Hibakujumoku as a Casualty of Atomic Bomb

June 2024 at Universitetet i Oslo

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For the titled presentation, I have summarized my research papers on A-bombed trees using my GPTs "Paper Interpreter of Landscape Architecture". The basis for this summary is the following four papers presented in Japanese. Thank you for your interest.

(1) Abnormal Tree Form of A-bombed trees in Hiroshima in the Spatial Relationship with the Ground Zero, Nagisa Owaki, Masakazu Suzuki ,Chikara Horiguchi, journal of the Japanese Institute of Landscape Architecture,77(5),627-632,2014 (Best Paper Award of JILA 2014)

(2) Searching Process and Issues on conservation of Undiscovered A-bombed trees in Nagasaki, Nagisa Owaki Masakazu Suzuki, Kazuhisa Ohbi, journal of the Japanese Institute of Landscape Architecture,79(5),541-544,2016

(3) Reconstruction method for 3D model of A-bombed tree by using TLS, Rihito Kumazaki, Yoichi Kunii, Masakazu Suzuki, Journal of Applied Survey Technology Vol.30 129-140,2019 (Applied Surveying Paper Encouragement Award of Japan Association of Surveyors 2019)

(4) Research Results Report: Grant-in-Aid for Scientific Research (C) 2017-2023 'Current Status and Issues of Environmental Policy Concerning the Conservation and Utilization of A-bombed trees in Hiroshima and Nagasaki', 2023

Abnormal Tree Form of A-bombed trees in Hiroshima in the Spatial Relationship with the Ground Zero, Nagisa Owaki, Masakazu Suzuki, Chikara Horiguchi, journal of the Japanese Institute of Landscape Architecture,77(5),627-632,2014

Abstract: On August 6, 1945, at 8:15 am, an Atomic bomb was dropped on Hiroshima city. Many people believed that no plant would grow for 75 years. However, a few months after the bombing, new shoots were observed on the Atomic-bombed trees. Today there are many "A-bombed trees (survivor trees)" in Hiroshima city, and they are the precious living war heritage which can tell us the history of the atomic bombing. In this study we hypothesized that the effect of the atomic bombing on these trees have been increasing over the last 67 years, which is shown by their inclination towards Ground Zero. In order to clarify the hypothesis, we measured the direction and angle of inclination, and the direction to Ground Zero at the point of each A-bombed tree. We assessed the significance of the directional inclination using the 'Rayleigh test'. In this study, we focused on the "type A trees." This type of tree has a single stem, survived the bombing, is alive at the original location and was not transplanted after the bombing. As a result, it was clarified that almost all of the "type A" A-bombed trees are inclined towards Ground Zero. The aim of this study was to clarify the abnormal formation of A-bombed trees in the positional relationship between their respective locations and Ground Zero. As a result, we found A-bombed trees possess a new significance, which is that each of them shows the direction to Ground Zero by their inclination. When you look at the city from a bird's-eye view, you will see that Ground Zero is surrounded by A-bombed trees. When you visit A-bombed trees on foot, check the direction to Ground Zero, then you can observe the effects of the atomic bombing on the trees. A-bombed trees offer many possibilities as "field museums" that preserve and convey the experience of atomic bombing.

Keywords: Hiroshima, atomic-bombed tree, war heritage, tree form survey, abnormal tree

1. Research Background and Purpose

(1) What are the "A-bombed trees?

At 8:15 AM on August 6, 1945, an atomic bomb was dropped on the city of Hiroshima. Immediately after the bombing, there were reports suggesting a 70 to 75-year period of biological sterility, but within the same year, a research team led by Masao Tsuzuki of the University of Tokyo announced in the newspapers that this sterility theory was mistaken.

The term "A-bombed trees" broadly refers to all trees that were exposed to the atomic bomb. However, because expanding the scope would obscure the actual extent of the damage, and because it would be difficult to grasp the actual number of trees including those in surrounding forests, the city of Hiroshima has recognized, investigated, and preserved trees that were damaged by the atomic bomb within a roughly 2 km radius from the hypocenter, an area characterized by total destruction and burning. The criteria for recognizing A-bombed trees include trees that were growing within approximately 2 km of the hypocenter before the war, trees that were bombed within 2 km and then transplanted, and those that have regenerated from their roots. Identification is made based on multiple testimonies or if the testified tree appears in pre-war aerial photographs, with the final decision made by tree doctors based on assessments such as tree age. Recognition is given per location, and at each location, there may be one species with one or more individuals or multiple species with multiple individuals. As of September 2013, 55 locations have been recognized.

(2) Previous Research and the Positioning of This Study

The first investigation of A-bombed trees was a part of the biological survey included in the Atomic Bomb Disaster Survey Report. The first survey was conducted in mid-October, two months after the bombing, in Nagasaki, and later that month in Hiroshima. The second round took place in late April of the following year in both Hiroshima and Nagasaki using similar methods. Two years after this survey, in 1947, a graduation thesis by Shinno Katsuta, "Anatomical Study of Plants Damaged by the Atomic Bomb," was published. This thesis soon went missing and was discovered in August 2010 by individuals associated with Hiroshima University and is now housed in the Hiroshima Peace Memorial Museum. In March 2001, the City of Hiroshima compiled a report on the A-bombed trees.

For approximately 60 years following the initial studies by Otaki and Funabashi (published in 2011) and Katsuta (1947), until the report by Horiguchi (2001), there was almost no research or investigation into A-bombed trees. It is speculated that this was due to the GHQ's press code directive issued on September 19, 1945, which prohibited reporting on the actual conditions of atomic bomb damage, a directive that influenced the situation for many years thereafter. The report by Horiguchi (2001) is a rare achievement that led to measures for the recovery of A-bombed trees based primarily on tree diagnosis, and served the significance of peace education by placing plates to indicate that they are A-bombed trees. However, there has been no research like this paper that classifies A-bombed trees based on certain criteria and discusses the actual conditions of tree form abnormalities in relation to their location from the hypocenter. Preliminary surveys conducted by the authors since 2009 have led to the hypothesis that A-bombed trees, when classified by the criteria mentioned later, differ in significance as atomic bomb heritage. In particular, it was suggested that certain types of A-bombed trees show cumulative damage from the bombing, manifesting tree form abnormalities that clarify their relative position to the hypocenter and, as a result, suggesting a tilt towards the hypocenter. This paper clarifies the reality by analyzing the external observation and inclination measurements of A-bombed trees in relation to the hypocenter, adds new perspectives on the significance and value of A-bombed trees as atomic bomb heritage, and proposes future challenges.

2. Survey Methods and Results

(1) Types of A-bombed trees and Selection of Subjects for Survey

A-bombed trees in Hiroshima City can be classified into 8 types based on whether they are (i) single-trunked or not, (ii) whether the above-ground parts that were damaged at the time of the bombing remain or not, and (iii) whether they were transplanted after the bombing or not, as shown in Table 1.

There are A-bombed trees whose above-ground parts were completely burned at or immediately after the bombing, which later revived from sprouts to their current state (Photo 1). Also, there are trees that have been transplanted to different locations after the bombing and have survived to the present day.

This paper focuses on and conducts a survey on A-bombed trees of Type A, which are single-trunked, retain clear above-ground damage from the time of the bombing, and have not been transplanted. These trees have cumulatively expressed the damage from the bombing in their tree form at the same location from the time of the bombing to the present. Of course, the current tree form is the result of human management and factors other than the bombing, but if a clear trend in relation to the relative location of the hypocenter can be found, it may be reevaluated as a living war heritage. For comparison with Type A, trees that were transplantable from Types B and C, which were transplanted or whose above-ground parts were lost and then revived, were also included. Type D does not exist, and types E, F, G, and H with multi-stemmed trunks cannot be measured for inclination and therefore are not subject to this survey. A list of the surveyed trees is shown in Table 2.

(2) External Survey of A-bombed trees

The tree forms of A-bombed trees exhibit unique abnormalities, including:

①Burns and atrophy caused by the heat rays, radiation, and fires from surrounding buildings (Photo 2).

②Enlargement of the trunk and stretching of roots on the opposite side of the damage.

③Holes in the tree caused by tissue death (Photo 3).

④Multi-trunk growth from the base or main trunk apex after the above-ground parts were burned away by the bombing (Photo 5).

⑤Inclination of the main trunk (Photo 4).

In this study, for A-bombed trees of types A, B, and C, observations were made for abnormalities ① through ④. Furthermore, as an index that could quantify the shape abnormalities, a measurement survey was conducted concerning abnormality ⑤ over three days from September 12 to 14, 2013.

Upon detailed observation of the base and the main trunk of Type A A-bombed trees, the following common features are frequently observed:

Black vertical traces of burns are visible on the side facing the hypocenter. In some cases, these appear as cracks (Photo 7).

The bark on the side facing the hypocenter has relatively fine splits and appears dark due to atrophy of the tissue, showing a concave curvature inside.

There is a bulging distortion on the opposite side of the hypocenter where growth enlargement occurs (Photo 6), with bark splits relatively large and lighter in color.

The bark on both sides at right angles to the direction of the hypocenter appears the same as in healthy trees.

There is less root extension on the side facing the hypocenter and more vigorous growth on the opposite side (Photo 8).

There are fewer new branches on the trunk side facing the hypocenter, and more on the opposite side. These damages are characteristics of the atomic bomb heritage.

As a result of these combined effects, when looking across the main trunk, it can be inferred that after 67 years since the bombing, the growth rate has differed between the side facing the hypocenter and its opposite side. Therefore, the part of the main trunk that remained immediately after the bombing has accumulated a difference in growth rate, resulting in an inclination (curvature) towards the hypocenter.

Such characteristic inclination of A-bombed trees towards the hypocenter has not been pointed out much before. Individual A-bombed trees were observed without noticing their relationship to the hypocenter and were thought to be leaning by chance. According to Horiguchi (2001), this is attributed to the backdraft of the blast, which is applicable to structures like iron towers, but generally, trees tend to return to vertical after temporary tilting caused by events like snow damage, as many cases have been observed. The new shoots that emerged from the top of the main trunk after the bombing grow almost vertically without showing much inclination, indicating that there is no significant difference in growth between the side facing the hypocenter and the opposite side in the tissues that developed after the bombing.

In this study, the specific biological and tissue causes for the unique inclination of A-bombed trees were not elucidated. Internal tissue analysis of A-bombed trees is necessary to clarify these causes; however, this paper is limited to external observations and measurements of the phenomena. The results of the external survey are shown in Table 2, and the location of the surveyed A-bombed trees is indicated in Figure 1.

(3) Method for Measuring the Inclination of A-bombed trees

The method for quantitatively measuring the inclination of A-bombed trees is as follows:

i) Measurement method and equipment

An iPhone (or iPad) is attached to a 5-meter aluminum surveying staff, and measurements are taken using the Spyglass application on the iPhone. Spyglass is calibrated in advance for horizontal alignment, and the hypocenter is stored on the displayed map as the Target Point. Spyglass can measure the GPS position coordinates, altitude, and bearing of the measurement point; the incline degree (tilt) in two directions – forward and backward pitch, and left and right roll relative to the perpendicular; and the distance and direction from the measurement point to a point (Target Point) registered on the map displayed on the screen. An example of the measurement screen is shown in Figure 3.

ii) Method for measuring the inclination direction, inclination angle, and direction of the hypocenter of A-bombed trees

For the A-bombed trees, the direction in which the main trunk is most inclined is visually determined from the base, and the device is placed horizontally in that direction to measure the bearing in degrees. This is defined as the inclination direction. The current map of the measurement site is overlaid to ensure that the measurement position and direction are correct and that the displayed numbers are stable and stationary. The device is tilted along the central line of the inclined main trunk from the central base of the most inclined main trunk, and the angle formed with the vertical line of the main trunk is measured in degrees with vertical being 0 degrees. This is defined as the inclination angle. At that time, the staff is adjusted so that the roll of the incline angle plane is at 0 degrees. Also, if there are RC buildings nearby, the columns and walls are used to confirm that the vertical angle is at 0 degrees, and if there is a deviation, the measurement value is corrected by the amount of deviation and recorded. The deviation was less than 2 degrees.

The direction to the hypocenter is indicated with the staff from the center of the main trunk, and the bearing to the hypocenter displayed on Spyglass is read. This is defined as the hypocenter direction. In measuring the inclination direction and angle of trees, judgment is required to determine which line represents the maximum inclination and inclination direction. In the current measurements, all measurements were made by the same measurer, and the line judged was clearly indicated with a 5m staff, and its validity was confirmed by another observer from a distance. Although efforts were made to minimize measurement errors, it is felt from the experience of measuring irregular tree shapes on-site that repeated errors of approximately ±4 degrees in bearing and ±2 degrees in inclination are expected. This should be considered when interpreting the results.

3. Analysis and Consideration of Survey Results

The measurement results are shown in Table 2.

(1) Distribution of Registered A-bombed trees in Hiroshima City

For A-bombed trees of types A, B, and C, registered locations were extracted without duplication, and the bearings from these points to the hypocenter were histogramed in Figure 4.

According to this, while there is a higher frequency of bearings around 220 degrees (northeast), it is apparent that the locations of A-bombed trees are distributed almost uniformly from 0 degrees to 360 degrees around the hypocenter. As shown in Figure 2, the distances from the hypocenter range from 370 meters to 2160 meters. This indicates that the A-bombed trees in Hiroshima City are spread out over the area without bias, and there is no significant deviation in the bearings and distances of the surveyed trees relative to the hypocenter.

(2) Analysis Results of the External Observation of A-bombed trees

The external observations of the A-bombed trees were classified into four categories: ① burn marks and cracks, ② enlargement on the side opposite to the hypocenter, ③ holes due to tissue death, and ④ multi-trunking from the base or the main apex due to post-bombing loss of the above-ground parts. The analysis results in Table 2 show that for trees closer to the hypocenter, the upper parts were almost entirely burnt, so there were no large burn marks or cracks. However, some trees (Tree numbers 3 & 4) showed effects on the growth due to the radiation received by the remaining roots, causing enlargement and inclination on the side opposite to the hypocenter. For trees closer to the hypocenter that retained their main trunk without significant burning, the main trunk suffered considerable damage, stunting growth (Tree number 5), and some were directly affected by fires from nearby buildings on the side opposite to the hypocenter. For trees within 1 to 2 km of the hypocenter, almost all displayed clear morphological characteristics of being A-bombed. Among the trees that retained their main trunks after the atomic bomb, types A and B showed tendencies of 1) burn marks and cracks (75%) and 2) enlargement on the side opposite the hypocenter (59%).

(3) Distribution of the Inclination Directions of A-bombed trees

Figure 5 histograms the inclination directions of the A-bombed trees of types A, B, and C. For each type and for all trees collectively, the inclination directions were vectorized, and the average direction vector was calculated. The uniformity of direction was tested using Rayleigh's test for non-randomness based on the average vector length r. In all cases, the null hypothesis that the inclination direction is uniformly distributed could not be rejected at any significant level. It is estimated that the inclination direction of the A-bombed trees is uniform in absolute bearing.

(4) Deviation Distribution of A-bombed trees' Inclination Directions and the Hypocenter's Direction

The relationship between the hypocenter direction (α), the inclination direction of A-bombed trees (β), and the deviation (δ) is considered. δ is defined as β-α, however, when β-α<0, then δ=β-α+360. This allows the deviation of the inclination direction of the A-bombed trees to be expressed in a circular manner on a scale of 360 degrees with the hypocenter direction set to 0. This has been histogramed in Figure 6. Looking only at Type A A-bombed trees, 62% of Type A samples fall within a narrow range of ±15 degrees, and 79% within ±30 degrees. Upon vectorizing the deviation angle of each A-bombed tree and performing circular statistical analysis, the average deviation angle for Type A was found to be 10.2 degrees, which is a small deviation from the hypocenter's direction, while for Type B it was 292.7 degrees, which significantly deviates from the hypocenter's direction. Upon conducting the Rayleigh test for uniformity of direction using the average direction vector length r, the null hypothesis for uniform distribution in relative direction for Type A was rejected at a risk level of 0.1% ($r=0.611$, $n=29$, $p<0.001$). On the other hand, for Type B, the null hypothesis could not be rejected at a 5% risk level ($r=0.356$, $n=22$, $p>0.05$). Therefore, it is estimated that the inclination direction of the A-bombed trees of Type A is strongly related to the direction of the hypocenter, while the inclination direction of the A-bombed trees of Type B is uniformly independent of the direction of the hypocenter. The analysis for Type C was omitted due to the small sample size not withstanding the test.

