

High-resolution digital canopy height models, terrain models, ortho-mosaic photos, and canopy tree crown shapes derived from UAV-borne LiDAR at 22 tree census plots across Japanese natural forests

Ryuichi Takeshige^{1,2}  | Kyaw Kyaw Htoo¹  | Masanori Onishi^{1,3} |
Farhadur Md. Rahman^{1,4}  | Kazuhiko Hoshizaki⁵  | Hideyuki Ida⁶  |
Masae Iwamoto Ishihara⁷  | Akira Itoh⁸  | Takayuki Kaneko¹  |
Ayumi Katayama⁹  | Shigeo Kuramoto¹⁰  | Hiroko Kurokawa¹  |
Masayuki Maki¹¹ | Kazuhiko Masaka¹²  | Tatsuro Nakaji¹³  |
Masahiro Nakamura¹⁴  | Naoyuki Nishimura¹⁵  | Mahoko Noguchi¹⁶  |
Atsushi Sakai¹⁶  | Atsushi Takashima¹⁷  | Naoaki Tashiro¹⁸  |
Naoko Tokuchi⁷  | Hiromi Yamagawa¹⁹  | Yusuke Onoda¹ 

¹Graduate School of Agriculture, Kyoto University, Kyoto, Japan

²Biodiversity Division, National Institute for Environmental Studies, Tukuba, Ibaraki, Japan

³DeepForest Technologies Co., Ltd., Kyoto, Japan

⁴Department of Remote Sensing and GIS, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Dhaka, Bangladesh

⁵Faculty of Bioresource Sciences, Akita Prefectural University, Akita, Japan

⁶Faculty of Education, Shinshu University, Nagano, Japan

⁷Field Science Education and Research Center, Kyoto University, Kyoto, Japan

⁸Graduate School of Science, Osaka Metropolitan University, Osaka, Japan

⁹Shiiba Research Forest, Kyushu University, Shiiba, Miyazaki, Japan

¹⁰Forestry and Forest Products Research Institute, Tsukuba, Ibaraki, Japan

¹¹Botanical Gardens, Tohoku University, Sendai, Miyagi, Japan

¹²Department of Forest Science, Faculty of Agriculture, Iwate University, Morioka, Iwate, Japan

¹³Uryu Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Horokanai, Hokkaido, Japan

¹⁴Tomakomai Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Tomakomai, Hokkaido, Japan

¹⁵Faculty of Informatics, Gunma University, Maebashi, Gunma, Japan

¹⁶Tohoku Research Center, Forestry and Forest Products Research Institute, Morioka, Iwate, Japan

¹⁷Yona Field, Subtropical Field Science Center, Faculty of Agriculture, University of the Ryukyus, Kunigami, Okinawa, Japan

¹⁸Ashoro Research Forest, Faculty of Agriculture, Kyushu University, Ashoro, Hokkaido, Japan

¹⁹Kyushu Research Center, Forestry and Forest Products Research Institute, Kumamoto, Japan

Ryuichi Takeshige and Yusuke Onoda share joint authorship.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial](https://creativecommons.org/licenses/by-nc/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

© 2025 The Author(s). *Ecological Research* published by John Wiley & Sons Australia, Ltd on behalf of The Ecological Society of Japan.

Correspondence

Ryuichi Takeshige and Yusuke Onoda,
Graduate School of Agriculture, Kyoto
University, Kitashirakawa Oiwake-cho,
Sakyo-ku, Kyoto, Japan.
Email: ryuichi.takeshige.frog@gmail.com
and onoda.yusuke.6c@kyoto-u.ac.jp

Funding information

JSPS KAKENHI, Grant/Award Numbers:
21H02564, 21H05314

Abstract

Recent developments in Unmanned Aerial Vehicles (UAVs) and Light Detection and Ranging (LiDAR) technology have enhanced the ability to capture precise three-dimensional forest information at a lower cost. This article reports four types of high-resolution digital datasets derived from UAV-LiDAR measurements and associated fieldwork. The dataset includes 5 cm resolution Digital Terrain Models (DTMs) and Canopy Height Models (CHMs), ortho-mosaic photos with sub-2.7 cm resolution, and 4328 tree crown polygons with information on 151 species, stem girth at breast height, and canopy height. Data were collected from 22 approximately 1-ha long-term monitoring plots across Japan, spanning major climate zones from subtropical to subarctic. These plots encompass evergreen conifer, broadleaf and conifer mixed, deciduous broadleaf, and evergreen broadleaf forests. UAV surveys were conducted from May 2022 to October 2023. Based on these data, we also report basic profiles of these natural forests: a median slope of 22.2° (ranging from 2.5° to 35.0° across sites), median canopy height of 19.2 m (10.5–25.2 m), median maximum canopy height of 29.4 m (17.6–39.8 m), median gap ratios of 1.7% (0–10.7%) and 7.7% (0–28.9%) depending on gap definitions, and median crown area of 42.9 m² (10.7–80.2 m²) for canopy trees. This dataset is the first publicly available collection of forest structure and individual tree crown information for Japanese natural forests. We hope this dataset will be useful for a wide range of studies and analyses, from site-specific case studies to global-scale meta-analyses. The metadata is available in MetaCat in JaLTER at <https://jalter.diasjp.net/data/ERDP-2025-04>.

KEYWORDS

DIAS, drone, forest census, JaLTER, the Monitoring Sites 1000 Project

1 | INTRODUCTION

Light Detection and Ranging (LiDAR) technology is useful for capturing the precise three-dimensional structure of forests (White et al., 2016). Data obtained from LiDAR can be used to generate digital terrain models (DTMs), digital surface models (DSMs), and canopy height models (CHMs), which are derived from the difference between the DSM and DTM. Additionally, RGB (red-green-blue) images captured simultaneously with LiDAR data can be processed to create high-resolution ortho-mosaic photos. Until the early 2010s, LiDAR sensors were typically mounted on manned aircraft (e.g., planes) to gather forest structural information over a landscape scale (e.g., over 1000 ha), but this approach is quite expensive and has relatively low spatial resolution (0.2–30 m) (Anderson & Gaston, 2013; Beland et al., 2019). Since the mid-2010s, advancements in Unmanned Aerial Vehicle (UAV) technology have greatly expanded the

applicability of LiDAR systems for higher spatial resolution forest surveys (0.01–0.2 m) at the stand scale (e.g., a few to several hundred hectares), enabling the acquisition of three-dimensional information at the individual tree level at a lower cost (Beland et al., 2019).

In this article, we report four digital products based on UAV-LiDAR surveys and simultaneous ground-truth work: DTM and CHM at 5 cm spatial resolution, ortho-mosaic photos at sub-2.7 cm spatial resolution, and projected crown polygons of individual canopy trees visible from UAV for 22 long-term tree census plots registered in the Monitoring Sites 1000 Project of the Ministry of Environment, Japan. The crown polygon data are linked to tree IDs through ground-truth work, thereby connecting the crown data to past tree census data, such as stem diameter at breast height and tree species.

This is the first dataset to describe fine-scale terrain information, forest structure, and individual tree crowns for many forest plots across a large climatic gradient.

Given that multidisciplinary studies have already been conducted and published for these study sites (e.g., tree census: Ishihara et al., 2011, Yoshikawa et al., 2024; litter fall: Suzuki et al., 2012; ground-dwelling beetles: Niwa et al., 2016; tea bag decomposition: Suzuki et al., 2019; insect herbivory: Takafumi et al., 2021; soil nitrogen properties: Urakawa et al., 2015; soil and soil microbe properties: Nakamura et al., 2022), this dataset enables new opportunities for integrated analyses to reveal ecological processes in Japanese natural forests. We hope this dataset will also be utilized and promoted across various scales of studies, from site-specific case studies to global-scale meta-analyses.

2 | DATA DESCRIPTION

2.1 | Identifier

ERDP-2025-04

2.2 | Contributor

2.2.1 | Dataset owners

Ryuichi Takeshige

Biodiversity Division, National Institute for Environmental Studies

Address: 16-2, Onogawa, Tsukuba, Ibaraki 305-8506, Japan.

