abundance and/or population size which affects rarity should be examined. Once initial Stars were assigned, the following guideline is proposed for adjustment of Star status for each species examined.

1. Population unspecified = keep the original Star category

1a. Population specified

2. Population known to be rare = upgrade a Star category

2a. Population known to be not rare

3. Population not common = keep the original Star category

3a. Population known to be common = downgrade a Star category

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