Looking individually at the five trees inclined opposite to the hypocenter, tree number 5 is close to the hypocenter and thus has less enlargement on the opposite side due to extensive damage. Tree number 11 has retained more significant damage from fires at the Hiroshima Military Academy on the opposite side of the hypocenter than from the direct effects of the bombing. Tree number 25 has fallen towards a river opposite the hypocenter. Tree number 29 is located at the boundary of a school property and has been repeatedly pruned. Tree number 52 is integrated with the temple gate and has been artificially managed. Such factors are considered to be one of the causes of the inclination opposite to the hypocenter.

For Type B, it is assumed that they were initially inclined towards the hypocenter, but transplantation resulted in a random distribution of inclination directions. Indeed, tree number 22, a *Ziziphus jujuba* with clear bomb damage marks and inclination, had an inclination direction unrelated to the hypocenter, which was immediately assumed to be due to transplantation, and this was later confirmed to be true. Figure 7 shows the inclination direction chart for all target trees. At registration site number 50 in the upper right of Figure 7, a group of 12 *Cinnamomum camphora* has been transplanted, and their inclination directions are radiating, indicating that while the transplantation may occasionally align with the direction of the hypocenter by chance, most are planted in random directions. This provides a suggestion for future management of A-bombed trees. Namely, transplanting A-bombed trees is not just about moving the trees while keeping them alive, but also about preserving the information as a heritage of the bombing by relatively maintaining the direction of the bombing. Transplanting operations may continue in the future.

Type C trees, which lost all above-ground parts immediately after the bombing and later revived from underground parts, are presumed to have less damage compared to Type A, where the above-ground parts remained. Therefore, they are distributed over a wider range in inclination direction than Type A. According to Figure 7, many of the red Type A trees are clearly inclined towards the hypocenter, while the blue Type B trees are inclined independently of the hypocenter. There are few samples of yellow Type C trees, but they show a mix of those inclined towards the hypocenter and those inclined independently.

4. Significance of A-bombed trees as Heritage of the Bombing

Until now, A-bombed trees have been revered as symbols that overturned the notion of a 75-year period of biological sterility in Hiroshima, while also serving as a means to convey the horrors of war to the world and future generations. In fact, seeds from A-bombed *Firmiana simplex* and *Ziziphus jujuba* have been distributed worldwide and are being cultivated in parks and other locations. There are stories of plants like the C*rinum asiaticum*, E*laeagnus*, and *Cycas revoluta* that have revived from their underground parts even after their above-ground parts were destroyed, or *Celtis sinensis var. japonica* that has grown into a giant tree from multi-trunked growth. A-bombed trees, *Cinnamomum camphora,* that were left on private property and have been transplanted and preserved in schools and parks are also often mentioned. There are instances where *Platanus orientalis* were transplanted within school grounds in response to building relocations. All these are examples of A-bombed trees that are not of Type A, making up about two-thirds of the total. The subjects mostly covered in newspapers, television, and picture books are these types of A-bombed trees, likely because they are notable for their vitality, and for topics like transplantation, seed collection, and distribution.

This paper, while recognizing the significance of A-bombed heritage other than Type A as mentioned before, will discuss the significance of Type A A-bombed trees, which make up about one-third of the total. These have lived quietly in the same place for 67 years without much prominence, but their calm continuity should be reevaluated. In other words, many groups of Type A A-bombed trees are inclined towards the hypocenter, as if pointing in the direction of the hypocenter for 67 years. When viewed from a bird's eye perspective, the A-bombed tree groups seem to envelop the hypocenter. When walking among these trees and observing them while being aware of the direction of the hypocenter, one can always find their traces. It is possible to understand the atomic bomb damage in Hiroshima in terms of its area from various distances and directions from the hypocenter. This is not something that can be understood merely from printed materials, but rather something that can be felt more deeply by experiencing it with one's own feet, eyes, and hands. In a sense, the forest of A-bombed trees is a hands-on field museum and a living textbook for peace education. The reasons for the inclination of the A-bombed trees towards the hypocenter are thought to be due to biological characteristics, as mentioned earlier, and rather than being mitigated over the 67 years, the effects of the bombing are even more evident. To receive the silent messages of these A-bombed trees, appropriate explanations (interpretation) are necessary. By fulfilling such conditions, it will be possible to properly understand the value of Type A A-bombed trees as heritage of the bombing, which have until now been modestly existing, and the efforts made to preserve them will be rewarded.

5. Future Challenges

The following are considered future challenges related to A-bombed trees:

① Recognize that A-bombed trees form a cohesive 'forest' that spreads over the city centering around the hypocenter, rather than being just a collection of individual trees, and understand their spatial interrelations.

② Clearly distinguish the management of living A-bombed heritage from buildings and structures, and in doing so, assign a series of individual numbers to A-bombed trees to enable integrated information management regardless of different owners or managers.

③ Preserve the relative direction to the hypocenter when saving A-bombed trees through transplantation, ensuring their healthy protection and cultivation.

④ Investigate the internal structure of A-bombed trees to elucidate the mechanism of their inclination.

⑤ Consider how to utilize A-bombed trees in peace education and what messages should be received from them.

⑥ Examine how tourists perceive and interpret the A-bombed trees and other atomic bomb heritage sites.

⑦ Consider how to convey information about A-bombed trees on site.

⑧ Position A-bombed trees comprehensively as war and atomic bomb heritage.

⑨ Finally, organizational, personal, and informational exchange is essential to address these various perspectives.

The immediate research task for the authors is to apply this method in Nagasaki City and conduct similar surveys. Moreover, to advance specific research that can contribute even slightly to the challenges mentioned above related to A-bombed trees.

Table 1:　Types of A-bombed trees

類型記号	幹立ち区分	地上部被害痕跡	移植の有無	本数
A	単幹	有り	無し	36
B	単幹	有り	有り	29
C	単幹	無し	無し	11
D	単幹	無し	有り	0
E	株立ち	有り	無し	8
F	株立ち	有り	有り	4
G	株立ち	無し	無し	8
H	株立ち	無し	有り	6

類型記号 (Category Code) - A symbol that represents a specific category or type for each A-bombed tree.
幹立ち区分 (Trunk Type) - A classification indicating how the trunk of the tree stands. "単幹" (Single Trunk) refers to trees with one main trunk, while "株立ち" (Clump) refers to trees that have multiple trunks growing from the base.
地上部被害痕跡 (Above-ground Damage Traces) - Information about the traces of damage visible on the above-ground parts of the tree.
移植の有無 (Transplantation Status) - Indicates whether the tree has been transplanted from its original location. "有り" (Yes) means the tree has been transplanted, "無し" (No) means it remains in its original place.
本数 (Number of Trees) - The number of trees of the same species present in the same location.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Table 2　The measurement results

樹木番号	広島市登録箇所番号	樹木名	学名	爆心地からの距離(m)	住所	樹木類型	樹形異常の症状					主幹傾斜角度(度)	爆心地方位(α)	主幹傾斜方位(β)	爆心地傾斜方位偏差(δ)
							①	②	③	④	⑤				
1	4	クスノキ	*Cinnamomum camphora*	370	中区中町7-24	C					●	17	215	285	70
2	6	クロガネモチ	*Ilex rotunda*	530	中区小町3	C					●	14	345	175	190
3	6	センダン	*Melia azedarach*	530	中区小町3	C		●			●	14	345	336	351
4	6	ムクノキ	*Aphananthe aspera*	530	中区小町3	C		●			●	14	345	328	343
5	7	マルバヤナギ	*Salix chaenomeloides*	740	中区基町21	A	●		●		●	23	215	47	192
6	7	ユーカリ	*Eucalyptus melliodora*	740	中区基町21	A	●		●		●	14	215	217	2
7	11	クロガネモチ	*Ilex rotunda*	910	中区基町21	A	●	●			●	3	211	196	345
8	12	クロガネモチ	*Ilex rotunda*	940	中区小町9-34	C				●	●	5	335	308	333
9	13	クスノキ	*Cinnamomum camphora*	1,010	中区基町16	A	●	●	●	●	●	5	165	148	343
10	16	クスノキ	*Cinnamomum camphora*	1,110	中区基町20	A	●	●	●	●	●	2	192	197	5
11	17	クスノキ	*Cinnamomum camphora*	1,120	中区基町21	A	●		●		●	7	215	38	183
12	18	クスノキ	*Cinnamomum camphora*	1,120	中区八丁堀2	A	●	●	●		●	7	220	205	345
13	19	イチョウ	*Ginkgo biloba*	1,130	中区寺町3-3	A	●	●		●	●	5	154	152	358
14	21	プラタナス	*Platanus oeientalis*	1,160	西区天満町1-27	A			●		●	28	99	70	331
15	21	プラタナス	*Platanus oeientalis*	1,160	西区天満町1-27	B			●		●	2	100	257	157
16	21	プラタナス	*Platanus oeientalis*	1,160	西区天満町1-27	B			●		●	9	100	10	270
17	21	プラタナス	*Platanus oeientalis*	1,160	西天満町1-27	B			●		●	4	100	81	341
18	22	クスノキ	*Cinnamomum camphora*	1,270	西区天満町1	A	●	●			●	3	97	73	336
19	25	イチョウ	*Ginkgo biloba*	1,370	中区上幟町2	A	●	●			●	43	244	263	19
20	25	ムクノキ	*Aphananthe aspera*	1,370	中区上幟町2	A	●		●	●	●	43	238	53	175
21	28	イチョウ	*Ginkgo biloba*	1,420	中区住吉町15-22	A	●	●			●	3	28	12	344
22	29	ナツメ	*Ziziphus jujuba*	1,430	西区観音町1	B	●	●	●	●	●	8	85	272	187
23	30	エノキ	*Celtis sinensis var. japonica*	1,440	中区上幟町6-29	A	●	●	●	●	●	8	246	238	352
24	36	クロガネモチ	*Ilex rotunda*	1,770	西区観音本町二丁目1-26	B	●	●	●	●	●	1	75	235	160
25	37	イチョウ	*Ginkgo biloba*	1,780	東区二葉の里二丁目6-25	A	●	●			●	2	232	221	349
26	38	クスノキ	*Cinnamomum camphora*	1,800	西区観音本町二丁目	A	●	●	●		●	11	72	78	6
27	38	クスノキ	*Cinnamomum camphora*	1,800	西区観音本町二丁目	A	●	●	●		●	2	72	68	356
28	38	クスノキ	*Cinnamomum camphora*	1,800	西区観音本町二丁目	A	●	●	●		●	4	72	73	1
29	38	クスノキ	*Cinnamomum camphora*	1,800	西区観音本町二丁目	A	●	●	●		●	6	72	255	183
30	39	ソメイヨシノ	*Prunus × yadoensis*	1,800	南区比治山町7-1	A	●		●		●	24	301	306	5
31	40	ソメイヨシノ	*Prunus × yadoensis*	1,800	中区白島九軒12-20	A	●				●	21	218	219	1
32	40	タブノキ	*Machilus thunbergii*	1,800	中区白島九軒12-20	A	●	●	●		●	6	218	212	354
33	41	イチョウ	*Ginkgo biloba*	1,810	東区二葉の里二丁目5-11	A	●	●			●	23	239	141	262
34	44	クスノキ	*Cinnamomum camphora*	1,850	西区三篠町一丁目11-5	B	●	●	●	●	●	8	170	186	16
35	47	カイヅカイブキ	*Juniperus chinensis 'Kaizuka'*	1,900	西区福島町一丁目18	B					●	23	95	60	325
36	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	3	200	20	180
37	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	5	200	126	286
38	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	7	200	99	259
39	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	4	200	294	94
40	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	10	200	106	266
41	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	9	200	101	261
42	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	3	200	97	257
43	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	8	200	114	274
44	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	3	200	136	296
45	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	6	200	192	352
46	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	9	200	197	357
47	50	クスノキ	*Cinnamomum camphora*	2,100	中区白島北町19	B	●	●	●	●	●	5	200	14	174
48	51	ソメイヨシノ	*Prunus × yadoensis*	2,110	中区白島北町1-41	A	●				●	17	205	206	1
49	51	クロマツ	*Pinus thunbergii*	2,110	中区白島北町1-41	B	●				●	5	205	33	188
50	51	クロマツ	*Pinus thunbergii*	2,110	中区白島北町1-41	B	●				●	13	205	23	178
51	51	クロマツ	*Pinus thunbergii*	2,110	中区白島北町1-41	B	●				●	4	205	38	193
52	53	イチョウ	*Ginkgo biloba*	2,160	東区牛田本町一丁目5-29	A	●		●	●	●	5	222	58	196
53	54	クスノキ	*Cinnamomum camphora*	2,160	中区稲生神社	A		●			●	10	21	21	0
54	54	クロガネモチ	*Ilex rotunda*	2,160	中区稲生神社	A					●	14	21	32	11
55	54	ツバキ	*Camellia japonica*	2,160	中区稲生神社	A					●	37	21	20	359
56	54	クロマツ	*Pinus thunbergii*	2,160	中区稲生神社	A					●	21	21	21	0

樹形異常の症状 ①火傷跡・亀裂　②爆心地反対側の肥大　③組織死滅による洞(うろ)④根元・主幹頂部からの株立ち　⑤主幹の傾斜　方位は北を0,360とする。

爆心地傾斜方位偏差(δ)は爆心地方位を0とし，そこから被爆樹木の主幹傾斜方位を時計回りに360度法で計測した値である。

樹木番号 (Tree Number) - The unique identifier assigned to each individual tree.
広島市登録箇所番号 (Hiroshima City Registration Site Number) - The specific registration number assigned to the location where the tree is registered in Hiroshima City.
学名 (Scientific Name) - The scientific or Latin name of the tree species.
爆心地からの距離 (Distance from Ground Zero) - The distance of the tree from the hypocenter of the atomic bomb explosion.
樹形異常の症状 (Symptoms of Tree Form Abnormality) - Describes any abnormalities in the shape or form of the tree that may have resulted from exposure to the atomic bomb.
主幹傾斜角度 (Main Trunk Inclination Angle) - The angle of inclination of the main trunk of the tree.
爆心地方位 (Direction to Ground Zero) - The compass direction from the tree to Ground Zero.
主幹傾斜方位 (Main Trunk Inclination Direction) - The compass direction in which the main trunk is inclined.
爆心地傾斜方位偏差 (Deviation of Inclination Direction from Ground Zero) - The deviation between the direction of the main trunk's inclination and the direction to Ground Zero.