Kyaw Kyaw Htoo, Yusuke Onoda

Graduate School of Agriculture, Kyoto University

Address: Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan.

Masanori Onishi

DeepForest Technologies Co., Ltd.

Address: 99, Tachiuri Nakano-cho, Shimogyo-ku, Kyoto 600-8006, Japan.

Graduate School of Agriculture, Kyoto University

Address: Kitashirakawa Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan.

Farhadur Md. Rahman

Department of Remote Sensing and GIS, Bangabandhu Sheikh Mujibur Rahman Agricultural University
Address: Gazipur-1706, Dhaka, Bangladesh.

2.2.2 | Contact person

Yusuke Onoda

Graduate School of Agriculture, Kyoto University

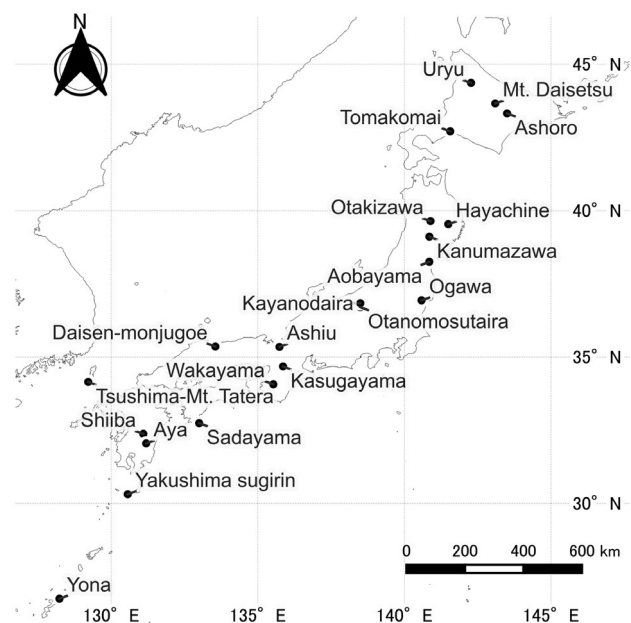


FIGURE 1 Location of the 21 study sites across the Japanese archipelago. The Ashiu site includes two plots (Ashiu-Masukamidani and Ashiu-Mondoridani), resulting in a total of 22 forest census plots represented in the dataset.

Address: Kitashirakawa Oiwake-cho, Kyoto 606-8502, Japan.

2.3 | Project title

Digital biosphere: Integrated biospheric science for mitigating global environmental change.

2.4 | Geographical coverage

2.4.1 | Geographical description

Japan. See Figure 1.

2.4.2 | Geographical position

Latitude: 26.74°N–44.37° N

Longitude: 128.23°E–143.51°E

2.5 | Temporal coverage

Field surveys started in May 2022 and ended in October 2023.

TABLE 1 The basic information of the sites and plots.

Site name	Plot ID	Latitude (°north)	Longitude (°east)	Functional type	Elevation (m)	MAT (°C)	Plot size (ha), plot shape (m)
Uryu	UR-BC1	44.37	142.37	BC	335	4.1	1.05 (70 × 150)
Mt. Daisetsu	TA-EC1	43.66	143.10	EC	974	2.5	1.0 (100 × 100)
Ashoro	AS-DB1	43.32	143.51	DB	360	4.7	1.0 (100 × 100)
Tomakomai	TM-DB1	42.71	141.57	DB	80	7.5	1.0 (100 × 100)
Otakizawa	OZ-DB1	39.64	140.89	DB	460	8.3	1.0 (80 × 125)
Hayachine	HY-EC1	39.54	141.50	EC	1215	4.6	1.0 (80 × 125)
Kanumazawa	KM-DB1	39.11	140.86	DB	435	8.9	1.0 (100 × 100)
Aobayama	AO-BC1	38.25	140.85	BC	120	12.2	1.0 (100 × 100)
Ogawa	OG-DB1	36.94	140.59	DB	635	10.2	1.2 (100 × 120)
Kayanodaira	KY-DB1	36.84	138.50	DB	1495	5.8	1.0 (100 × 100)
Otanomosutaira	OT-EC1	36.70	138.50	EC	1730	4.8	1.0 (100 × 100)
Daisen-monjugoe	DI-DB1	35.36	133.55	DB	1110	9.1	1.0 (100 × 100)
Ashiu-Masukamidani	AU-EC1	35.35	135.74	EC	750	10.2	1.0 (100 × 100)
Ashiu-Mondoridani	AU-DB1	35.35	135.74	DB	720	10.4	1.0 (100 × 100)
Kasugayama	KA-EB1	34.68	135.86	EB	310	14.1	1.0 (100 × 100)
Tshushima-Mt. Tatera	TT-EB1	34.15	129.22	EB	160	15.4	1.0 (100 × 100)
Wakayama	WK-EC1	34.07	135.53	EC	825	11.1	1.0 (100 × 100)
Sadayama	SD-EB1	32.74	133.00	EB	320	17.0	0.98 (100 × 100)
Shiiba	SI-DB1	32.38	131.10	DB	1190	10.5	1.0 (100 × 100)
Aya	AY-EB1	32.05	131.19	EB	490	14.6	1.0 (100 × 100)
Yakushima-sugirin	YS-EC1	30.31	130.57	EC	1200	13.4	1.0 (100 × 100)
Yona	YN-EB1	26.74	128.23	EB	250	21.0	1.0 (100 × 100)

Note: All information is cited from the official dataset of the Monitoring Sites 1000 Project (https://www.biodic.go.jp/moni1000/findings/data/index_file.html). Abbreviations: DB, deciduous broadleaf forest; EB, evergreen broadleaf forest; EC, evergreen conifer forest; BC, broadleaf and conifer mixed forest; MAT, mean annual temperature.

2.6 | Taxonomic coverage

A total of 4328 crowns with 4056 individuals, including 151 species in 88 genera and 45 families of gymnosperms and angiosperms.

2.7 | Methods

2.7.1 | Study sites

Data were collected from 22 long-term monitoring natural forest plots (across 21 forest sites) distributed throughout the Japanese archipelago, covering major forest types in Japan: evergreen conifer, broadleaf and conifer mixed, deciduous broadleaf, and evergreen broadleaf forests (Ishihara et al., 2011). Mean annual temperature ranges from 1.5°C to 20.5°C (Table 1, Figure 1). These plots are registered in the Monitoring Sites 1000 Project of the

Ministry of Environment, Japan (<https://www.biodic.go.jp/moni1000/>). Typically, all trees with a girth at breast height (GBH) ≥ 15 cm within a 1-ha rectangular plot were measured annually at core sites or 5-year intervals at semi-core sites using measuring tapes. Local investigators identify individual trees at the species level.

2.7.2 | Sampling design, field methodology, and the data process

LiDAR data collection and processing

We used a UAV-LiDAR system (DJI Matrice 300 RTK + Zenmuse L1, DJI, China) to obtain point clouds and RGB aerial photos for each forest census plot. The flight plans were created using the DJI Pilot App with the following settings: overlap rates at 80% for both forward and side, flight height at 100 m above ground level using terrain-follow mode, and flight speeds ranging from 5 to

10 m/s (Table S1). The LiDAR sensor was set to 160 kHz in non-repetitive mode, capturing three reflection positions per laser pulse. We employed a real-time kinematic (RTK) system to ensure accurate positioning of the UAV-LiDAR. For surveys conducted in 2022, we used a mobile ground station system (DJI-DRTK2), recording precise station locations for future applications. In 2023, we used a network RTK system at some sites where mobile telecommunication was available.