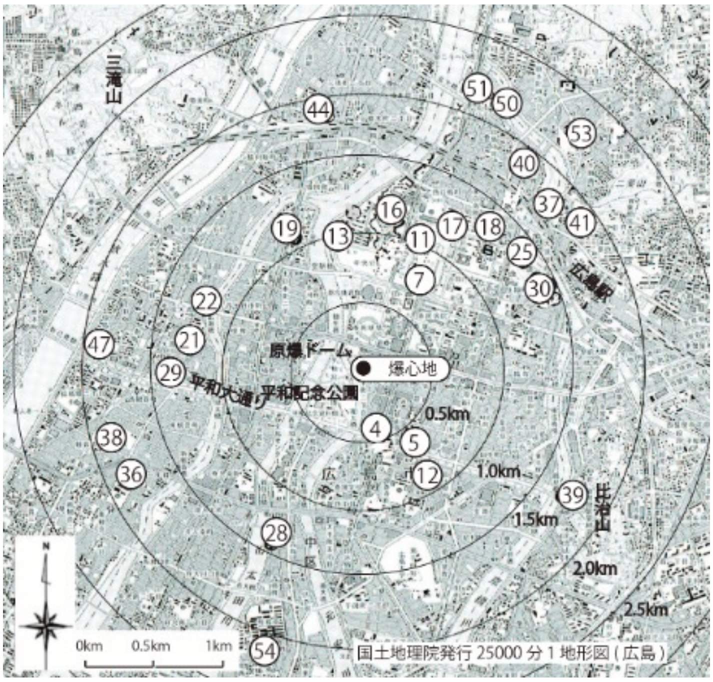

Figure 1 The location of the surveyed A-bombed trees

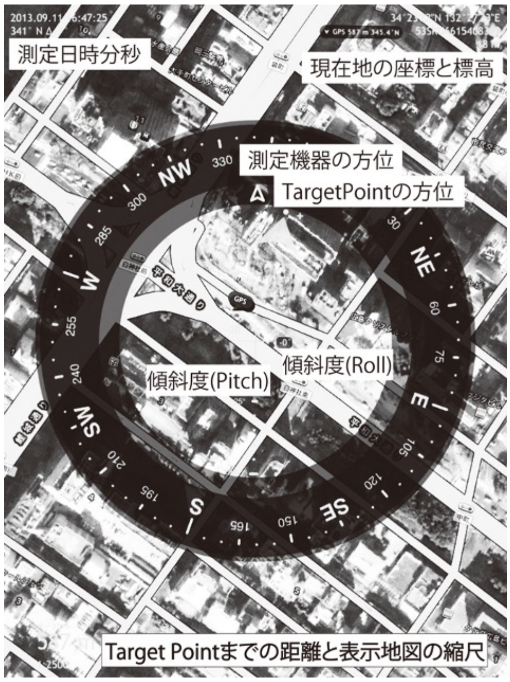

Figure 3 An example of the measurement screen

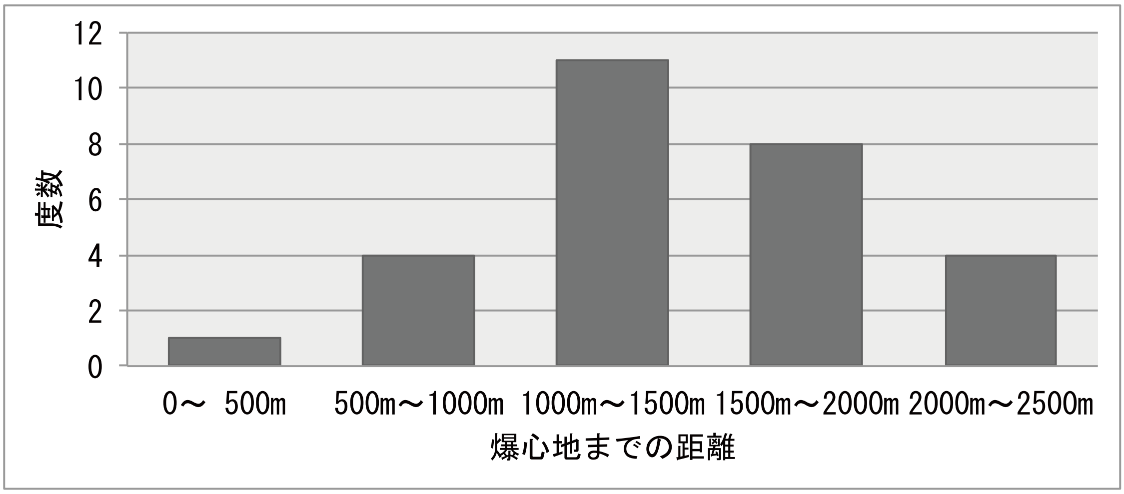

Figure 2 The distances from the hypocenter range

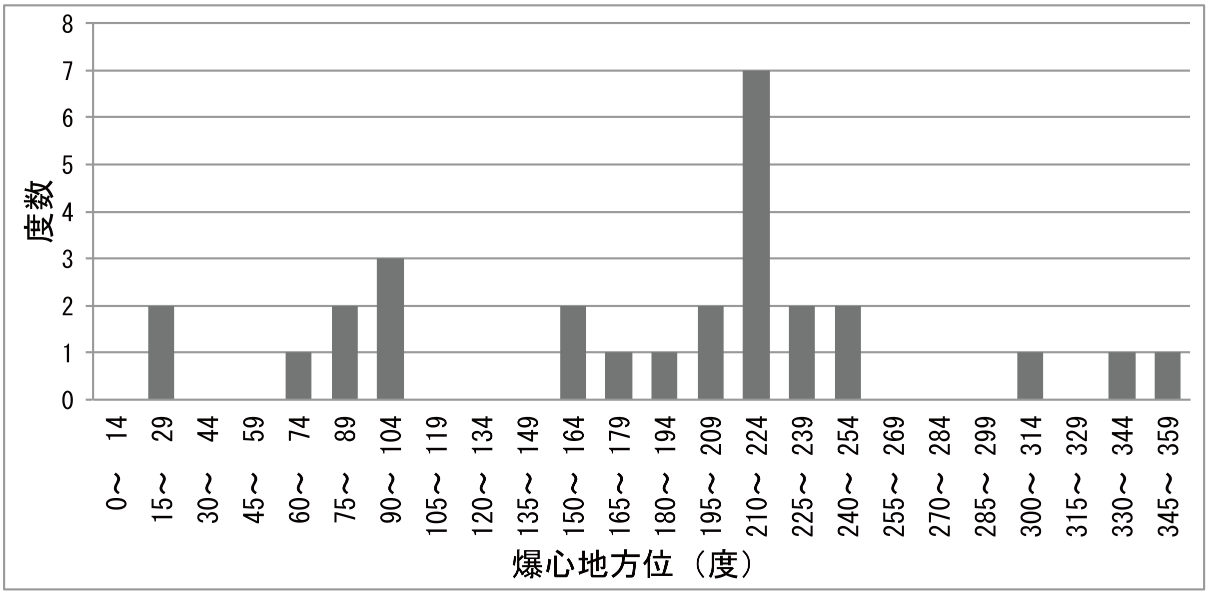

Figure 4　Histogram of the bearings from these points to the hypocenter (α)

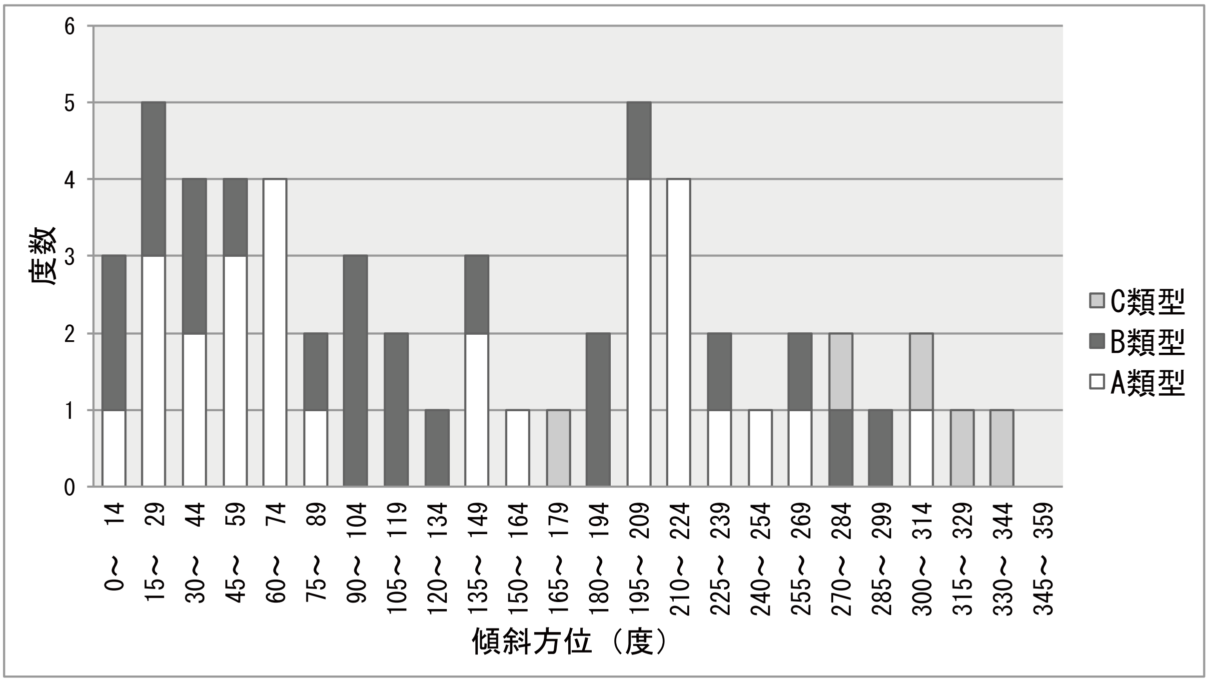

Figure 5　Distribution of the Inclination Directions of A-bombed trees (β)

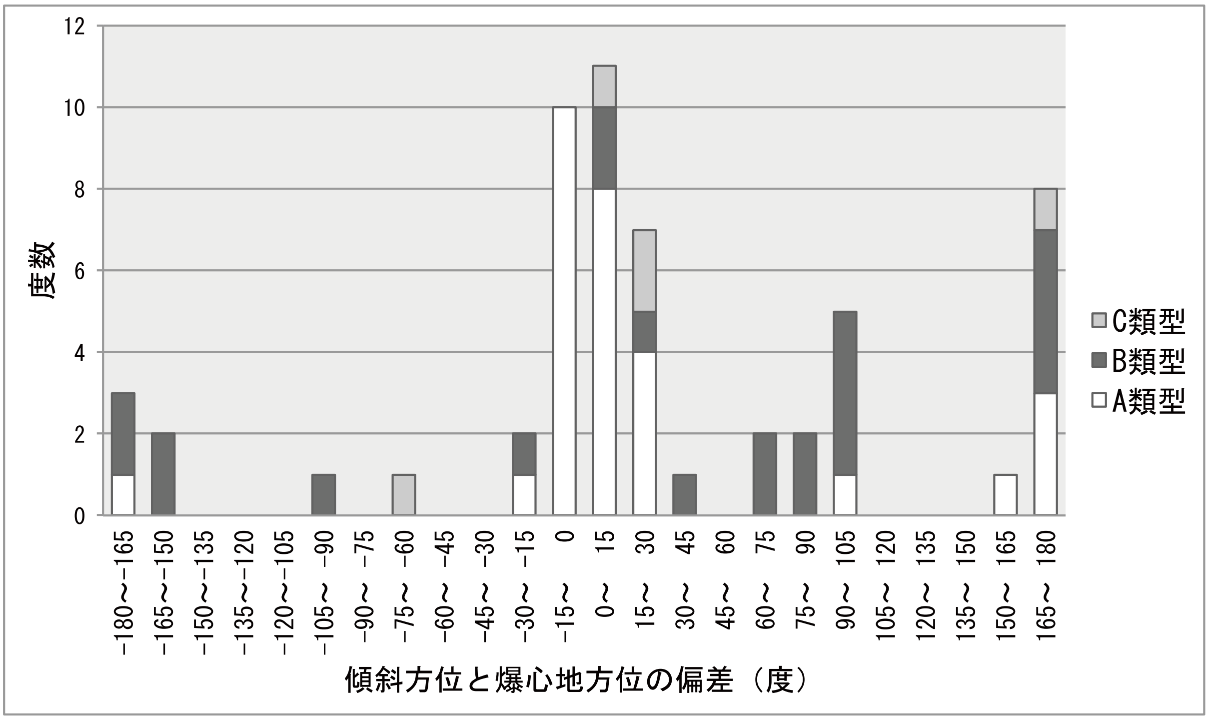

Figure 6　Deviation Distribution of A-bombed trees' Inclination Directions and the Hypocenter's Direction (δ=α-β)

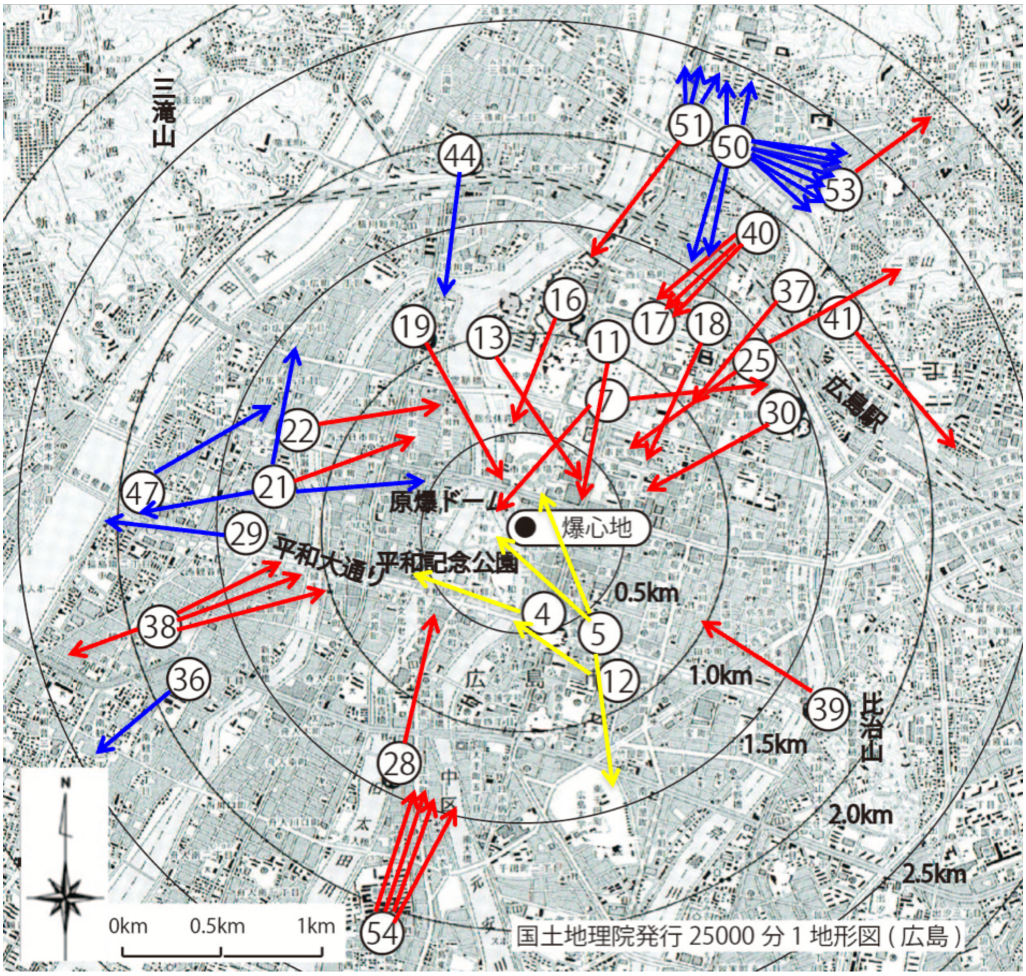

Figure 7　The inclination direction chart for all target trees
red:typeA　　blue:typeB　　yellow:typeC

Searching Process and Issues on conservation of Undiscovered A-bombed trees in Nagasaki, Nagisa Owaki, Masakazu Suzuki, Kazuhisa Ohbi, journal of the Japanese Institute of Landscape Architecture,79(5),541-544,2016

Abstract: In Nagasaki city, "A-bombed trees" stand as valuable war heritage. The primary aim of this study was to assess the conservation challenges and current status of these trees in Nagasaki, contrasting it with findings from Hiroshima. We examined abnormal tree forms in Nagasaki and developed a methodology to identify previously undiscovered A-bombed trees. Notably, the number of bombed trees in Nagasaki is fewer than in Hiroshima, possibly due to the distinct topographical features of the two cities. Historical aerial photography was analyzed by overlaying images from before and after the bombing, allowing us to visually identify green spaces that have persisted over time and pinpoint potential locations of undiscovered A-bombed trees. Field investigations in these identified areas revealed that the likelihood of finding undiscovered A-bombed trees is low in forest zones but high within shrines, temples, educational institutions, and public facilities. This research not only highlights the challenges in locating and conserving A-bombed trees in Nagasaki but also enhances our understanding of their potential presence across different urban and peri-urban settings.

Keywords: Nagasaki, war heritage, abnormal tree form, A-bombed trees, aerial photograph

1. Introduction

(1) Research Background

As the 70th anniversary of the atomic bombings approaches, there has been an increase in related media coverage. However, there has been little change in the volume of existing and new research on trees affected by the bombings since immediately after World War II. Existing studies on such trees are almost exclusively focused on Hiroshima, with even fewer studies on trees in Nagasaki, leaving the actual condition of the trees affected by the bombings in Nagasaki largely unknown. These trees are referred to as "hibakujumoku", meaning trees that were exposed to the atomic bombs.

In Nagasaki, the Standards for Handling Atomic Bomb-Affected Buildings, etc., were implemented in 1998. Based on these standards, affected trees have been ranked and recognized. Currently, approximately 35 recognized hibakujumoku exist within about a 4 km radius of the hypocenter in 32 locations in Nagasaki. In comparison, Hiroshima has about 170 recognized hibakujumoku in 55 locations within a 2 km radius of its hypocenter. There is no joint research between the two cities on these trees, and understanding the actual conditions of preservation, recognition, and tree deformities in both cities will be crucial as these trees are preserved as atomic bomb heritage in the future.

(2) Objectives and Significance of This Study

The purpose of this study is to clarify the actual condition of the trees in Nagasaki that were affected by the atomic bomb, based on the characteristics identified in previous studies. This will be achieved through physical surveys, literature reviews, and interviews regarding the affected trees in Nagasaki. By comparing the results from Nagasaki with those from surveys of the affected trees in Hiroshima, the study aims to understand the similarities and differences in the distribution, recognition, and treatment of affected trees in both cities. Additionally, this research intends to develop a methodology for identifying trees that are presumed to be affected in Nagasaki and to conduct field searches. Discovering trees in previously unexplored mountainous or urban areas of Nagasaki that are presumed to be affected will demonstrate that these trees have survived healthily without treatment. This could provide new insights for the future recognition and preservation strategies of affected trees in both cities and identify challenges and issues in their future recognition.

2. Current Status and Comparison of A-bombed trees in Nagasaki and Hiroshima

(1) Differences in the Distribution of Recognized A-bombed trees Between Nagasaki and Hiroshima

Figure 1 shows the distribution of recognized A-bombed trees in Nagasaki, while Figure 2 depicts those in Hiroshima. A comparison reveals that in Hiroshima, the trees are distributed almost evenly within a radius of about 2.5 km from the hypocenter. In contrast, Nagasaki has fewer trees, and they are distributed in a linear fashion. This is likely due to the geographical features of the two cities; Hiroshima is flat with an urban area that spreads out evenly, whereas Nagasaki is a long, narrow cityscape surrounded by mountains to the north and south. In recognizing A-bombed trees, it is presumed that trees within wooded mountain areas in Nagasaki have not been recognized because the recognition of A-bombed trees has been limited to the narrow urban area, with no trees recognized within about a 4 km radius in these areas.

(2) Differences in Recognition Status

As mentioned, 32 locations with A-bombed trees have been recognized in Nagasaki, categorized from A to D based on the extent of bomb damage: 14 places are ranked A, 7 are B, 8 are C, and 3 are D. Unlike Hiroshima, where recognized A-bombed trees are located on public land, schools, and at religious sites, half of the recognized trees in Nagasaki are located on private property. Trees on private property are managed by their owners, and their survival is not guaranteed. There is a risk that these trees could disappear due to changes in ownership, which is a significant concern. The approach of transplanting to public lands, as seen in Hiroshima, may need to be considered in Nagasaki as well. Additionally, recognition of A-bombed trees in Nagasaki is not based on individual trees but rather on the location, encompassing multiple trees. This site-based registration can pose problems for conservation if a tree at a registered site dies, as the recognition and maintenance of the deceased tree may not be adequately managed. In contrast, Hiroshima has been assigning individual numbers to all A-bombed trees since 2015 to facilitate their conservation.

(3) Differences in Treatment Methods for A-bombed trees in Hiroshima and Nagasaki

Observations of the treatment methods applied by arborists through municipal initiatives to recognized A-bombed trees in both cities reveal distinct approaches. In Hiroshima, surgical interventions on trees are minimized; instead, treatments focus on improving soil conditions and providing support structures like stakes. In contrast, in Nagasaki, there is a proactive approach to surgical treatments, such as filling trunks with resin or mortar.

3 Research Methods

(1) Morphology and Physical Survey of Typical A-bombed trees Based on observations

From Hiroshima (Figure 3), a schematic of a typical A-bombed tree morphology is presented. This study conducted a physical survey of A-bombed tree morphology based on Figure 3. The age and circumference at breast height were omitted from this survey as they were not listed in Nagasaki's A-bombed tree records.

Common morphological abnormalities observed in Hiroshima's A-bombed trees include:

① Burn Marks ② Clacks in the Trunk ③ Shrinkage of Roots on the Hypocenter Side ④ Sprouts ⑤ Shrinking of the Trunk Surface on the Hypocenter Side ⑥ Elongation of Roots on the Side Opposite the Hypocenter ⑦ Enlargement of the Trunk Surface on the Side Opposite the Hypocenter ⑧ Inclination of the Main Trunk

These eight items were the focus of the survey conducted over four days (September 9-12, 2015).

The physical survey included six trees from five locations currently recognized as A-bombed trees in Nagasaki, and five trees from four locations where trees are presumed to be a-bombed based on aerial photo comparisons and large tree surveys, totaling 11 trees. The survey results, including location, species, distance from the hypocenter, presence of morphological abnormalities, and recognition status, are shown in Table 1. Additionally, Figure 4 illustrates the locations of the surveyed A-bombed trees.

Trees within a radius of about 2 km from the hypocenter all exhibited morphological abnormalities due to the effects of the bombing. Trees located more than 2 km from the hypocenter (excluding tree number 7), although not currently recognized as A-bombed trees in Nagasaki, showed typical abnormalities of A-bombed trees such as atrophy on the side of the trunk facing the hypocenter and hypertrophic growth on the opposite side, even though no significant external injuries like burns or cracks were observed.

(2) Mapping and Exploration for Undiscovered A-bombed trees

This research explored the potential existence of A-bombed trees within a radius of approximately 3 km from the hypocenter by comparing the presence of wooded areas in aerial photographs taken immediately after the atomic bombing and current aerial photos.

While the standard for recognizing A-bombed trees in Hiroshima is within a radius of about 2 km, there are a few recognized trees near a radius of approximately 2.5 km, and in Nagasaki, recognized trees exist near a radius of about 3 km. Based on observations in both Hiroshima and Nagasaki, it is challenging to detect traces of the bombing beyond approximately 2.5 km, leading to the decision that exploring within a radius of approximately 3 km is sufficient.

i) Data Used and Image Processing Aerial photographs from immediately

After the atomic bombing, taken by the U.S. military in 1947 and 1948, were used; six images were involved. These images, provided by the Geospatial Information Authority of Japan, have been digitized as 1200dpi TIFF images and were purchased through the Japan Map Center. Current aerial photographs were downloaded from the Geospatial Information Authority of Japan's "Map and Aerial Photograph Viewing Service," which consists of thirteen 400dpi JPEG color digital images from 2010. These photographs from two different periods were stored in a Geographic Information System (GIS), where georeferencing (geometric correction) was conducted. The image transformation processes were mainly performed using a second-order polynomial transformation, with existing map references from the Nagasaki city basic map information (road edges, waterlines, buildings) provided by the Geospatial Information Authority of Japan, using a plane rectangular coordinate system (System I).

The GIS software used was ArcGIS 10.2.2.

ii) Giant Tree Mapping

Based on the results of the Ministry of the Environment's Giant Trees and Forests Survey (the 6th Basic Survey for Nature Conservation), point data for giant trees within a 3km radius from the hypocenter in Nagasaki was created on GIS. This data was analyzed by overlaying current and post-bombing aerial photographs. Within the 3km radius from the drop site, there are 41 giant trees located at 9 sites. Some of these trees are currently recognized by Nagasaki city as A-bombed trees; the study focuses on those not recognized as such. Figures ① to ⑤ in Figure 5 represent sites where A-bombed trees are recognized. However, it was found that there are giant trees not recognized as A-bombed trees on the same properties, suggesting the presence of potential A-bombed trees.

iii) Mapping of Green Spaces with Potential Presence of A-bombed trees

Using the aerial photographs from two different periods obtained through the data processing mentioned earlier, a comparison of wooded areas was conducted. If a wooded area existed immediately after the atomic bombing and still exists today, it is possible that it contains trees that could be presumed to be A-bombed. These relevant wooded areas were visually identified and mapped.

A part of the aerial photographs mapped is shown in Figure 6. The blackened areas indicate places where green spaces have persisted from immediately after the bombing to the present.

iv) Exploration for Trees Presumed to be A-Bombed

Explorations were conducted in the green spaces mapped in ii) and iii), searching for trees presumed to be a-bombed. The exploration sites are indicated in Figure 4. The exploration involved interviews with the owners of the green spaces and reviews of post-bombing aerial photographs to understand the conditions of the green spaces after the bombing and conducting physical surveys of the trees.

4. Analysis and Discussion of Survey Results

(1) Comparison of Morphological Abnormalities in A-bombed trees between Hiroshima and Nagasaki

When compared to the A-bombed trees in Hiroshima, it was observed that the trees in Nagasaki tended to have less severe external damage due to the bombing. According to the physical survey results in Hiroshima, about half of the trees within a radius of approximately 0.5 km to 1 km from the hypocenter had their above-ground parts completely burned away. Furthermore, nearly all the trees within a radius of 1 km to 2 km exhibited morphological abnormalities and external injuries caused by the bombing. In contrast, in Nagasaki, within a radius of about 0.5 km to 1 km, there were few trees that regenerated after having their above-ground parts entirely burned. Additionally, although traces of the bombing were present in the trees within a radius of 1 km to 2 km, the extent of these traces was milder, and there were fewer trees with significant external injuries or morphological abnormalities. Beyond a radius of about 2 km, notable injuries were almost non-existent.

The presence of bombing traces is a critical factor in the recognition of A-bombed trees, and the lesser extent of such traces in Nagasaki compared to Hiroshima could be a contributing factor to the differences in the number of trees officially recognized as A-bombed in each city.

(2) Trees Presumed to be A-Bombed

Field investigations revealed trees with typical morphological abnormalities of A-bombed trees, such as those numbered 7, 8, 9, and 10 in Table 1, which are located within green spaces that have persisted from before the bombing to the present and also correspond to the locations listed in the giant tree survey (Photos 1 and 2). However, these trees are located more than 2 km from the hypocenter, and the extent of external injuries is minor, making it difficult to definitively identify them as A-bombed trees due to the lack of specific confirmatory evidence from photos or other records from the time of the bombing.

Additionally, trees exhibiting morphological abnormalities consistent with those of A-bombed trees were found (Photos 3 and 4). The tree in Photo 4, present in both pre- and post-bombing photographs, is clearly an A-bombed tree, yet it is not officially recognized as such by Nagasaki City. According to the principal of the elementary school where the tree is located, it is not recognized because it does not show visible signs of bombing, although the physical survey observations did indicate signs of bombing damage.

From these findings, it is evident that locations with trees presumed to be A-bombed are likely to be shrines, temples, educational facilities, and historical sites where the potential for discovering such trees is higher. In contrast, mixed forests regenerated after the bombing or planted forests in mountainous areas are less likely to contain such trees. This pattern suggests that the visibility and accessibility of these areas significantly affect the recognition and preservation efforts of A-bombed trees.

5. Summary and Future Challenges

From the results, it has been established that the extent of external injuries on A-bombed trees in Nagasaki is less severe compared to those in Hiroshima. When recognizing A-bombed trees, it is necessary to not only acknowledge trees with obvious signs of bombing, such as burns, but also those showing typical morphological abnormalities as illustrated in Figure 3. In preserving these trees, it is essential to consider the differences in treatment methods between the two cities and to discuss future preservation strategies for A-bombed trees, including sharing information on treatment methods.

Furthermore, it has been clarified that the likelihood of finding presumed A-bombed trees in the mountainous areas of Nagasaki is low. However, there is potential for the existence of such trees within urban areas.

The challenges related to A-bombed trees and trees presumed to be a-bombed in Nagasaki are as follows:

① Revise the current criteria for recognizing A-bombed trees in Nagasaki to include typical morphological abnormalities possessed by A-bombed trees, and conduct detailed surveys of trees presumed to be a-bombed located on the same properties as currently recognized sites or within green spaces continuous over two time periods.

② In re-evaluating and recognizing new trees presumed to be a-bombed, it is anticipated that several trees may be recognized at the same location as currently recognized A-bombed trees. To preserve A-bombed trees effectively, it is necessary to move away from site-based recognition towards individual identification, assigning individual numbers and managing information accordingly.

③ The survey conducted within this paper was unable to cover all areas within a 3km radius of Nagasaki, including green spaces, mountainous areas, and public facilities comprehensively. Further surveys and resolution of these issues will require systematic and human resources, as well as information exchange on site.

④ Although trees presumed to be a-bombed were identified in this paper, there is a need to develop and verify methodologies, standards, and recognition processes to definitively confirm trees as a-bombed in the future.

These steps are essential for enhancing the recognition and preservation of A-bombed trees, which serve not only as living memorials of historical events but also as significant ecological and cultural resources.