We processed the raw data to generate point clouds using a standard protocol that includes noise removal and data calibration in DJI Terra software (see Htoo et al., 2024). Due to variations in the flight speeds, the average point cloud density ranges from 851 to 1855 points/m² (Table S1). For the 2022 data, we extracted ground points from the point clouds using the Simple Morphological Filter algorithm (Pingel et al., 2013) and constructed DTMs and CHMs following the protocols established in our previous studies (Htoo et al., 2024; Onoda et al., 2024). For the 2023 data, we utilized DF LAT Pro software (ver. 1.0.0, DeepForest Technologies, Japan), which implements advanced ground filtering methods (Onishi, unpublished), to construct DTMs and CHMs. In all cases, the authors visually inspected the ground point data, and residual noises, when present, were manually removed.

We also generated ortho-mosaic photos with MetaShape (ver. 2.1.3, Agisoft, Russia). For some sites (Uryu, Mt. Daisetsu, Tomakomai, Otakizawa, and Ashiu-Masukamidani), MetaShape could not construct ortho-mosaic photos; therefore, we used DJI Terra to generate the ortho-mosaic photos for these sites instead. The spatial resolution of the derived ortho-mosaic photos varies slightly across sites, ranging from 2.2 to 2.6 cm (Table S1).

The generated DTMs, CHMs, and ortho-mosaic photos were clipped based on the central coordinates of each plot, with a 100 m-radius circular buffer applied to ensure complete coverage of the monitoring area (Figure 2). For some plots (Kasugayama, Wakayama, and Aya), the clipped area is not completely circular because these plots are located at the edge of the scanned area.

Individual tree crown segmentation

The delineation of individual tree crowns was performed in two steps. First, we segmented tree crowns using UAV-LiDAR-derived products in eCognition Developer software (ver. 9.0.0, Trimble Inc., USA). Detailed segmentation procedures are described in Htoo et al. (2024). Briefly, we applied the “multiresolution segmentation algorithm” to delineate individual tree crown boundaries, utilizing multiple layers including RGB ortho-mosaic photos, CHMs, and surface slope model. To optimize

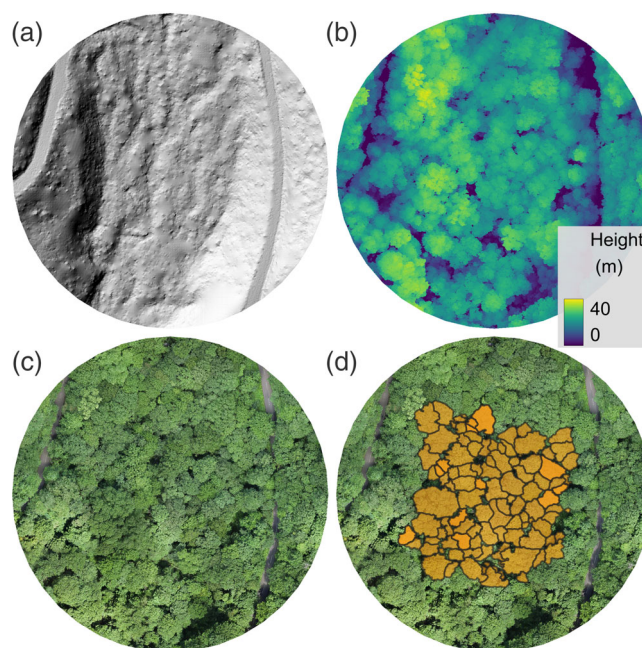


FIGURE 2 An example of the data (Kanumazawa site). The dataset contains three raster files and one vector file for each site: (a) A Digital Terrain Model (DTM) with a spatial resolution of 5 cm, using the hillshading technique to depict the terrain surface; (b) A Canopy Height Model (CHM) with a spatial resolution of 5 cm; (c) Ortho-mosaic photo with a spatial resolution of 2.4 cm; and (d) shapefile of the individual tree crown map.

segmentation, we assigned the layer weights to determine the relative importance of each layer in the segmentation process, drawing on prior studies (Htoo et al., 2024; Moe et al., 2020; Onishi & Ise, 2021). The optimal weight combinations for each site were determined through multiple trials, and the final values are shown in Table S2.

Second, we validated the shape and size of the segmented crowns through fieldwork. Ground truthing included refining the shapes of auto-segmented crowns and linking each crown polygon to its tree ID by reading the tags attached to the stem. The ortho-mosaic photo, CHM, DTM, and plot corner locations were uploaded to GPS-enabled iPads (Apple Inc., USA). We used the Field Maps application (ESRI, USA) for the fieldwork. In the early stages of our fieldwork in 2022, we used Adobe Photoshop software (Adobe Systems Incorporated, USA) instead of Field Maps. The final crown polygon maps, including 4328 crowns, were created in ArcMap Desktop (ver. 10.8.1, ESRI, USA) based on the field-digitized crown outlines and the auto-segmented crown data.

The final crown segments were linked with the latest publicly available tree census data from the Monitoring Sites 1000 Project (updated on July 11, 2019, https://www.biodic.go.jp/moni1000/findings/data/index_file.html) based on the stem IDs identified in the field. Since

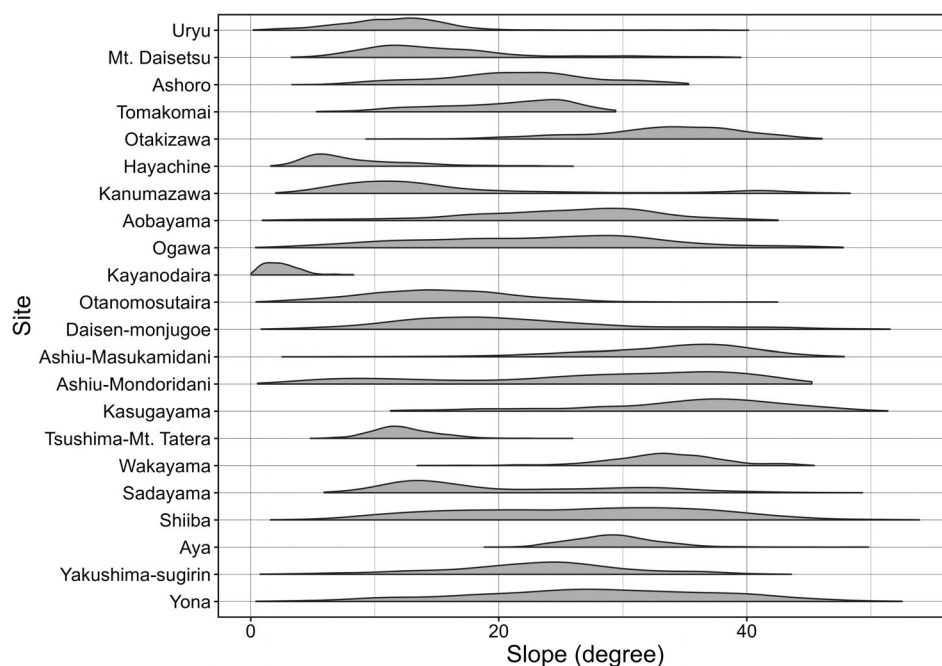


FIGURE 3 Distribution of terrain slope calculated from the Digital Terrain Model (DTM). The slope is derived from the DTM resampled to 2.5 m spatial resolution.

TABLE 2 Basic information derived from 2.5 m-resampled Digital Terrain Models (DTMs) for each plot.