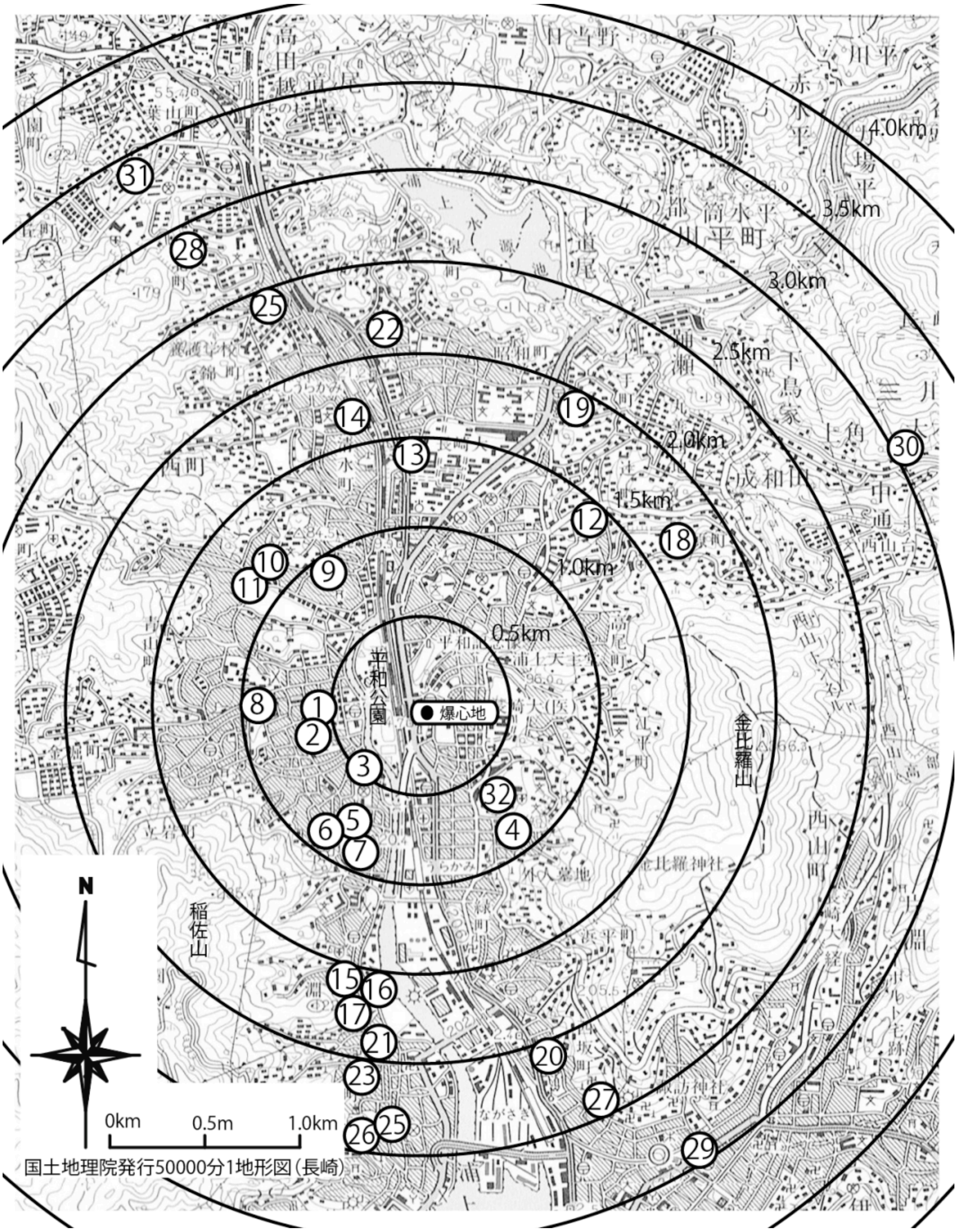

Figure 1　The distribution of recognized A-bombed trees in Nagasaki

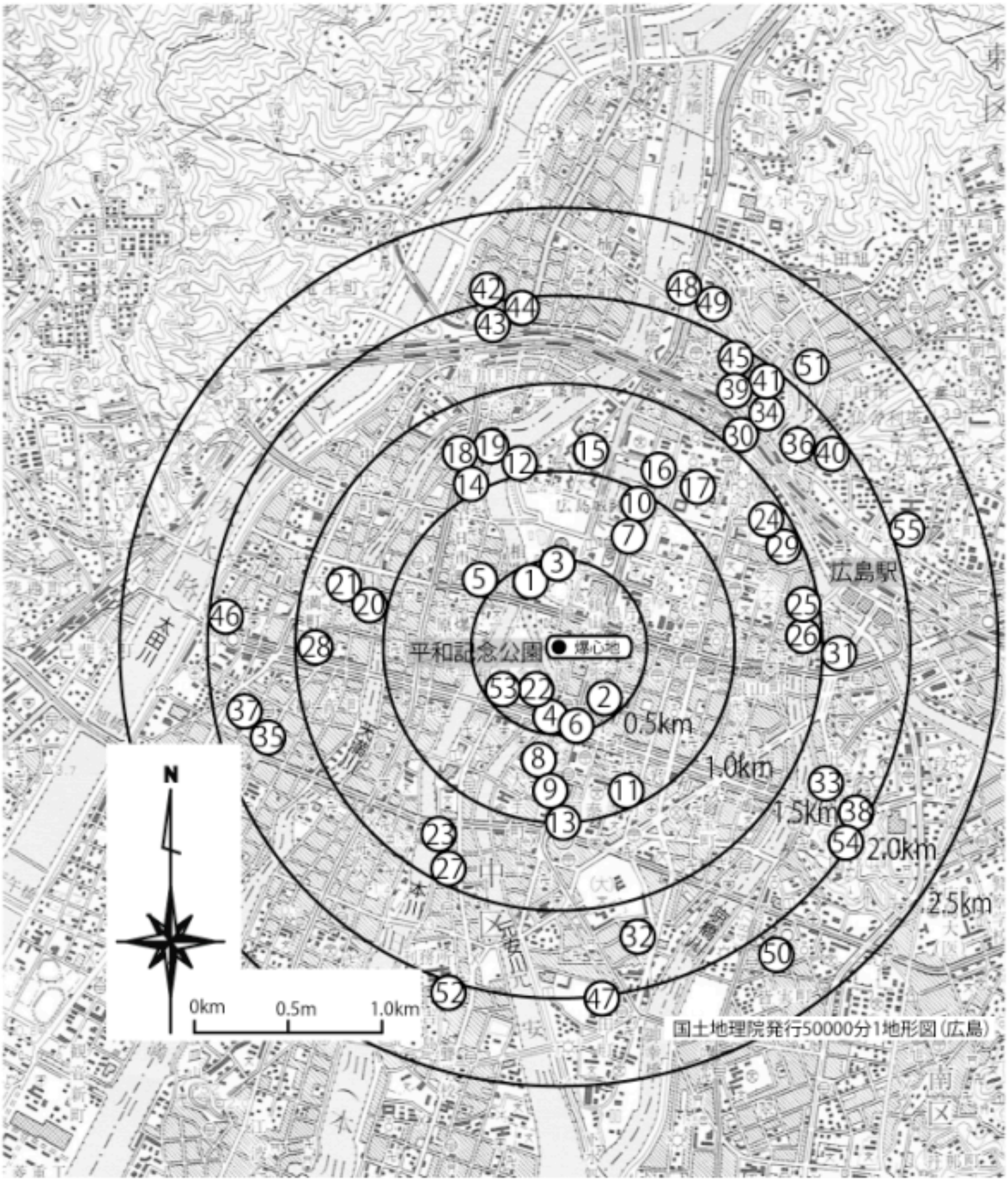

Figure 2　The distribution of recognized A-bombed trees in Hiroshima

樹形異常の症状 (Symptoms of Tree Form Abnormality)
①火傷跡 (Burn Marks)
②幹の亀裂 (Cracks in the Trunk)
③爆心地側の根の縮小 (Shrinkage of Roots on the Hypocenter Side)
④ヒコバエ (Sprouts) - Sprouts
⑤爆心地側の幹肌の萎縮 (Shrinking of the Trunk Surface on the Hypocenter Side)
⑥爆心地反対側の根の伸長 (Elongation of Roots on the Side Opposite the Hypocenter)
⑦爆心地反対側の幹肌の肥大 (Enlargement of the Trunk Surface on the Side Opposite the Hypocenter)
⑧主幹の傾斜 (Inclination of the Main Trunk)

Table 1　The survey results

樹木番号	調査箇所番号	調査地	樹種	爆心地からの距離(m)	樹形異常の症状 ①	②	③	④	⑤	⑥	⑦	⑧	認定
1	1	桜町小学校	クロガネモチ	3,000	有	有	有	無	有	有	有	有	有
2	2	稲佐小学校(枯死)	クスノキ	1,900	有	無	有	無	有	有	無	無	有
3	2	稲佐小学校	クスノキ	2,000	有	無	有	無	無	有	有	有	無
4	3	淵神社(門脇)	クスノキ	1,500	無	無	有	無	有	有	有	有	有
5	3	淵神社(鳥居脇)	クスノキ	1,720	無	無	有	無	無	無	無	無	有
6	10	長崎医科大学付属病院	クスノキ	750	無	無	有	無	有	有	有	有	有
7	5	諏訪神社脇道路	クスノキ	2,810	有	有	無	無	無	無	有	有	無
8	5	諏訪神社脇道路	クスノキ	2,700	無	無	無	無	無	無	無	有	無
9	6	長崎県立図書館裏	クスノキ	2,770	無	無	有	無	有	有	有	有	無
10	6	立山防空壕跡前緑地	クスノキ	2,680	無	無	有	無	有	有	無	有	無
11	7	住吉神社	クスノキ	2,090	無	無	無	無	無	無	有	有	有

樹形異常の症状①火傷跡②幹の亀裂③爆心地側の根の縮小④ヒコバエ⑤爆心地側の幹肌の萎縮⑥爆心地反対側の根の伸張⑦爆心地反対側の幹肌の肥大⑧主幹の傾斜

(学名)クロガネモチ:*Ilex rotunda*　クスノキ:*Cinnamomum camphora*

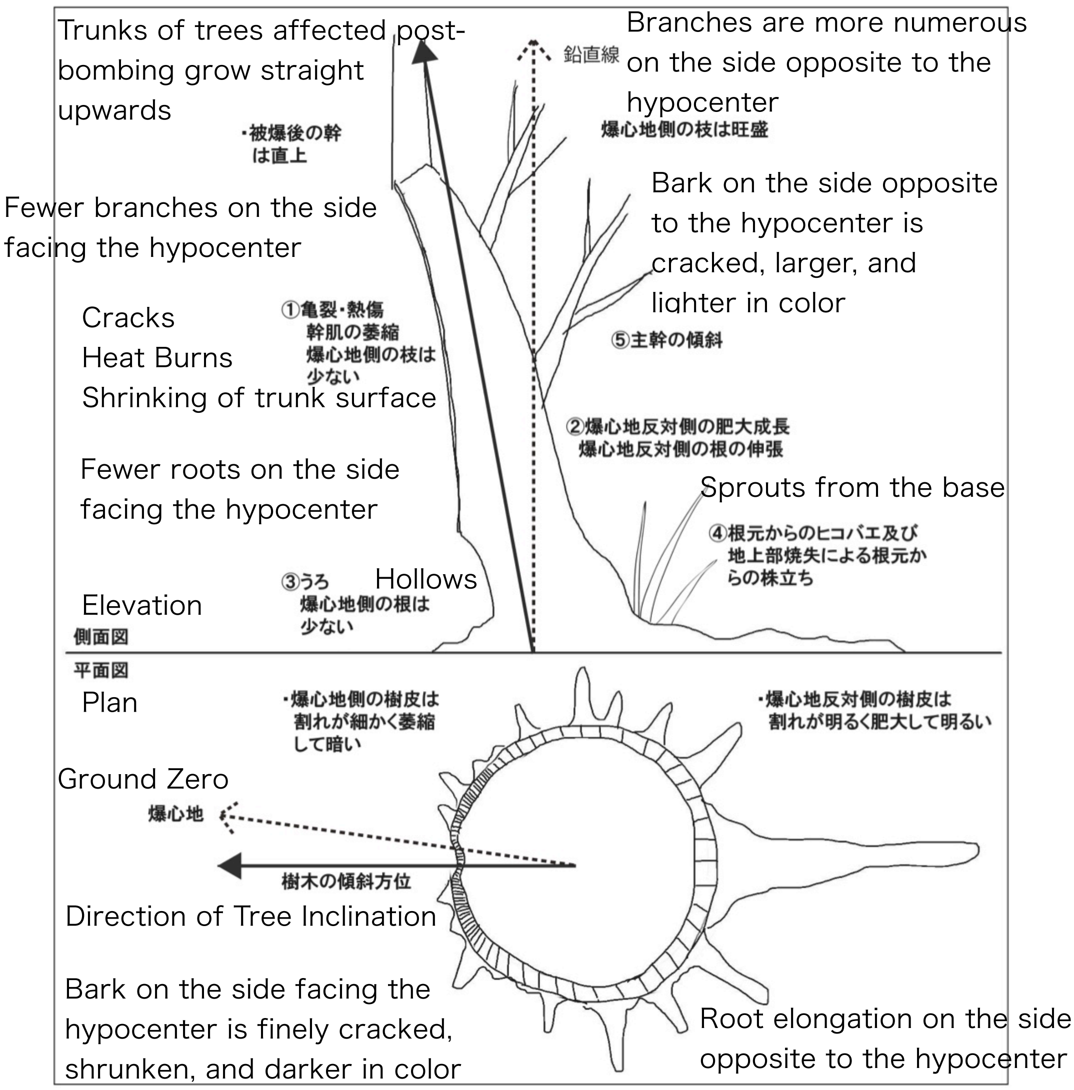

Figure 3　Morphology and Physical Survey of Typical A-bombed trees Based on observations from Hiroshima

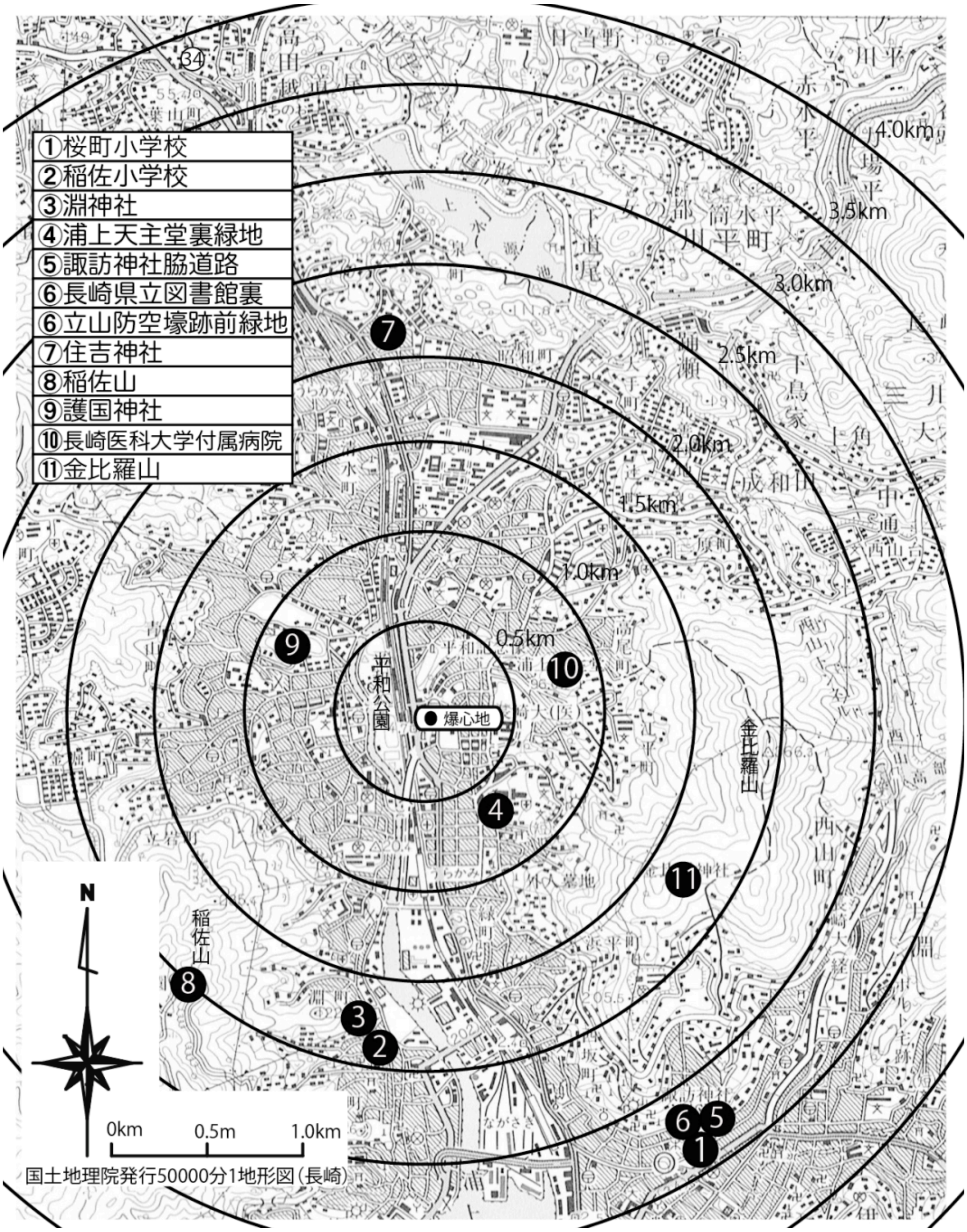

Figure 4　The locations of the surveyed A-bombed trees

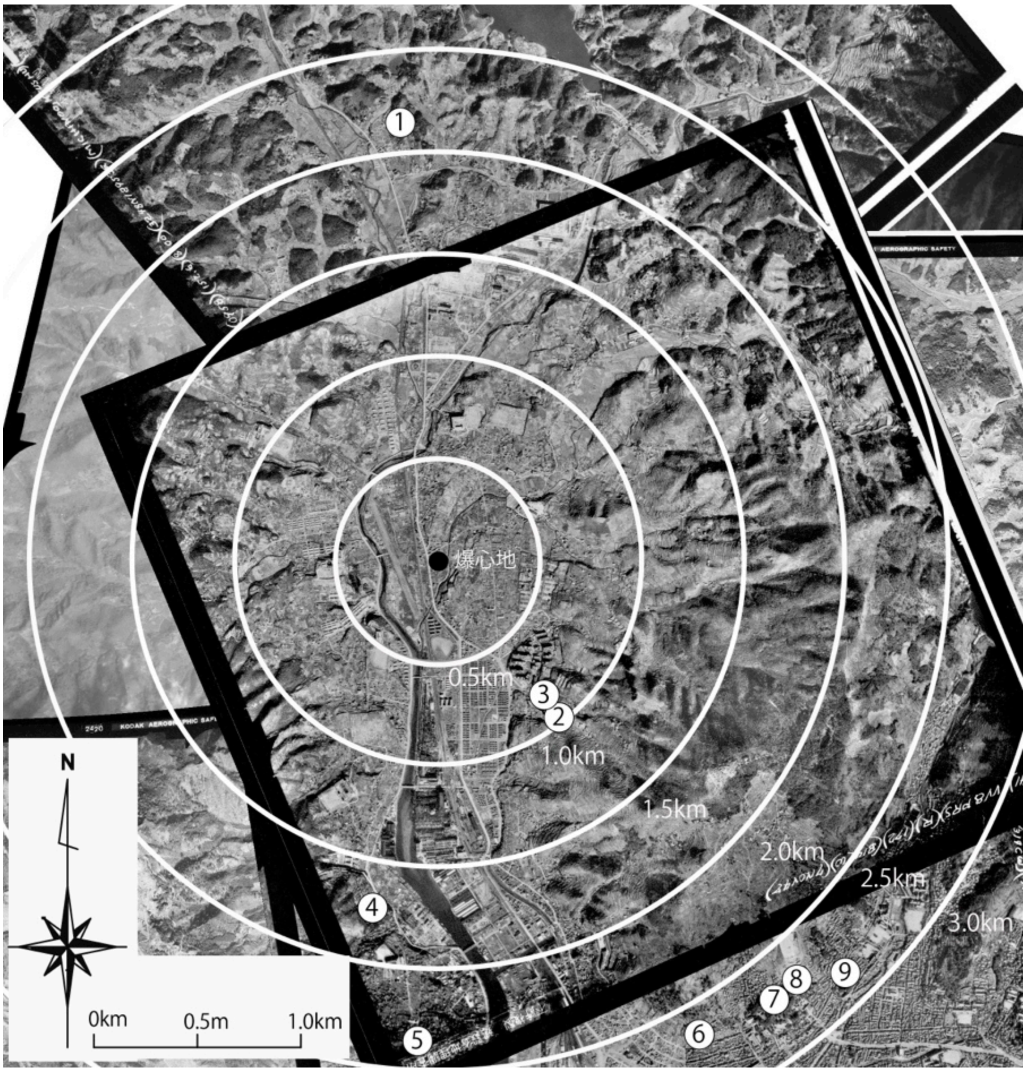

Figure 5　Sites where A-bombed trees are recognized

Figure 6　A part of the aerial photographs mapped

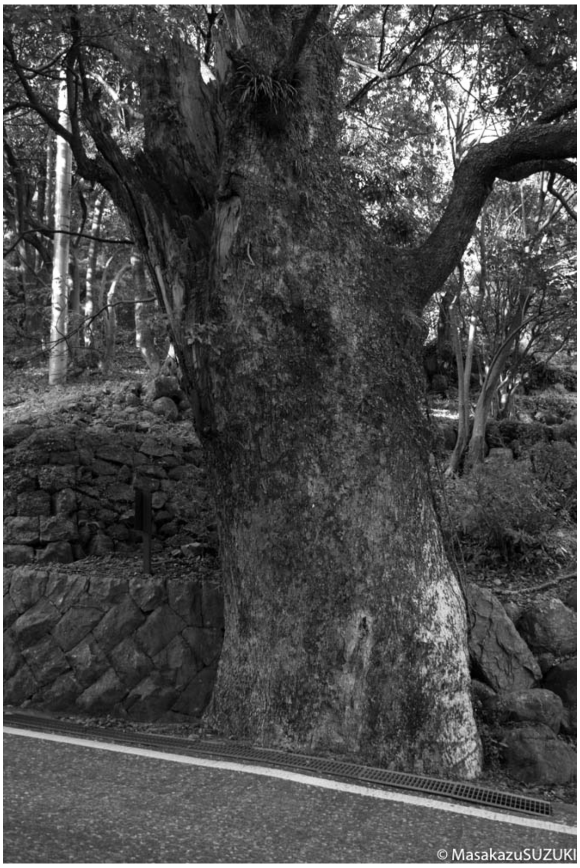

Photo 1

Photo 2

Photo 3

Photo 4

Reconstruction method for 3D model of A-bombed tree by using TLS

By Rihito Kumazaki, Yoichi Kunii, Masakazu Suzuki

Journal of Applied Survey Technology Vol.30 129-140,2019

Abstract: This study investigates the abnormal structural tendencies of A-bombed trees, specifically their inclination towards ground zero. By utilizing terrestrial laser scanning, we measured the deviation between the azimuth angle of ground zero and the tree's tilt angle. We employed open-source software to construct a Quantitative Structural Model (QSM), which facilitates the estimation of tree volume, above-ground biomass, and structural details from the collected data. This model enabled the production of a detailed 3D representation of the A-bombed tree's structure, which was subsequently printed using a 3D printer. The integration of laser measurement technology thus advances methodologies for assessing the physical condition of A-bombed trees, supporting their preservation efforts. The tactile and visual accessibility of the 3D models enhances the understanding of the unique morphological features of A-bombed trees, fostering greater recognition of their historical significance.

Keywords: A-bombed tree, terrestrial laser scanning (TLS), 3D tree model, Quantitative structural model (QSM)

1. Introduction

Domestic and overseas surveys have made significant contributions to the preservation of archaeological sites and cultural structures for future generations. For instance, the use of Terrestrial Laser Scanners (TLS) at ancient Roman sites has proven effective in precisely documenting mosaics. Similarly, TLS has supported the creation of damage diagrams for large, deteriorating structures on Gunkanjima (Battleship Island). These examples illustrate the effectiveness of laser measurement technology for historical and structural conservation. However, there is limited research demonstrating the utility of this technology for 'living' heritage, such as the A-bombed trees in Hiroshima and Nagasaki. These trees, which have survived the atomic bombings, continue to thrive 74 years after the war, embodying the memory of the atomic bombings as 'living' A-bombed heritage. On August 6, 2018, the Ministry of Health, Labour and Welfare announced a policy to support the preservation of these trees, many of which are at risk due to aging and disease. Thus, capturing the current state of these trees in three-dimensional data using laser measurement technology is increasingly important. An example is the *Cinnamomum camphora* in the Goshinji Cemetery in Nagasaki, which was documented in October 2016 and showed significant changes in shape. This study proposes a new approach using TLS to preserve and examine these A-bombed trees, evaluating its usefulness.

2. Research Objectives

The purpose of this study is to capture the tree shape anomalies of the A-bombed trees using TLS data, and to construct 3D tree models from this data. Previous surveys in Hiroshima have noted specific anomalies in the tree shapes of the A-bombed trees. Research by Owaki et al. has shown that these trees tend to lean toward the hypocenter. This study aims to add further credibility to this fact by calculating the inclination angles from the TLS data and comparing these with the azimuth of the hypocenter. While some A-bombed trees, such as the Ginkgo in Shukkeien Garden, exhibit inclinations over 30 degrees, it is often difficult to visually recognize such tree shape anomalies. Therefore, constructing detailed 3D models from the TLS data can help make these anomalies easier to understand. One method to aid in visual recognition is creating physical models using 3D printing, which allows both visual and tactile engagement with the unique tree shapes. However, creating these models requires the construction of accurate 3D tree models from the TLS data. This study proposes the TLS-QSM method as a primary technique for creating these models, exploring the significance of 3D tree models in ongoing preservation efforts for the A-bombed trees.

3. Target A-bombed trees and Calculation of Inclination

3.1 Characteristics of A-bombed trees

The A-bombed trees have distinctive tree shape abnormalities resulting from the heat and blast of the atomic bomb. These characteristics are divided into five types. For this study, we focused on type ⑤, "trunk inclination," and selected trees that have not been transplanted and are single-stemmed, retaining signs of damage to their above-ground parts (types ① to ④). Trees that have been transplanted or are multi-stemmed were excluded from measurement as their inclination towards the hypocenter cannot be accurately determined.

3.2 Calculation of Tree Inclination

3.2.1 Data Acquisition of A-bombed trees

The TLS used for measurements was the RIEGL "LMS-Z390i." Measurements have been conducted on ten A-bombed trees in both Hiroshima and Nagasaki. The data obtained from the trees and their distances from the hypocenter are shown in Figure 2 (partially omitted). For accurate calculation of tree inclination, calibration was performed to align the survey coordinate system's X-axis with north.

3.2.2 Method and Results of Inclination Calculation

The calculation of inclination was performed using the main trunk's point cloud. First, a threshold was set on the main trunk's point cloud, and cross-sectional point cloud data was extracted every 0.2m from the ground upwards, with each extracted cross-sectional point cloud having a thickness of 0.02m along the Z-axis (Figure 3). This extraction method created cross-sectional point cloud data resembling sliced circles (or ellipses). To deduce the central points of these circles, the coordinates (X, Y) of four points that define the major and minor axes of the circle were read from the circumference, and the center points were derived to calculate the target tree's inclination angle, azimuth of inclination, and the deviation percentage from the azimuth difference towards the hypocenter. Figure 4 illustrates the process used to measure the distance between two points to read coordinates from the segmented cross-sections. These procedures were applied to each cross-section to calculate the mentioned values. The azimuth towards the hypocenter was determined using Google Maps based on the latitude and longitude of the A-bombed trees and the hypocenter. Table 1 (Omitted)shows the calculated results for the ten targeted trees.

4. Creation of 3D Tree Models

(Text is omitted, and selected Figures are provided.)

5. Results and Discussion

5.1 Results of Calculating the Inclination of A-bombed trees

Previous studies have shown a tendency for A-bombed trees to incline towards the hypocenter. Traditional methods involved using a smartphone app to visually determine the direction in which the trunk is most inclined at its base, calculating the inclination angle and direction. Although this method allows for immediate comprehension of the inclination angle, the reliance on visual judgment introduces concerns about accuracy. Therefore, a need arose for quantitative calculation of the inclination, which was addressed by employing TLS to verify the inclination of A-bombed trees. The results quantitatively determined the inclination angles and directions for the ten trees studied. It was noted that two *Cinnamomum camphora* (Shiribuka Park and Hijiyama Park) showed significant deviation due to their greater distance from the hypocenter and the sheltered nature of their locations. Currently, there are over 200 A-bombed trees in Hiroshima (161 trees) and Nagasaki (46 trees), suggesting that further data collection and sample enlargement are necessary.

5.2 Creation of 3D Tree Models

5.2.1 Considerations on Restoration with This Method

Traditional 3D modeling techniques for trees, which involve creating meshes from point clouds of branches, have often relied on manual and visual restoration due to the challenges of meshing complex branch structures. However, the TLS-QSM method automated this process, significantly reducing the time required to create 3D tree models. Nonetheless, while the TLS-QSM method's cylindrical models do not adequately represent the distinct features of A-bombed trees typically most prominent from the base to the main trunk, combining these cylindrical models with mesh processing enables the creation of 3D models that reflect the external trauma caused by the atomic bomb. Additionally, models printed with a 3D printer have facilitated visual recognition of the inclination, a tree shape anomaly that is difficult to perceive in situ (Figure 13). This validates the efficacy of restoring A-bombed trees using this method as it accurately reflects their characteristics.

One challenge noted is that the construction of a QSM requires a complete and dense capture of branch and trunk point clouds, excluding leaves. For the evergreen trees studied, like the *Celtis sinensis var. japonica*, leaf-off scans, which are feasible for deciduous trees during their leaf-shedding period, are not possible, and the presence of leaves affects the acquisition of branch and trunk point clouds. Moreover, the separation of leaf and wood point clouds is currently performed manually, necessitating the development of effective separation techniques.

5.2.2 Significance of Creating 3D Models of A-bombed trees

The creation of 3D models of A-bombed trees is significant for several reasons:

① Preservation of Accurate Tree Shapes: Captures the precise tree shape at the time of measurement, serving as a baseline for understanding changes due to various factors.

② Sensory Experience: Allows a comprehensive view and tactile interaction with the tree's texture, facilitating an understanding of individual characteristics and damage.

③ Hands-on Exhibits: Models that map the texture of A-bombed trees enable interactive and observational opportunities for a wide audience.

④ Recognition of Individuality: Placing many A-bombed trees together allows for the recognition of each tree's uniqueness.

In Hiroshima, efforts have been made since 1996 to list A-bombed trees and budget for their preservation and treatment as part of peace initiatives. However, many trees face risks of aging and disease. Accumulating data on the shape changes of these trees through 3D models can aid specialists like arborists in assessing their health. Furthermore, printed models allow for a deeper understanding of the A-bombed trees, which can be useful in peace education by helping grasp the reality of tree shape anomalies. Additionally, by understanding the inclination of A-bombed trees towards the hypocenter, it's possible to use 3D models on a map to visualize the spatial relationship between the trees and the hypocenter, thus contributing to the recognition of the collective "forest" that spreads across the city around the hypocenter, highlighting their interrelated spatial dynamics.

RIEGL “LMS-Z390i."