Plot ID	Mean elevation (m) $\pm$ SD	Elevation range (m)	Mean slope ($^{\circ}$) $\pm$ SD	Slope range
UR-BC1	330.4 $\pm$ 4.4	315.0–337.5	11.9 $\pm$ 5.3	0.2–40.1
TA-EC1	993.8 $\pm$ 7.4	973.5–1008.9	15.5 $\pm$ 6.8	3.3–39.5
AS-DB1	326.7 $\pm$ 11.6	304.7–362.7	21.2 $\pm$ 6.2	3.3–35.3
TM-DB1	70.5 $\pm$ 7.2	53.5–88.0	20.3 $\pm$ 5.2	5.3–29.4
OZ-DB1	463.2 $\pm$ 21.6	423.6–517.2	33.3 $\pm$ 6.1	9.3–46.1
HY-EC1	1210.2 $\pm$ 4.6	1201.2–1223.5	8.6 $\pm$ 4.3	1.6–26.0
KM-DB1	446.5 $\pm$ 5.3	436.1–465.4	16.5 $\pm$ 10.9	2.0–48.3
AO-BC1	100.8 $\pm$ 9.9	81.6–118.5	25.0 $\pm$ 7.8	0.9–42.5
OG-DB1	626.1 $\pm$ 8.7	612.1–649.9	23.3 $\pm$ 9.6	0.4–47.8
KY-DB1	1493.8 $\pm$ 1.0	1491.7–1497.2	2.5 $\pm$ 1.5	0.0–8.3
OT-EC1	1733.1 $\pm$ 6.7	1720.7–1748.8	15.4 $\pm$ 6.4	0.4–42.5
DI-DB1	1104.0 $\pm$ 8.3	1086.8–1123.9	21.1 $\pm$ 9.5	0.8–51.6
AU-EC1	743.4 $\pm$ 13.7	714.0–774.1	33.6 $\pm$ 6.8	2.5–47.8
AU-DB1	711.6 $\pm$ 7.1	699.4–729.9	27.2 $\pm$ 11.5	0.6–45.2
KA-EB1	372.7 $\pm$ 22.0	326.8–416.3	35.0 $\pm$ 8.2	11.3–51.4
TT-EB1	163.9 $\pm$ 6.1	151.2–178.3	12.3 $\pm$ 2.7	4.8–26.0
WK-EC1	801.1 $\pm$ 19.4	755.9–847.7	33.4 $\pm$ 4.7	13.4–45.4
SD-EB1	306.7 $\pm$ 11.4	271.5–325.6	21.0 $\pm$ 9.3	5.9–49.3
SI-DB1	1153.9 $\pm$ 10.0	1132.5–1178.6	26.4 $\pm$ 9.9	1.6–53.9
AY-EB1	463.6 $\pm$ 14.4	433.7–494.8	29.5 $\pm$ 3.8	18.8–49.8
YS-EC1	1201.4 $\pm$ 5.8	1187.0–1217.2	23.2 $\pm$ 7.4	0.8–43.6
YN-EB1	261.9 $\pm$ 13.1	237.1–290.4	27.9 $\pm$ 9.9	0.4–52.5

Abbreviation: SD, standard deviation.

FIGURE 4 Distribution of the canopy height calculated from the 5-cm spatial resolution Canopy Height Model (CHM).

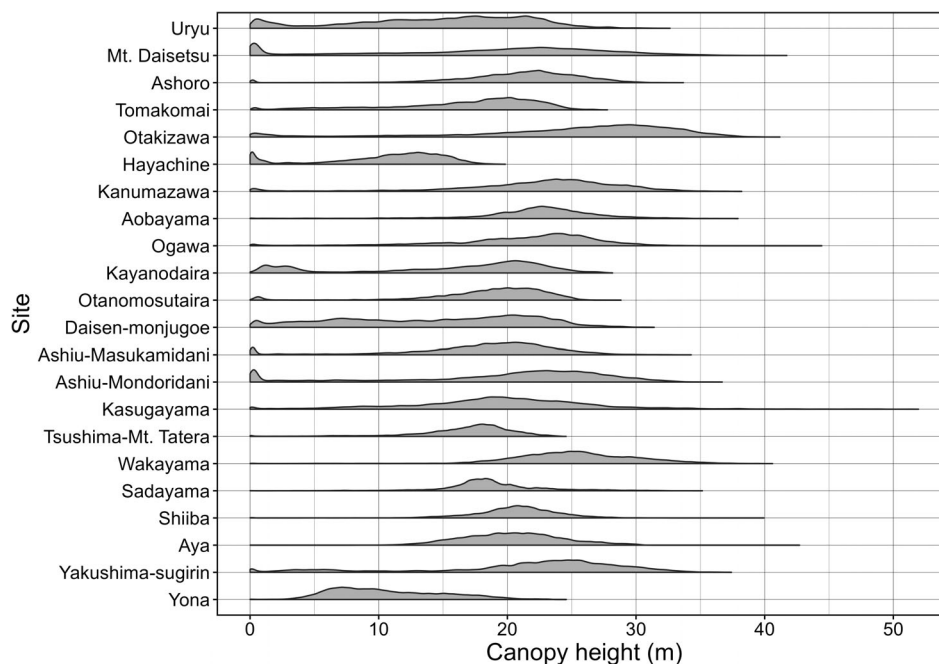


TABLE 3 Basic information derived from Canopy Height Models (CHMs) for each plot.

Plot ID	Mean canopy height (m) $\pm$ SD	Canopy height range (m)	Percentiles			
			5%	50%	95%	99%
UR-BC1	14.7 $\pm$ 6.9	0–32.6	1.1	15.8	24.2	27.6
TA-EC1	18.2 $\pm$ 9.4	0–41.7	0.3	20.4	31.0	34.8
AS-DB1	21.0 $\pm$ 4.7	0–33.7	13.3	21.6	27.5	29.4
TM-DB1	16.7 $\pm$ 5.7	0–27.8	4.7	18.2	23.5	25.1
OZ-DB1	24.9 $\pm$ 8.6	0–41.2	4.0	27.0	34.9	37.1
HY-EC1	10.5 $\pm$ 4.7	0–19.9	0.3	11.6	16.2	17.6
KM-DB1	22.4 $\pm$ 6.5	0–38.2	9.3	23.5	30.8	33.6
AO-BC1	22.3 $\pm$ 5.0	0–37.9	13.1	22.8	29.4	33.1
OG-DB1	21.3 $\pm$ 5.9	0–44.4	9.5	22.5	28.8	31.5
KY-DB1	15.4 $\pm$ 7.6	0–28.2	1.3	18.1	24.2	26.4
OT-EC1	18.6 $\pm$ 4.7	0–28.8	10.2	19.5	24.1	25.2
DI-DB1	14.3 $\pm$ 7.3	0–31.4	2.0	15.3	24.5	27.5
AU-EC1	18.1 $\pm$ 5.9	0–34.3	4.0	19.2	25.7	28.4
AU-DB1	19.6 $\pm$ 8.4	0–36.7	0.4	21.9	29.8	32.1
KA-EB1	19.5 $\pm$ 7.2	0–52.0	7.1	19.6	31.2	39.6
TT-EB1	16.8 $\pm$ 3.8	0–24.6	8.9	17.5	21.6	23.1
WK-EC1	25.2 $\pm$ 4.9	0–40.6	18.1	25.2	32.9	35.8
SD-EB1	18.8 $\pm$ 4.0	0–35.2	12.9	18.4	26.5	30.4
SI-DB1	20.7 $\pm$ 3.3	0–39.9	15.2	20.9	25.7	28.0
AY-EB1	20.4 $\pm$ 3.8	0–42.7	14.4	20.4	27.0	29.3
YS-EC1	21.3 $\pm$ 8.0	0–37.4	3.7	23.3	31.0	33.5
YN-EB1	10.8 $\pm$ 4.3	0–24.6	5.0	10.0	18.5	21.2

Abbreviation: SD, standard deviation.

TABLE 4 Basic information of forest gaps defined by two different gap definitions.