Nagasaki University

Chinnamomum camphora

19Sep2019

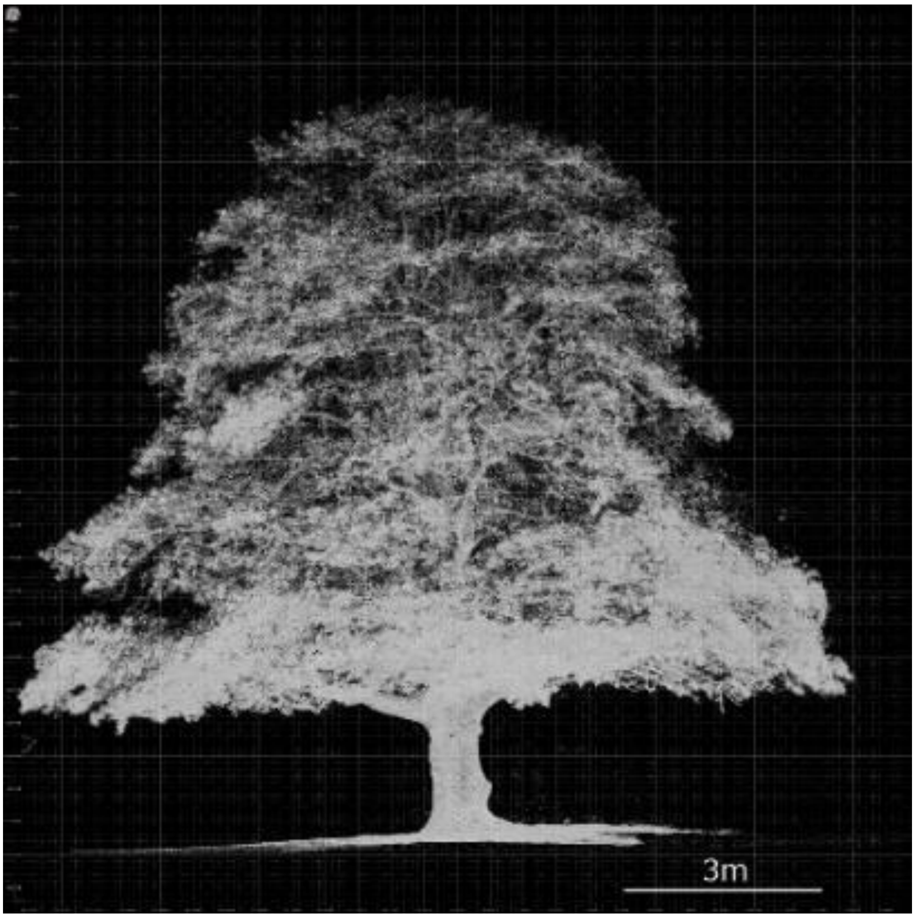

Figure 2-1 Hiroshima Castle *Irex rotunda*

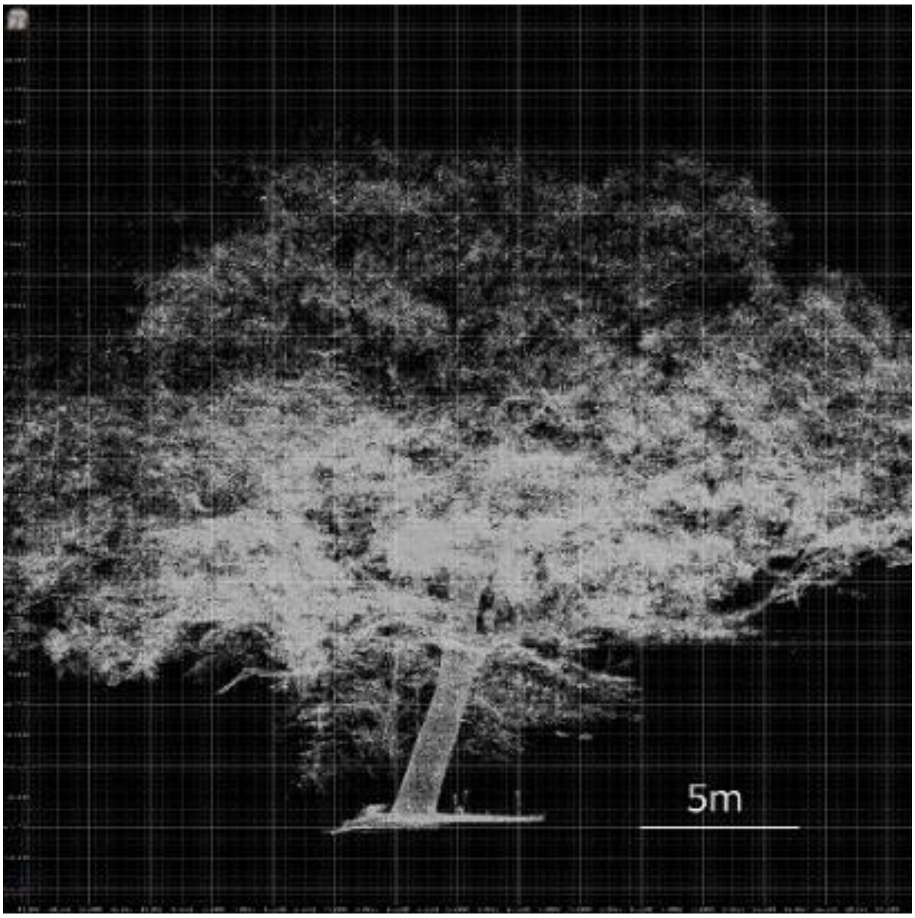

Figure2-6 Hijiyama *Cinnamomum camphora*

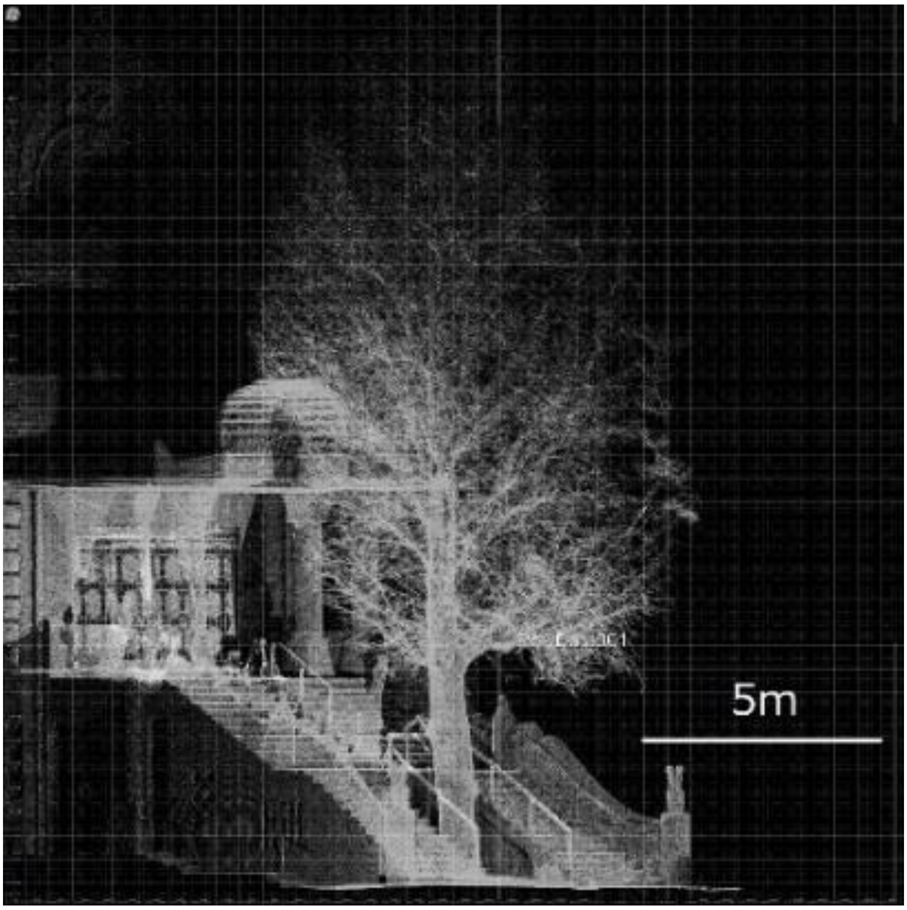

Figure 2-7 Hosenbo *Ginkgo biloba*

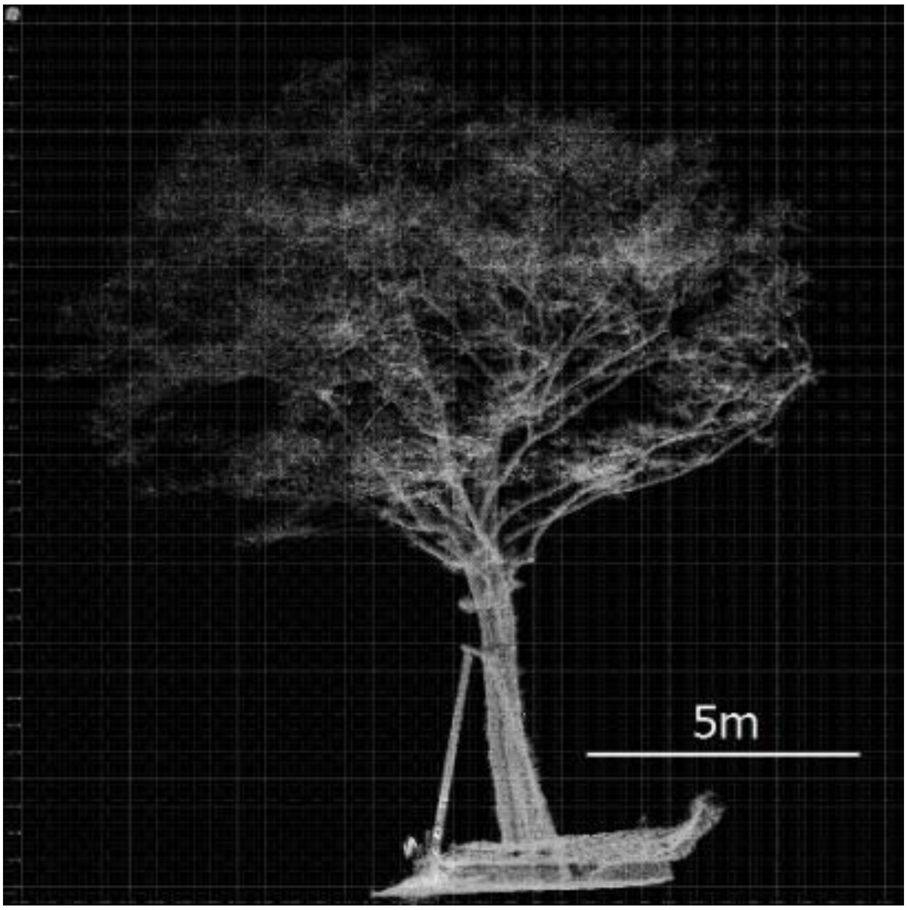

Figure 2-8 Noborimachi *Celtis sinensis var. japonica*

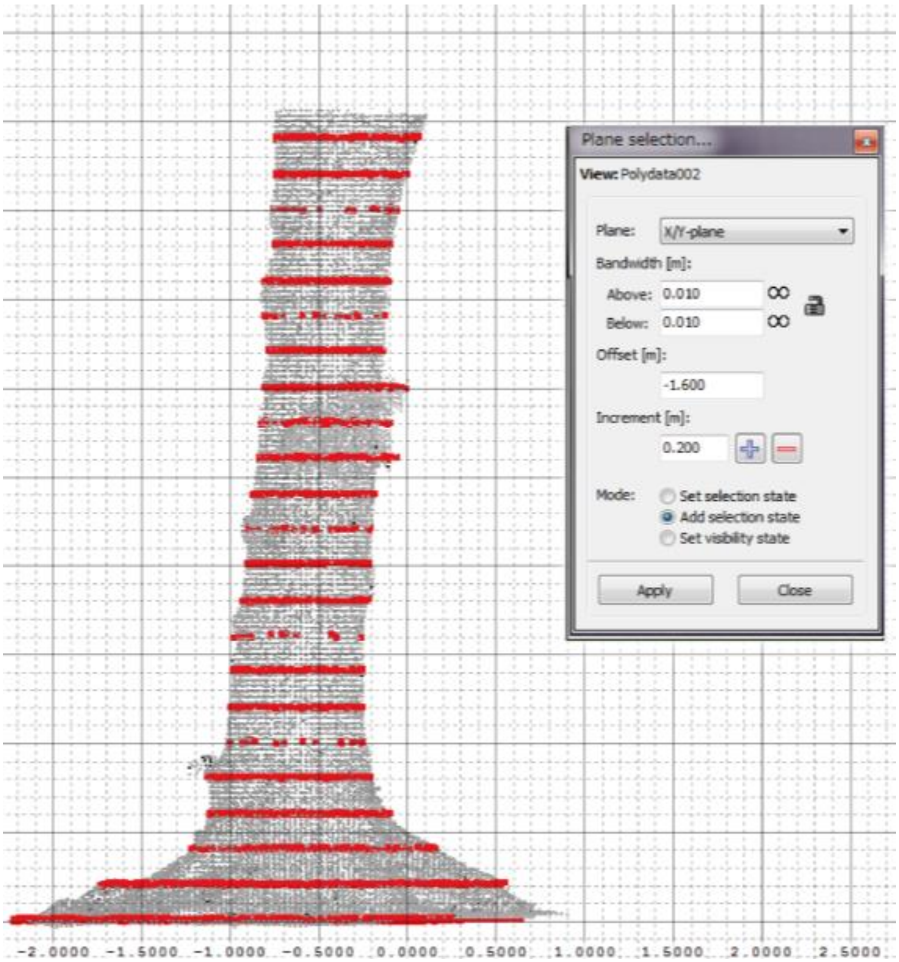

Figure 3　Extraction of the main trunk cross-section

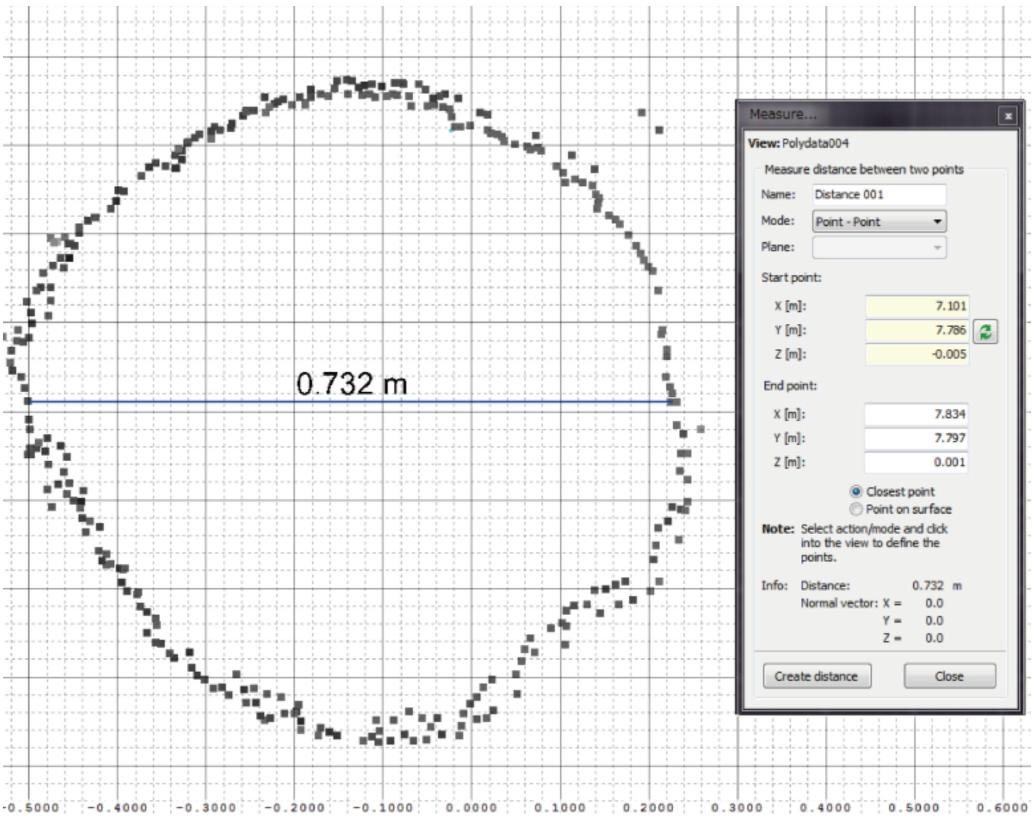

Figure 4　Measurement of point cloud coordinates

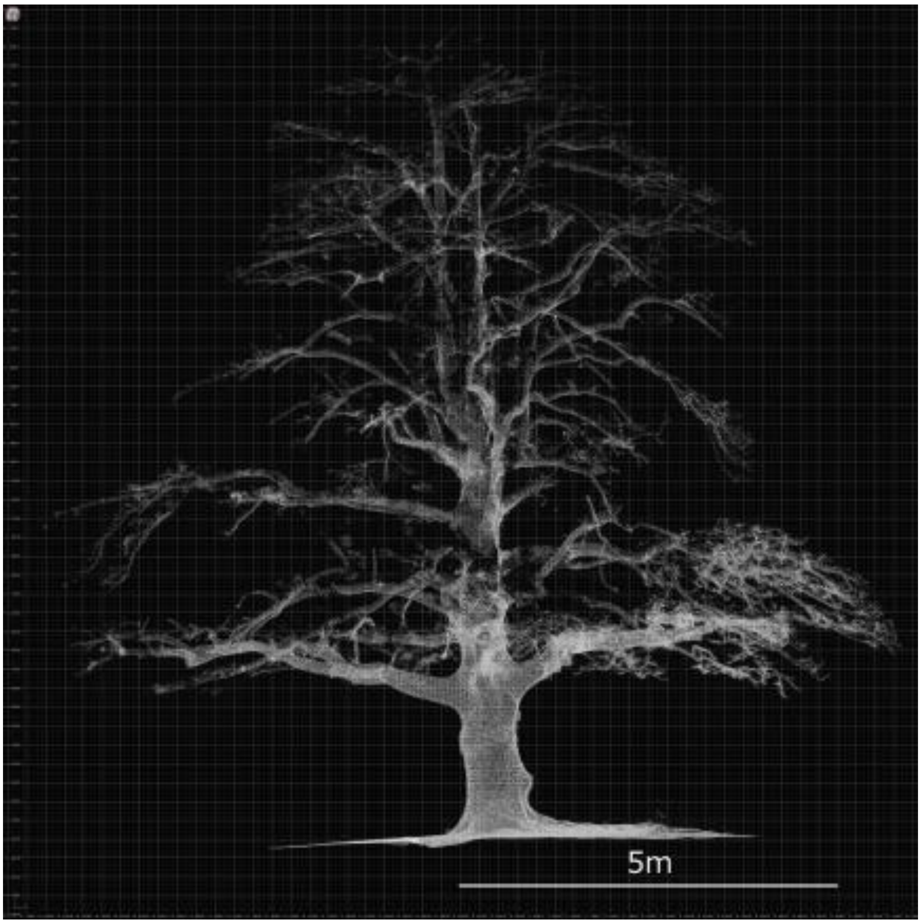

Figure 8-3　Measurement of point cloud coordinates

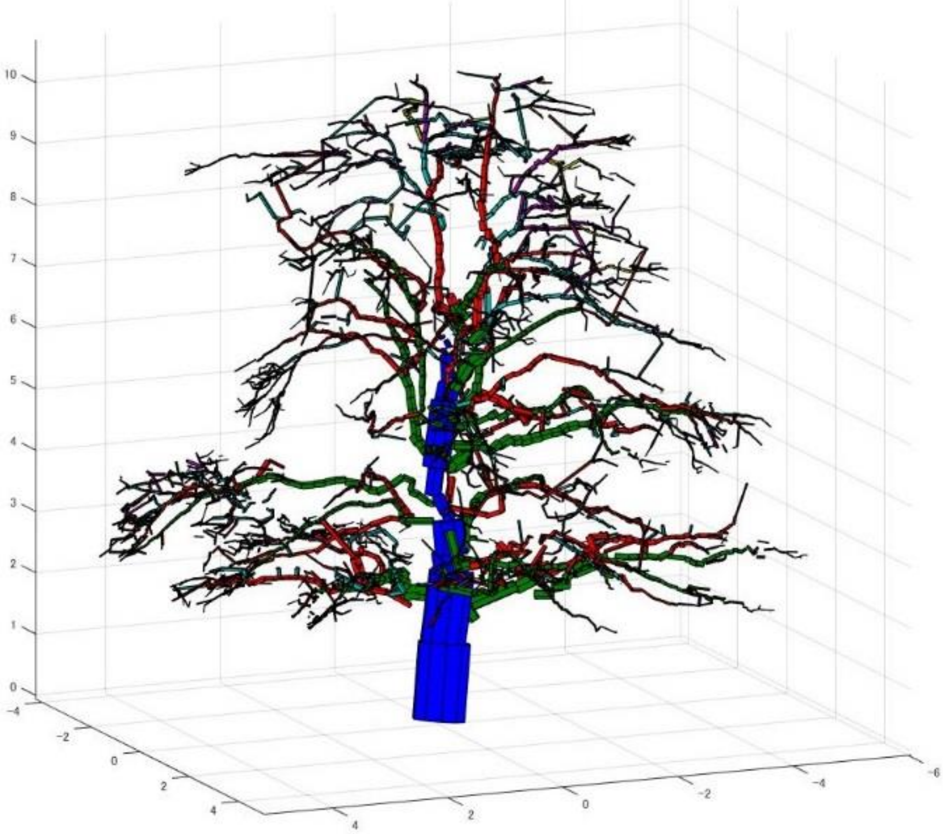

Figure 9-2　Cylindrical Models　*Ilex rotunda*

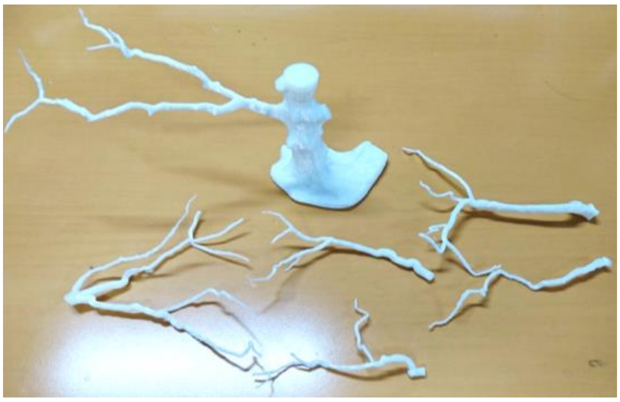

Figure 12-① Parts printed by a 3D printer

Ilex rotunda
in Hiroshima Castle

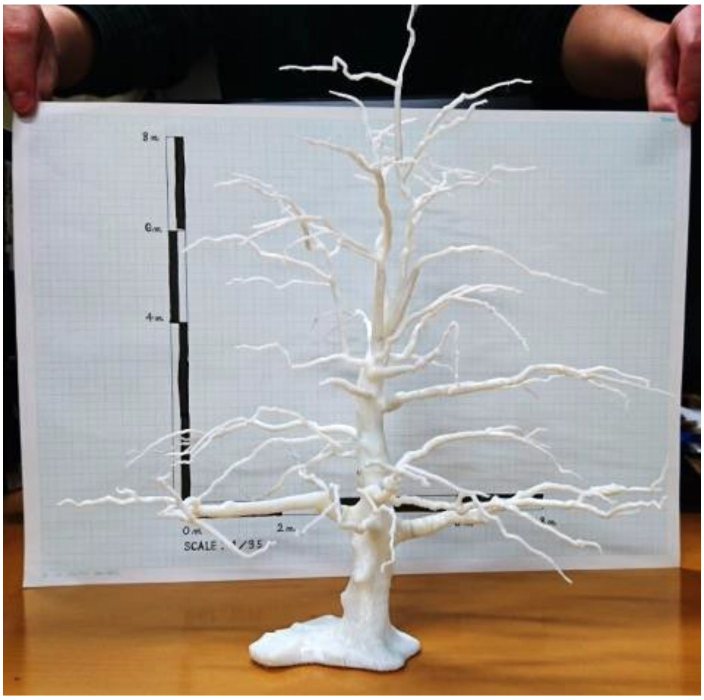

Figure 12-③ Completion of the 3D tree model

Figure 13 Verification of tilt from the model

Research Results Report : Grant-in-Aid for Scientific Research (C) 2017-2023 'Current Status and Issues of Environmental Policy Concerning the Conservation and Utilization of A-bombed trees in Hiroshima and Nagasaki', MasakazuSuzuki, 2023

Research Results Summary

The current status of A-bombed trees (trees certified by the authorities based on various evidences and testimonies) existing in Hiroshima and Nagasaki was measured using the latest 3D laser measurement technology. The results revealed that these A-bombed trees continue to preserve and inherit the reality of atomic bomb damage within the urban sprawl, even today, and that conserving them for future generations contributes to peace education and peace tourism. However, these trees are merely recognized by the cities of Hiroshima and Nagasaki, and are managed by various entities such as shrines, temples, parks, roads, and individuals, with virtually no legal protection. There have indeed been instances where trees were mistakenly cut down. The study discusses the direction of designating these groups of A-bombed trees as nationally recognized cultural properties for preservation, and based on these research results, recommendations were made to both cities.

Academic and Social Significance of the Research Results

Compared to the presence of atomic bomb survivors, the existence of A-bombed trees is relatively unknown globally. The significance of this research lies in 1) grasping and communicating to the world the status of A-bombed trees in Hiroshima and Nagasaki, offering a different perspective from the testimonies of survivors through various disseminations of the research findings. 2) Each of these A-bombed trees preserves the reality of the atomic bomb damage at specific urban locations, and to objectively understand this, the trees were meticulously modeled in 3D using a laser scanner. 3) Discovering issues in the conservation status of A-bombed trees and considering strategies to preserve and inherit their value as international heritage of the atomic bombing. The study concludes that moving from mere 'recognition' by the two cities to some form of 'cultural property' designation by the nation is necessary.

1. Background at the Start of the Research

Post-war research on the atomic bombing was significantly restricted by the General Headquarters (GHQ) press codes after World War II, and continued to be repressed even after the end of the occupation policy due to the influence of the Cold War. As of October 15, 2016, there are 7,152 papers containing the keyword "atomic bomb" and 1,777 papers on "bombing victims" listed in CiNii, a database for Japanese academic resources. However, there are only three papers related to "bomb-affected trees" (two of which are by the research representative), indicating that they are barely recognized as a subject of research.

Over 70 years have passed since the war, and it has become difficult to directly inherit experiences from the bombing survivors, increasing the significance of bomb-related materials and heritage. Aside from the World Heritage site of the Atomic Bomb Dome, many other bomb-affected buildings have been registered and recognized, and preservation and utilization efforts are underway. In Hiroshima City, about 170 bomb-affected trees are registered, and about 30 in Nagasaki City. The responsibility for these trees lies with various entities: the national, prefectural, and city governments, shrines and temples, and private owners, each with different methods of conservation management. In Nagasaki City, there are concerns about the survival of privately owned bomb-affected trees.

The current research representative has clarified, through previous studies, that bomb-affected trees have unique significance as bomb heritage, which is not shared by bomb-affected buildings. However, this recognition is not widely shared by the municipal authorities of both cities. It is urgent to clarify the future approach to the preservation and utilization of bomb-affected trees, based on legal and administrative assurances, to carry out international environmental policies.

The research representative first became aware of the existence of bomb-affected trees during a landscape survey of Hiroshima's Shukkeien Garden in 2009. Subsequently, the inclination angles and directions of about 30 untransplanted single-stem bomb-affected trees were measured. Almost all are inclined in the direction of the hypocenter. It is presumed that the different degrees of damage caused by the heat rays received at the time of the bombing have resulted in abnormal tree shapes due to the accumulated growth differences over approximately 70 years. The "group of bomb-affected trees" scattered throughout the city, centered on the hypocenter, are valuable bomb heritage that represent both the regeneration from atomic bomb damage and the enduring aftereffects in real time. Moreover, it has become clear that bomb-affected trees should be categorized into several types based on their characteristics. When conserving and utilizing bomb-affected trees according to their individual characteristics, it is essential to consider academic studies as well as educational, tourist, and design elements, including environmental policy considerations.

2. Objectives of the Research

The content to be clarified in this study is wide-ranging, but ultimately, by synthesizing them, the aim is to re-evaluate the significance of bomb-affected trees as atomic bomb heritage common to Hiroshima and Nagasaki and to contribute to the future preservation and utilization of these trees. The specific objectives are as follows: (1) Identification of individual bomb-affected trees, elucidation of attribute information, and classification. (2) Elucidation of the spatial distribution of bomb-affected trees. (3) Clarification and visualization of the shape characteristics of bomb-affected trees. (4) Discovery and registration of undiscovered and unregistered bomb-affected trees. (5) Examination of legal and administrative guarantees for the conservation of bomb-affected trees. (6) Clarification of the characteristics of bomb-affected trees as bomb heritage and consideration of preservation measures. (7) Examination of utilization measures for bomb-affected trees.

3. Research Methods

(1) Confirmation of the bomb-affected trees for study and visualization as spatial information, including the current status and surrounding environment: Currently, bomb-affected trees are numbered by location, ranging from one individual of one species to multiple individuals of multiple species. Individual identification is not performed. Therefore, for

bomb-affected trees already registered in Hiroshima and Nagasaki cities, unique numbers will be assigned, and attribute information, which will serve as the basis for future surveys, will be observed, measured, recorded, and organized. In doing so, the interrelationship between the bomb-affected trees and their surrounding environment will also be clarified.

(2) Classification based on the attributes of bomb-affected trees: Although referred to collectively as "bomb-affected trees," these include trees that were transplanted after the war and preserved, those that survived in place without transplantation, those that lost all above-ground parts immediately after the bombing and regenerated from underground parts, those that retain injury marks on their above-ground parts, and those that have produced seeds or saplings for distribution. The significance of these trees as atomic bomb heritage differs based on these attributes, yet no distinction has been made. Hence, bomb-affected trees will be classified based on various attribute distinctions, and their biological characteristics and their nature as atomic bomb heritage will be considered.

(3) Precise measurement of inclined bomb-affected trees: To grasp the precise shape of bomb-affected trees that are significantly inclined toward the hypocenter, target trees will be selected, conditions for external diagnostic surveys will be set, and three-dimensional modeling will be conducted using laser scanners. This is an essential task when registering as cultural properties.

(4) Discovery of undiscovered and unregistered bomb-affected trees: Clarify the criteria for distinguishing bomb-affected trees from healthy trees. There are many uninvestigated forests within 3 km of the hypocenter in Nagasaki City, where there is a high possibility of undiscovered bomb-affected trees. These areas will be selected using GIS, and on-site surveys will be conducted upon obtaining survey permission from the landowners.

4. Research Results

The research conducted is not seeking a single solution but is advancing various phenomena simultaneously. The progress of the research and its results are presented in sequence. The final summary will be published as a book.

(1) Classification of Bomb-Affected Trees: The bomb-affected trees were classified by species, basic tree form, transplantation status, and degree of damage. This clarified the necessity to consider the heritage significance of bomb-affected trees individually, as it varies by type.

(2) Precise Measurement of Bomb-Affected Trees: Several representative bomb-affected trees were selected for measurement with a 3D laser scanner. This allowed for the reproduction of bomb-affected trees with a few centimeters resolution and the estimation of the inclination direction and gradient from the geometric center of cross-sectional point clouds. This confirmed the earlier simple survey results that some types of bomb-affected trees are inclined toward the hypocenter. Furthermore, 3D printing was used to construct a three-dimensional model based on 3D laser scanning data.

(3) Discussions were held with Hiroshima City Hall administrative sections on incorporating bomb-affected trees into peace tourism and examining the direction of future bomb-affected tree conservation measures.

(4) The Nobel Peace Prize awarded to ICAN in 2017, related to nuclear abolition, increased international interest in bomb-affected trees. With the cooperation of the researchers, the planting of a second-generation bomb-affected tree sapling in the United Nations headquarters' front yard by the UN Secretary-General and the presentation of second-generation bomb-affected tree seeds to the University of Oslo by the Mayor of Hiroshima and Nagasaki as a ceremony the day before the Nobel Peace Prize ceremony were realized.

(5) The research status regarding bomb-affected trees was explained to the Cultural Properties Division of the Agency for Cultural Affairs, and a common understanding of the necessity for a national positioning regarding the significance and conservation of bomb-affected trees as atomic bomb heritage was reached. However, coordination with local administration is essential for cultural property recognition of bomb-affected trees, and it

became clear that consensus on whether they fit within the framework of historic sites, places of scenic beauty, or natural monuments is needed. This matter has been informed to Hiroshima and Nagasaki cities, and continuous consideration has been requested.

(6) 3D laser scanning measurements of bomb-affected trees at Noboricho Junior High School and Hokoku Shrine in Hiroshima City were performed. Based on this data, a 3D print prototype was tested, and discussions were held on the potential use for peace education with the Hiroshima City Peace Promotion Department, the Hiroshima Peace Memorial Museum, and the Peace Memorial Hall. Related papers were published in the Journal of the Japan Society of Photogrammetry and Remote Sensing and received the Paper Encouragement Award.

(7) Participated in the "Bomb-Affected Trees Symposium" organized by the Japan Botanical Garden Association at Hiroshima Botanical Park and exhibited the research results of bomb-affected trees. Interviewed by Chugoku Shimbun, and a special feature on bomb-affected trees was prominently reported on the front page.

(8) Information exchanges with Nagasaki City's Atomic Bomb Countermeasures Division and the Nagasaki Atomic Bomb Museum confirmed that the current status of recognized bomb-affected trees is inadequately understood and requires careful examination. Further strategies for the survey of undiscovered and uncertified bomb-affected trees were discussed. It became clear that a common understanding of bomb-affected tree preservation measures is necessary between Hiroshima and Nagasaki. Interviewed by the Asahi Shimbun Nagasaki Bureau, and an article about the measurement of bomb-affected trees at Fuchi Shrine was published. A preliminary survey for 3D laser scanning was conducted on bomb-affected trees in Nagasaki City.

(9) As a result of the research meeting on war heritage with Tokyo University of Agriculture and Meiji University, a method was developed to simultaneously measure the interior and exterior of bomb-affected trees using equipment owned by each university.

(10) Interviewed by the Chugoku Shimbun over the phone about the challenges of preserving bomb-affected trees, and the research was introduced on the full page 12 of the Peace section in the morning edition on 2019.01.07.

(11) Supervised the academic part of an illustrated book about bomb-affected trees titled "The Voices of the Trees" produced by a housewives' group in Hiroshima City, inspired by this research. The production process was covered by Hiroshima TV and broadcasted for about 10 minutes on TSS Prime News on 2019.07.30.

(12) Conducted simultaneous internal acoustic diagnostic measurements and external 3D laser scanning of the Tokyo air raid war-damaged Ginkgo at Tobiki Inari Shrine in Tokyo, in collaboration with a researcher of war-damaged trees. This was the first academic attempt at three-dimensional internal and external simultaneous measurement of trees. The situation was covered by Tokyo Shimbun, with articles published in the evening edition on 2019.08.14 and the morning edition on 2019.08.26. The commonality of war-damaged trees and bomb-affected trees as war heritage was considered, and the importance of preserving war-damaged trees was explained to visiting Sumida City officials.

(13) Conducted field surveys of trees affected by the Great Fire of Hakodate, and considered the commonalities and differences between these broadly defined disaster-affected trees and bomb-affected trees and war-damaged trees.

(14) Performed 3D external morphological measurements of bomb-affected trees in Nagasaki City with a laser scanner. The situation was covered by NHK Nagasaki and broadcasted for about 8 minutes on Evening Nagasaki on 2019.09.20.

(15) Conducted a survey of unregistered presumptive bomb-affected trees with a curator of the Nagasaki Atomic Bomb Museum.

(16) At the Kanto Branch Conference of the Japan Institute of Landscape Architecture (Chiba University) on 2019.11.23-24, a poster presentation on

the survey results in Nagasaki and an oral presentation on laser measurement in Hiroshima and Nagasaki were made.

(17) A peer-reviewed paper on 3D models of bomb-affected trees was published in the Journal of the Japan Society of Photogrammetry and Remote Sensing, which received the 30th Applied Surveying Encouragement Award. An overview was published in the August 2019 issue of "Surveying" as the winning paper.

(18) "Towards Ground Zero" by Masakazu Suzuki, Yoichi Kunii, Hirotsugu Kanno was published in the British research introduction magazine impact, RESEARCH IN A GLOBAL EMERGENCY, MAY 2020, p45-47, informing the international community about the current state of bomb-affected tree research.

(19) At the National Conference of the Japan Institute of Landscape Architecture 2020.5, a poster presentation "3D measurement and comparison of changes over time for A-bombed trees in Hiroshima and Nagasaki using TLS" by Koga Daisei, Kunii Yoichi, and Suzuki Masakazu was made, objectively expressing the aging changes of bomb-affected trees.

(20) At the special exhibition "Bomb-Affected Trees Exhibition: The 75th Year Record" held at Hiroshima Botanical Park from 20201031 to 20201210, a display "Progress in bomb-affected tree research using 3D data" by Kunii Yoichi, Koga Daisei, and Suzuki Masakazu, A1 panel in three parts was exhibited. Approximately 17,000 visitors attended during the exhibition period, conveying the significance of bomb-affected trees to the general public.

(21) At the 2020 Kanto Branch Conference of the Japan Institute of Landscape Architecture 2020.11 (WEB-held), "Research on 3D measurement of bomb-affected trees using TLS and extraction of abnormal tree shapes" was presented. It demonstrated that the morphological abnormalities of bomb-affected trees persist even after 75 years post-war.

(22) On 2020.12.10, a WEB class on peace education through bomb-affected trees was conducted by Gautesete Junior High School in Norway, connecting with a high school in Israel and the NPO Ant-Hiroshima in Hiroshima, with

the applicant introducing and explaining photos of bomb-affected trees from home. By connecting Norway, Israel, and Japan on the day of Nobel Peace Prize ceremony and having junior high and high school students lead discussions on peace education through bomb-affected trees, it demonstrated that bomb-affected trees can serve as a medium for peace education regardless of nationality or age. At the same time, exchanges between botanical gardens in Norway and Japan are progressing.

(23) To increase social interest in bomb-affected trees, current photographs of bomb-affected trees in Hiroshima and Nagasaki taken during the research process were edited and electronically published as "The Portraits of Hiroshima & Nagasaki Bomb-Affected Trees" by Masakazu Suzuki, 2021,1-35pp, on Kindle via Amazon on August 6, the anniversary of the atomic bombing. The book was downloaded from Japan, the United States, Germany, and Mexico.

(24) While issues concerning the national designation of bomb-affected trees as cultural properties have been raised with the cities of Hiroshima and Nagasaki, direct discussions have been difficult due to the COVID-19 pandemic. Research on atomic bomb-related literature and materials is being conducted to meet the requirements for designation as cultural properties, with a continuously produced literature list including reviews.

(25) Viewing the conservation of bomb-affected buildings and bomb-affected trees as integral, the preservation of the former Hiroshima Army Clothing Depot brick warehouse was considered based on suggestions made to the Governor of Hiroshima Prefecture, and an opinion on the preservation and utilization of the Hiroshima Army Clothing Depot and bomb-affected trees was posted on the citizen's activity group website HihukushoLAB. The media's interest and public awareness increased, changing Hiroshima Prefecture's policy from demolition to preservation and use. Currently, the prefecture is planning a large-scale workshop for citizen-participated conservation and utilization, for which materials have been provided.

(26) Contributed materials to the "Bomb-Affected Trees Exhibition: The 75th Year Record" at Hiroshima Botanical Park, and the records were

published in the Hiroshima Botanical Park Cultivation Record No. 42, 2021, p1-4.

(27) At the "Kenzo Tange Pavilion" Exhibition at the Harvard Graduate School of Design, "Dialogue for Our Future of Planet Earth: Isamu Noguchi's Peace Monument and A-bombed trees" was held, and the photograph work "When We Wish upon a Starry Night" was invited to be exhibited, raising awareness of bomb-affected trees in the United States.

(28) In Hiroshima City, due to a communication breakdown between the prefecture and city, one of the bomb-affected trees was mistakenly felled. An article about the incident was published in the Tokyo Shimbun on 20230422. The importance of establishing the cultural property status for the preservation of bomb-affected trees was re-recognized.