Plot ID	Definition 1				Definition 2			
	<i>n</i>	Mean gap area (m ²) ± SD	Gap area range	Gap rate (%)	<i>n</i>	Mean gap area (m ²) ± SD	Gap area range	Gap rate (%)
UR-BC1	59	15.1 ± 28.3	2.0–197.6	7.2	29	85.9 ± 122.7	10.2–510.4	20.2
TA-EC1	49	23.8 ± 37.5	2.1–167.8	10.7	20	123.4 ± 328.3	10.8–1490.8	22.5
AS-DB1	7	18.1 ± 19.4	2.3–49.6	1.1	4	38.9 ± 21.5	11.3–63.6	1.3
TM-DB1	22	8.3 ± 9.4	2.6–43.6	1.5	12	108.5 ± 179.1	14.5–668.0	10.6
OZ-DB1	33	11.7 ± 13.4	2.1–53.9	2.9	16	68.0 ± 80.3	10.4–332.3	8.2
HY-EC1	65	18.1 ± 36.4	2.1–220.3	9.7	32	51.8 ± 75.8	10.2–389.9	13.7
KM-DB1	16	14.6 ± 16.8	2.0–52.4	1.9	10	61.2 ± 48.1	24.9–167.9	5.1
AO-BC1	9	3.9 ± 1.7	2.1–6.9	0.3	13	20.2 ± 11.0	10.1–42.2	2.3
OG-DB1	13	12.6 ± 8.1	2.5–23.8	1.2	11	64.8 ± 77.0	10.0–269.8	5.2
KY-DB1	54	15.8 ± 21.8	2.0–102.2	7.3	16	157.6 ± 267.2	10.7–1062.3	21.5
OT-EC1	16	19.6 ± 20.8	2.2–69.5	2.6	10	40.3 ± 37.0	13.0–121.7	3.3
DI-DB1	31	16.1 ± 28.7	2.1–151.5	4.7	15	205.2 ± 536.7	11.7–2104.2	28.9
AU-EC1	23	18.0 ± 25.9	2.3–102.6	3.6	18	46.7 ± 58.6	10.1–206.6	7.2
AU-DB1	21	33.6 ± 56.6	2.0–173.0	7.3	13	118.1 ± 265.1	17.4–996.0	15.9
KA-EB1	18	9.0 ± 7.7	2.2–29.4	1.3	13	134.5 ± 199.5	10.1–619.3	14.6
TT-EB1	12	5.7 ± 3.9	2.0–15.5	0.6	8	43.7 ± 48.7	11.2–153.7	3.0
WK-EC1	3	4.3 ± 2.0	2.3–6.3	0.1	5	30.5 ± 24.2	11.0–70.6	1.2
SD-EB1	0	0 ± 0	0–0	0	5	28.8 ± 29.8	10.3–81.5	1.1
SI-DB1	2	4.5 ± 0.2	4.4–4.7	0.1	1	19.5 ± 0	19.5–19.5	0.2
AY-EB1	0	0 ± 0	0–0	0	0	0 ± 0	0–0	0
YS-EC1	17	12.1 ± 11.3	2.3–45.0	1.9	14	98.5 ± 122.6	10.5–321.7	12.8
YN-EB1	3	3.2 ± 1.3	2.3–4.7	0.1	10	242.4 ± 683.3	10.9–2185.5	20.0

Note: Definition 1, a height below 2 m and an area of at least 2 m²; definition 2, a height below one-third of the maximum canopy height (99th percentile of CHM) and an area of at least 10 m².
 Abbreviation: *n*, the number of gaps; SD, standard deviation.

the datasheet formats vary slightly among plots in the Monitoring Sites 1000 Project, we standardized stem and individual tree information by referencing the respective columns from each plot's datasheet (the correspondence is shown in Table S3). This process allowed us to identify 4056 individuals from 4328 crowns. For each extracted crown, we added the latest GBH data of the stem, census dates, and species name from the publicly available dataset, along with crown area and canopy height information based on the present study. Species names were verified and assigned corresponding genus and family information based on YList, a database of plant names in Japan (Yonekura & Kajita, 2003), resulting in 45 families, 88 genera, and 151 species. Canopy height data were extracted within crown boundaries, and minimum, mean, median, standard deviation, and maximum height values were calculated for each crown.

2.7.3 | Some forest profile information based on UAV-LiDAR

Based on our new dataset, we present some basic forest profiles of Japanese natural forests, including terrain slope, canopy height variation, forest gap ratios, crown sizes, and functional compositions. To minimize the effect of areas outside the plot boundary, we generated a 5-m buffer around plot boundaries and clipped the raster datasets for terrain slope, canopy height, and forest gap analyses accordingly. We used the GPS (Global Positioning System) coordinates of the plot corners provided by the corresponding site managers for many sites. For sites where the coordinates were unavailable, we recorded the coordinates of the four corners during the fieldwork using handheld GPS devices (GPSMap 62S and eTrex Touch 35J, Garmin). All statistical indices were calculated in R ver. 4.4.1 (R Core Team, 2024) and we utilized

TABLE 5 Basic information derived from the dataset of crown shapes.

Plot ID	The number of individuals			Mean crown area (m ²) ± SD	Crown area range (m ²)	Individual-number- based ratio (%)			Crown-area-based ratio (%)		
	Total	Unidentified	Species			EC	DB	EB	EC	DB	EB
UR-BC1	246	0	13	33.2 ± 30.8	3.3–199.0	21.5	78.5	0	24.3	75.7	0
TA-EC1	175	0	5	37.1 ± 23.4	4.1–140.8	87.4	12.6	0	88.6	11.4	0
AS-DB1	147	0	18	45.3 ± 36.7	4.0–213.4	0	100	0	0	100	0
TM-DB1	158	3	18	39.0 ± 32.2	3.2–184.2	3.1	96.9	0	2.6	97.4	0
OZ-DB1	137	2	12	56.8 ± 47.0	3.3–254.7	34.3	65.7	0	13.9	86.1	0
HY-EC1	302	0	10	25.1 ± 27.2	1.9–247.8	76.2	23.8	0	64.8	35.2	0
KM-DB1	105	0	12	80.2 ± 68.2	6.2–448.5	0	100	0	0	100	0
AO-BC1	198	3	19	40.7 ± 25.8	4.5–159.3	40.1	54.8	5.1	39.1	57.1	3.7
OG-DB1	110	1	23	66.9 ± 60.0	7.3–422.4	0	100	0	0	100	0
KY-DB1	96	0	7	76.7 ± 45.6	7.5–226.7	0	100	0	0	100	0
OT-EC1	236	0	6	33.5 ± 27.1	3.2–152.6	76.2	23.8	0	57.3	42.7	0
DI-DB1	105	1	12	52.8 ± 38.4	5.4–239.8	0	100	0	0	100	0
AU-EC1	303	0	11	29.5 ± 21.7	3.1–170.2	83.4	16.2	0.3	74.3	25.6	0
AU-DB1	118	0	19	63.2 ± 61.7	5.0–380.3	4.0	96.0	0	9.9	90.1	0
KA-EB1	182	1	25	40.1 ± 33.8	2.2–225.4	13.3	25.0	61.7	13.6	27.2	59.2
TT-EB1	133	0	18	55.1 ± 50.1	4.0–240.5	2.3	3.8	94.0	2.1	7.9	90.0
WK-EC1	235	0	14	39.9 ± 25.4	4.1–144.6	72.6	22.6	4.9	76.4	16.8	6.8
SD-EB1	133	3	13	63.4 ± 57.0	9.1–375.4	0	0	100	0	0	100
SI-DB1	222	0	30	32.2 ± 26.9	3.5–164.7	6.3	92.3	1.4	13.3	85.7	1.1
AY-EB1	167	0	18	51.8 ± 43.4	4.7–275.7	0.6	4.3	95.1	0.7	2.1	97.2
YS-EC1	130	1	9	55.1 ± 35.8	7.8–198.5	92.3	3.1	4.6	92.2	5.1	2.6
YN-EB1	457	54	46	10.7 ± 10.0	0.7–71.8	0	6.8	93.2	0	5.1	94.9

Note: “Individual-number-based ratio” represents the percentage of each functional type based on the count of individual trees, while “Crown-area-based ratio” represents the percentage based on the crown area occupied by each functional type.

Abbreviation: EB, evergreen broadleaf trees; EC, evergreen conifer trees; DB, deciduous broadleaf trees; SD, standard deviation.

“terra” package (Hijmans, 2021) and “sf” package (Pebesma, 2018) to handle the spatial data.

First, the terrain slope of each plot was calculated using the “terrain” function in the terra package, based on the DTMs that were resampled to 2.5 m spatial resolution. Mean slope values for each plot ranged from 2.5° (Kayanodaira) to 35.0° (Kasugayama) (Figure 3 and Table 2), with 9 out of 22 plots exceeding 25°, reflecting the steep and varied topography of Japanese natural forests. The median slope value for the entire dataset was 22.1°.

Second, we analyzed the size distribution of CHMs. We calculated the mean, standard deviation, 5th, 50th, 95th, and 99th percentiles of CHM (Figure 4 and Table 3). Mean height values ranged from 10.5 m (Hayachine) to 25.2 m (Wakayama), with a median height of 19.7 m across the dataset. The 99th percentile height, representing the maximum forest height of each plot, ranged from 17.6 m (Hayachine) to 39.6 m (Kasugayama), with a median of 29.4 m.

Third, we analyzed forest gaps within each plot using CHMs. While the measurements and the definitions of forest gaps vary widely among prior studies (Tian et al., 2023), we used two gap definitions based on vertical height and horizontal extent: (1) gaps with a height below 2 m and an area of at least 2 m² (Solano et al., 2022), and (2) gaps with a height below one-third of the maximum canopy height (99th percentile of CHM) and an area of at least 10 m² (similar to Yamamoto, 1989 and Nakashizuka et al., 1995). We extracted gaps according to these definitions using the “ForestGapR” package (Silva et al., 2019). The gap ratio was calculated for each definition by dividing the total gap area by the total plot area (including 5 m margins). The number, size, and gap ratio for each plot are shown in Table 4. Overall, the ranking of plots by gap ratio was consistent between the two definitions, though values were typically lower with the first definition. Across 22 plots, the median gap ratio was 1.7%, with a maximum of 10.7% at Mt. Daisetsu

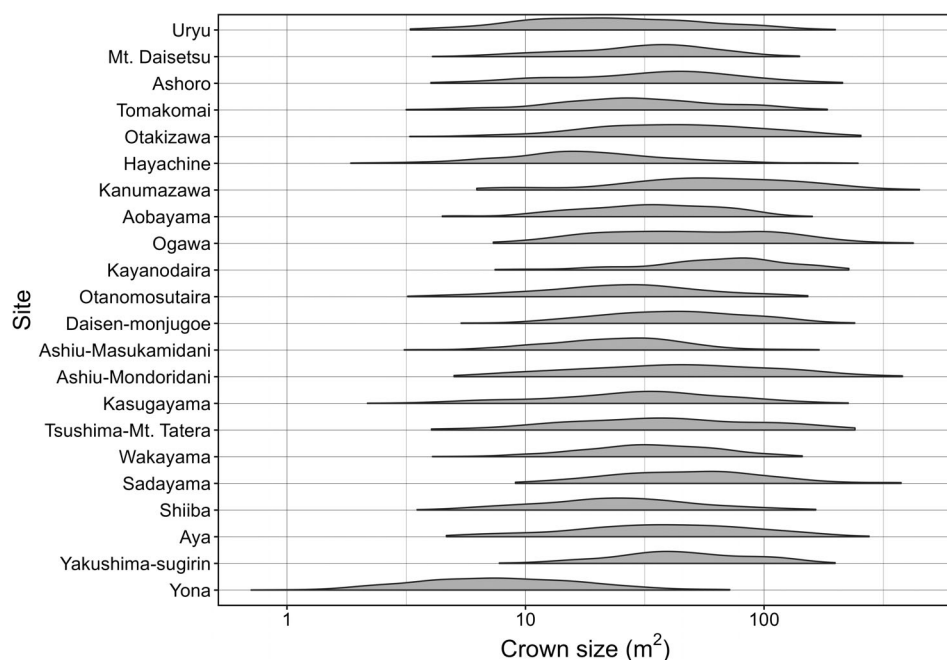


FIGURE 5 Distribution of the crown area that reached the forest canopy and was identified within ortho-mosaic photos. The x-axis represents log-scaled crown area.

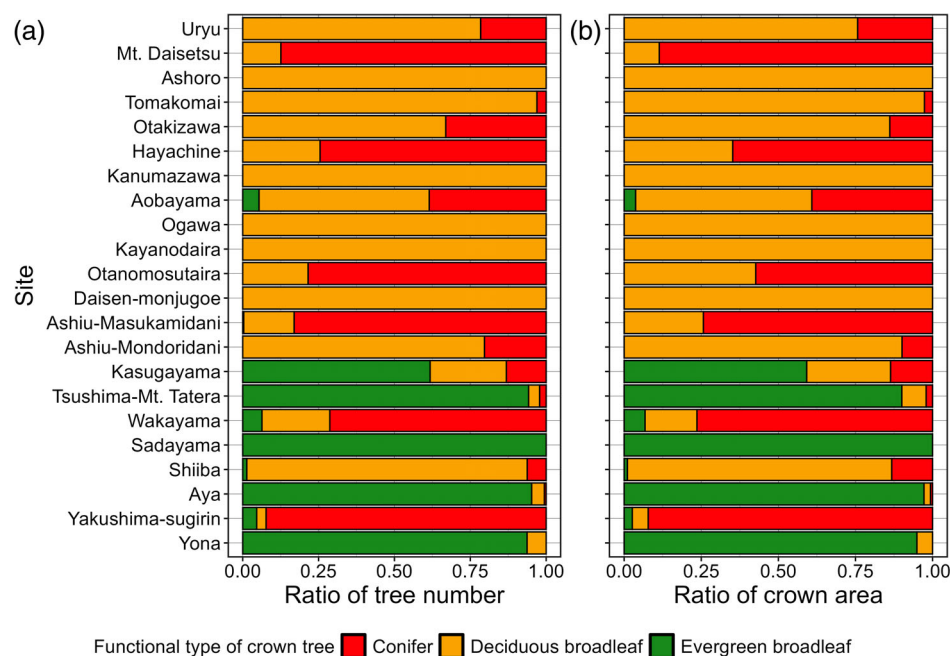


FIGURE 6 Ratio of crown area compiled with three functional types of trees in terms of (a) the number of trees and (b) the crown area. Red represents conifer trees, orange represents deciduous broadleaf trees, and green represents evergreen broadleaf trees, respectively.

and 0% at both Sadayama and Aya under definition 1. For definition 2, the median gap ratio was 7.7%, with a maximum of 28.9% at Daisen-monjugoe and a minimum of 0% at Aya.

Finally, we analyzed the crown information for canopy trees. For each plot, we summarized tree counts (the number of individuals identified from the above), average crown areas, and total crown areas occupied by three functional types (deciduous broadleaf, evergreen broadleaf, and evergreen conifer) (Table 5). The mean crown

area ranges from 10.7 m² (Yona) to 80.2 m² (Kanumazawa), with a median of 27.8 m² across the dataset (Figure 5). Ratios of functional types differed between tree counts and crown areas, particularly between conifers and deciduous broadleaves: conifers showed higher values in the count, while deciduous broadleaves had higher values in the crown area (Figure 6). The detailed analysis of crown size and growth strategy is discussed elsewhere (Htoo et al., 2024; Htoo et al. unpublished).

TABLE 6 File names and variable definitions of each data file.

Folder name	File name	File format	Variable name	Types of data	Variable definition
DTM	Site name_Plot ID_DTM (e.g., Aobayama_AO-BC1_DTM)	Raster (GeoTIFF)	DTM	Numeric (double)	Ground elevation within each pixel (m, above sea level).
CHM	Site name_Plot ID_CHM (e.g., Aobayama_AO-BC1_CHM)	Raster (GeoTIFF)	CHM	Numeric (double)	Absolute canopy height within each pixel (m).
Ortho	Site name_Plot ID_Ortho (e.g., Aobayama_AO-BC1_Ortho)	Raster (GeoTIFF)	Red, Green, Blue	Numeric (8-bit integer)	Digital number of each RGB band within each pixel. Variable names represent data of each wavelength.
Crown	Site name_Plot ID _Crown (e.g., Aobayama_AO-BC1_Crown)	Vector (Esri shapefile)	site	Character string	Site name in Table 1.
			plot	Character string	Plot name in Table 1.
			tag_field	Character string	Actual tag number in the field at the time of fieldwork.
			stem_ID	Character string	Stem ID, corresponding to the official Moni1000 dataset (Table S3).
			indv_ID	Character string	Individual tree ID, corresponding to the official Moni1000 dataset (Table S3).
			family	Character string	Tree family name (“LAPG Family” in YList).
			genus	Character string	Tree genus name.
			spc_latin	Character string	Scientific name of the tree.
			spc_japan	Character string	Japanese local name of the tree.
			gbh_latest	Character string	Latest GBH value of the stem in publicly available data.
			ca_m2	Number (double)	Crown area (m ²) of the tree.
			chm_min	Number (double)	Minimum canopy height within the shape, derived from CHM.
			chm_mean	Number (double)	Mean canopy height within the shape, derived from CHM.
			chm_median	Number (double)	Median canopy height within the shape, derived from CHM.
			chm_sd	Number (double)	Standard deviation of canopy height within the shape, derived from CHM.
			chm_max	Number (double)	Maximum canopy height within the shape, derived from CHM.
			gbh_date	Character string	Date of field survey for GBH measurement. Format: YYYYMMDD
			chm_date	Character string	Date of UAV flight in this study. Format: YYYYMMDD
			isDead	Character string	Tree status from the latest census data: “T” for dead, “F” for alive.
			confidence	Character string	Confidence in species identification. Most of the crowns are “high”, but some are “low” due to the lack of field tags, missing tree census data, or potential field errors.

Note: YList, a database of plant names in Japan (Yonekura & Kajita, 2003, <http://ylist.info/>).

2.7.4 | Data verification procedures

We note that the crown shape data at the Yona site cover only about 60% of the plot due to the extremely time-consuming fieldwork required for the high abundance of small canopy trees. We could not identify the tree ID for delineated crowns in a few cases. This was due to the absence of tree tags, discrepancies between actual tag numbers and those in the publicly available census data, or the occasional misreading of tags during fieldwork. Crowns with such uncertainties are noted as “low” in the “confidence” column of the dataset.

2.8 | Data structure

2.8.1 | Data files

Data files are shown in Table 6.

2.8.2 | File format

Digital terrain models (DTMs), canopy height models (CHMs), and ortho-mosaic photos are provided in GeoTIFF format. Crown shapes are provided as ESRI shapefiles with UTF-8 encoding. All data products are projected in the Japan Plane Rectangular Coordinate System (JGD 2011), with the appropriate zone specified for each site (Table S1).

2.8.3 | Header information

Headers corresponding to variable names (see Section 2.8.4) are included as the band names in the raster dataset (DTMs, CHMs, ortho-mosaic photos) and as the first row in the vector dataset (crown shapes).

2.8.4 | Variable definition

The variables are listed in the order in which they appear in each data file (Table 6). Site and plot names are consistent with those used in the original Monitoring Site 1000 Project (Table 1) and related data papers (Ishihara et al., 2011; Nakamura et al., 2022; Niwa et al., 2016; Suzuki et al., 2012, 2019; Takafumi et al., 2021).

2.9 | Accessibility

2.9.1 | License and usage right

This dataset is provided under a Creative Commons Attribution-NonCommercial 4.0 International license

(CC-BY-NC 4.0) (<https://creativecommons.org/licenses/by-nc/4.0/>). The authors believe that archiving and sharing datasets is important for advancing various fields in science. At the same time, it is ethically important that users recognize that the researchers who gathered these data may be using them for scientific analyses, papers, or publications that are currently planned or in preparation. We therefore request that users contact the authors if the dataset is to be used in any publication at least within 2 years of the data release.

2.9.2 | Location of storage

<https://doi.org/10.20783/DIAS.669>

ACKNOWLEDGMENTS

We are grateful to the site managers, as well as the technical and office staff members of the forest monitoring sites, for their logistical support and assistance with research permissions. We also thank Chika Mizukami, Ichiro Uehara, Kaede Konrai, Kazuki Arakawa, Kengo Ikebata, Kento Suhara, Kotaro Komatsu, Mao Kusaka, Michio Oguro, Miho Tsujii, Motonari Ohyama, Qin Qian-ning, Shunichiro Kimura, Yoshimi Sawada, Yusuke Hogaki, and Yuya Hashimoto for their support during the field campaign. This study was supported by JSPS KAKENHI Grant Numbers 21H05314 and 21H02564 to YO.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

ORCID

Ryuichi Takeshige  <https://orcid.org/0000-0002-4341-5957>

Kyaw Kyaw Htoo  <https://orcid.org/0000-0003-3144-0028>

Farhadur Md. Rahman  <https://orcid.org/0000-0002-5403-4375>

Kazuhiko Hoshizaki  <https://orcid.org/0000-0001-7654-9129>

Hideyuki Ida  <https://orcid.org/0000-0001-6540-2586>

Masae Iwamoto Ishihara  <https://orcid.org/0000-0002-8365-7766>

Akira Itoh  <https://orcid.org/0000-0002-2493-1681>

Takayuki Kaneko  <https://orcid.org/0009-0002-5536-7945>

Ayumi Katayama  <https://orcid.org/0000-0002-4200-8575>

Hiroko Kurokawa  <https://orcid.org/0000-0001-8778-8045>

Kazuhiko Masaka  <https://orcid.org/0000-0003-0513-6292>

- Tatsuro Nakaji  <https://orcid.org/0000-0002-3161-1539>
- Masahiro Nakamura  <https://orcid.org/0000-0002-9909-3977>
- Naoyuki Nishimura  <https://orcid.org/0000-0002-4779-0842>
- Mahoko Noguchi  <https://orcid.org/0000-0002-3393-5131>
- Atsushi Sakai  <https://orcid.org/0000-0003-1074-8525>
- Atsushi Takashima  <https://orcid.org/0000-0002-2073-690X>
- Naoaki Tashiro  <https://orcid.org/0009-0004-0548-1373>
- Naoko Tokuchi  <https://orcid.org/0000-0001-5508-5951>
- Hiromi Yamagawa  <https://orcid.org/0000-0002-1034-7011>
- Yusuke Onoda  <https://orcid.org/0000-0001-6245-2342>

REFERENCES

- Anderson, K., & Gaston, K. J. (2013). Lightweight unmanned aerial vehicles will revolutionize spatial ecology. *Frontiers in Ecology and the Environment*, 11(3), 138–146. <https://doi.org/10.1890/120150>
- Beland, M., Parker, G., Sparrow, B., Harding, D., Chasmer, L., Phinn, S., Antonarakis, A., & Strahler, A. (2019). On promoting the use of lidar systems in forest ecosystem research. *Forest Ecology and Management*, 450, 117484. <https://doi.org/10.1016/j.foreco.2019.117484>
- Hijmans, R. J. (2021). *terra: Spatial data analysis*. CRAN.
- Htoo, K. K., Onishi, M., Rahman, M. F., Kitajima, K., & Onoda, Y. (2024). The space occupation and use by tree crowns explain variations of individual growth rates in an old-growth temperate forest in Japan. *Forest Ecology and Management*, 569, 122185. <https://doi.org/10.1016/j.foreco.2024.122185>
- Ishihara, M. I., Suzuki, S. N., Nakamura, M., Enoki, T., Fujiwara, A., Hiura, T., Homma, K., Hoshino, D., Hoshizaki, K., Ida, H., Ishida, K., Itoh, A., Kaneko, T., Kubota, K., Kuraji, K., Kuramoto, S., Makita, A., Masaki, T., Namikawa, K., ... Yoshida, Y. (2011). Forest stand structure, composition, and dynamics in 34 sites over Japan. *Ecological Research*, 26(6), 1007–1008. <https://doi.org/10.1007/s11284-011-0847-y>
- Moe, K. T., Owari, T., Furuya, N., Hiroshima, T., & Morimoto, J. (2020). Application of UAV photogrammetry with LiDAR data to facilitate the estimation of tree locations and DBH values for high-value timber species in northern Japanese mixed-wood forests. *Remote Sensing*, 12(17), 2865. <https://doi.org/10.3390/rs12172865>
- Nakamura, M., Terada, C., Ito, K., Matsui, K., Niwa, S., Ishihara, M., Kenta, T., Yoshikawa, T., Kadoya, T., Hiura, T., Muraoka, H., Ishida, K., Agetsuma, N., Nakamura, R., Sakio, H., Takagi, M., Mori, A. S., Kimura, M. K., Kurokawa, H., ... Tokuchi, N. (2022). Evaluating the soil microbe community-level physiological profile using EcoPlate and soil properties at 33 forest sites across Japan. *Ecological Research*, 37(3), 432–445. <https://doi.org/10.1111/1440-1703.12293>
- Nakashizuka, T., Katsuki, T., & Tanaka, H. (1995). Forest canopy structure analyzed by using aerial photographs. *Ecological Research*, 10(1), 13–18. <https://doi.org/10.1007/bf02347651>
- Niwa, S., Toyota, A., Kishimoto, T., Sasakawa, K., Abe, S., Chishima, T., Higa, M., Hiura, T., Homma, K., Hoshino, D., Ida, H., Kamata, N., Kaneko, Y., Kawanishi, M., Kobayashi, K., Kubota, K., Kuraji, K., Masaki, T., Niiyama, K., ... Yoshida, T. (2016). Monitoring of the ground-dwelling beetle community and forest floor environment in 22 temperate forests across Japan. *Ecological Research*, 31(5), 607–608. <https://doi.org/10.1007/s11284-016-1379-2>
- Onishi, M., & Ise, T. (2021). Explainable identification and mapping of trees using UAV RGB image and deep learning. *Scientific Reports*, 11(1), 903. <https://doi.org/10.1038/s41598-020-79653-9>
- Onoda, Y., Onishi, M., Htoo, K. K., Hogaki, Y., Farhaduvar, R. M., Takeshige, R., & Oguchi, R. (2024). UAV LiDAR digitization of 11 forest types in the Osaka Metropolitan University Botanical Garden. *Japanese Journal of Ecology*, 74(1), 25. https://doi.org/10.18960/seitai.74.1_25
- Pebesma, E. (2018). Simple features for R: Standardized support for spatial vector data. *The R Journal*, 10(1), 439–446. <https://doi.org/10.32614/rj-2018-009>
- Pingel, T. J., Clarke, K. C., & McBride, W. A. (2013). An improved simple morphological filter for the terrain classification of airborne LIDAR data. *ISPRS Journal of Photogrammetry and Remote Sensing*, 77, 21–30. <https://doi.org/10.1016/j.isprsjprs.2012.12.002>
- R Core Team. (2024). *R: A language and environment for statistical computing*. R Core Team.
- Silva, C. A., Valbuena, R., Pinagé, E. R., Mohan, M., Almeida, D. R. A., Broadbent, E. N., Jaafar, W. S. W. M., Papa, D., Cardil, A., & Klauberg, C. (2019). ForestGapR: An R package for forest gap analysis from canopy height models. *Methods in Ecology and Evolution*, 10(8), 1347–1356. <https://doi.org/10.1111/2041-210x.13211>
- Solano, F., Modica, G., Praticò, S., Box, O. F., & Piovesan, G. (2022). Unveiling the complex canopy spatial structure of a Mediterranean old-growth beech (*Fagus sylvatica* L.) forest from UAV observations. *Ecological Indicators*, 138, 108807. <https://doi.org/10.1016/j.ecolind.2022.108807>
- Suzuki, S. N., Ataka, M., Djukic, I., Enoki, T., Fukuzawa, K., Hirota, M., Hishi, T., Hiura, T., Hoshizaki, K., Ida, H., Iguchi, A., Iimura, Y., Ise, T., Kenta, T., Kina, Y., Kobayashi, H., Kominami, Y., Kurokawa, H., Makoto, K., ... Watanabe, K. (2019). Harmonized data on early stage litter decomposition using tea material across Japan. *Ecological Research*, 34(5), 575–576. <https://doi.org/10.1111/1440-1703.12032>
- Suzuki, S. N., Ishihara, M. I., Nakamura, M., Abe, S., Hiura, T., Homma, K., Higa, M., Hoshino, D., Hoshizaki, K., Ida, H., Ishida, K., Kawanishi, M., Kobayashi, K., Kuraji, K., Kuramoto, S., Masaki, T., Niiyama, K., Noguchi, M., Nomiya, H., ... Yoshida, Y. (2012). Nation-wide litter fall data from 21 forests of the monitoring sites 1000 project in Japan. *Ecological Research*, 27(6), 989–990. <https://doi.org/10.1007/s11284-012-0980-2>
- Takafumi, H., Kanno, Y., Abe, S., Abe, T., Enoki, T., Hirao, T., Hiura, T., Hoshizaki, K., Ida, H., Ishida, K., Maki, M., Masaki, T., Naoe, S., Noguchi, M., Otani, T., Sato, T., Sakimoto, M., Sakio, H., Takagi, M., ... Nakamura, M. (2021). Assessing insect herbivory on broadleaf canopy trees at 19 natural forest sites across Japan. *Ecological Research*, 36(3), 562–572. <https://doi.org/10.1111/1440-1703.12215>

- Tian, A., Halik, Ü., Fu, W., Sawirdin, S., Cheng, S., & Lei, J. (2023). Research history of forest gap as small-scale disturbances in forest ecosystems. *Forests*, 15(1), 21. <https://doi.org/10.3390/f15010021>
- Urakawa, R., Ohte, N., Shibata, H., Tateno, R., Hishi, T., Fukushima, K., Inagaki, Y., Hirai, K., Oda, T., Oyanagi, N., Nakata, M., Toda, H., Kenta, T., Fukuzawa, K., Watanabe, T., Tokuchi, N., Nakaji, T., Saigusa, N., Yamao, Y., ... Isobe, K. (2015). Biogeochemical nitrogen properties of forest soils in the Japanese archipelago. *Ecological Research*, 30(1), 1–2. <https://doi.org/10.1007/s11284-014-1212-8>
- White, J. C., Coops, N. C., Wulder, M. A., Vastaranta, M., Hilker, T., & Tompalski, P. (2016). Remote sensing technologies for enhancing forest inventories: A review. *Canadian Journal of Remote Sensing*, 42(5), 619–641. <https://doi.org/10.1080/07038992.2016.1207484>
- Yamamoto, S.-I. (1989). Gap dynamics in climax *Fagus crenata* forests. *Shokubutsugaku zasshi*, 102(1), 93–114. <https://doi.org/10.1007/bf02488116>
- Yonekura, K., & Kajita, T. (2003). BG plants japanese-scientific names index (Ylist). <http://ylist.info/>
- Yoshikawa, T., Totsu, K., Takeuchi, Y., Kadoya, T., Enoki, T., Fujii, S., Fukamachi, A. S., Hirota, M., Hoshizaki, K., Iiyama, N., Ishikawa, Y., Itô, H., Kobayashi, H., Kohyama, T. S., Konno, Y., Makita, A., Mori, A. S., Nagamatsu, D., Nakashizuka, T., ... Hiura, T. (2024). Forest

monitoring data of 45 plots across the Japanese archipelago during 1980–2021. *Ecological Research*, 39(3), 391–406. <https://doi.org/10.1111/1440-1703.12457>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Takeshige, R., Htoo, K. K., Onishi, M., Rahman, F. M., Hoshizaki, K., Ida, H., Ishihara, M. I., Itoh, A., Kaneko, T., Katayama, A., Kuramoto, S., Kurokawa, H., Maki, M., Masaka, K., Nakaji, T., Nakamura, M., Nishimura, N., Noguchi, M., Sakai, A., ... Onoda, Y. (2025). High-resolution digital canopy height models, terrain models, ortho-mosaic photos, and canopy tree crown shapes derived from UAV-borne LiDAR at 22 tree census plots across Japanese natural forests. *Ecological Research*, 40(4), 657–670. <https://doi.org/10.1111/1440-1703.12555>