2. 発表論文等

第2章に掲載した論文等は各団体から転載の許可を得て掲載しております。

なお、著作権は各団体に帰属するため、転載を禁じます。

2. 発表論文等については、1.研究成果の1.1、1.2、1.3、1.4の分類順、さらに、細分類内で発表年月順に掲載した。

2.1 論文・技術報告等

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2）Site fidelity in lineages of mixed-species heron colonies……39

樹木医学会
樹木医学会第22回大会講演要旨集（2018）22（2）：93-94

速報

事例にみる街路樹の点検・診断の現状

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I. はじめに

街路樹は，植栽後から長期間経過したことにより大径木化・衰弱化が見られるものが増加し，台風などの強風時には一部に倒伏や落枝による交通障害などを起こしている．このような状況の中で，街路樹整備に関する技術的指針である「道路緑化技術基準」が平成27年3月31日に改正され，道路交通の障害などを未然に防止しつつ街路樹に求められる機能を総合的に発揮させるために必要となる安全点検が具体的に位置づけられた．しかし，街路樹の点検・診断方法は，道路における街路樹の位置づけ（求める緑化機能）や植栽環境，管理体制や予算規模，地域によっては住民感情などにより大きく左右され，一律に決められるものではない．そのため，道路管理者が今後事業化を図る際の参考となるよう先進事例について調査し，点検・診断方法の類型化を行い，実施項目，体制等について整理，把握した．

II. 調査方法

調査は，全国から抽出した街路樹の点検・診断に取り組んでいる道路管理者（表–1）に対してアンケートとヒアリング形式により行った．調査内容は，①基本的事項として点検目的，方針，マニュアル等の整備状況，②点検・診断方法として点検項目，点検票，③体制として点検手法，点検者資格要件，頻度，そのほかに異状木の措置，精度確保策，実施の効果等とした．

III. 結果と考察

表–1. 調査対象とした道路管理者と点検・診断

	道路管理者	街路樹本数	開始年度	契機となった障害
ヒアリング調査	札幌市	約22万本	H24	ポプラ倒伏など
	仙台市	約5万本	H22	ケヤキ倒伏
	東京都	約60万本	H10	ケヤキ倒伏
	東京国道事務所	約2.2万本	H24	−
	神奈川県	約1.6万本	H27	近隣での倒伏
	京都市	約4万本	H22	−
	大阪市	約16万本	H27	ケヤキ倒伏
	吹田市	約0.9万本	H26	−
	尾道市	約0.2万本	H26	近隣での倒伏
	福岡市	約5.5万本	H24	ケヤキ倒伏
アンケート調査	帯広市	約3万本	H25	−
	横浜市	約13万本	H26	ユリノキ倒伏
	相模原市	約1.2万本	H20	不明
	新潟市	約3.6万本	H27	不明
	名古屋市	約10万本	H14	プラタナス倒伏
	西宮市	約2.2万本	H27	近隣での倒伏
	広島市	約3.6万本	H27	−
	日田市	約0.1万本	H27	ケヤキ倒伏
	那覇市	約1.3万本	不明	−

*札幌市と東京国道事務所は現行の点検・診断の改定年度.

街路樹の点検・診断は，平成10年度に東京都が着手したのを始まりとして，最近の10年間にはポプラ，ケヤキ，ユリノキ，プラタナス等の倒伏を契機に，大都市を中心に拡がった（表–1）．道路管理者は点検では通常巡回・定期巡回・異常時巡回をして，診断では簡易診断，腐朽率等の機器診断を含む樹木健全度調査，植栽環境調査，剪定等の作業時における異状確認などを行っている．これらを類型化すると，管理対象となる街路樹の位置づけ及び樹種や樹形，植栽環境，予算規模等に応じて，主に点検･診断の実施内容と実施者の違いにより，詳細型・標準型・簡易型の3タイプとなった（表–2）．実施にあたっての指針やマニュアル類としては，管理者独自で策定されているもののほか，先行自治体のものが活用されていた．点検･診断の実施者としては，自治体などの職員（造園，土木），緑地管理業者，樹木医が選定されており，

Yasuo Iizuka[1,*] and Satoshi Funakubo[1]（2018）**A case study on the current state of inspection and diagnosis of street trees.** Tree and Forest Health 22：93～94

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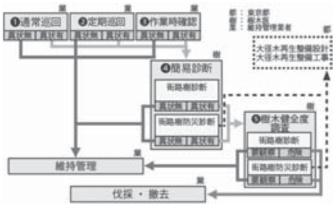
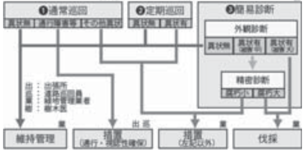
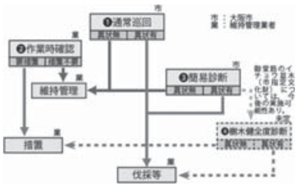
※樹木医学会は記事中の材料および方法を個別に推奨するものではありません．本記事は樹木医学会第22回大会におけるポスター発表の内容です．

表–2.　類型別の街路樹点検・診断の内容方法，手順，診断項目

<table>
<tr><th>類型</th><th>Ⅰ：詳細型</th><th>Ⅱ：標準型</th><th>Ⅲ：簡易型</th></tr>
<tr><td>診断内容</td><td>樹木医などの専門家による
樹木健全度調査</td><td>樹木医などの専門家による簡易診断</td><td>職員による簡易診断</td></tr>
<tr><td>道路管理者</td><td>仙台市，東京都，神奈川県，京都市，吹田市，福岡市，横浜市，相模原市，新潟市，名古屋市，西宮市，広島市</td><td>札幌市，東京国道事務所，日田市</td><td>帯広市，大阪市，尾道市，那覇市</td></tr>
<tr><td>診断手順の例</td><td>◌東京都の例

</td><td>◌東京国道事務所の例

</td><td>◌大阪市の例

</td></tr>
<tr><td>診断者と主な診断項目の例</td><td>◌東京都の例
【簡易診断／樹木医】
樹皮枯死欠損･腐朽，開口空洞，キノコ，木槌打診（異常音），傾斜，揺れ，落枝の危険性，病虫害，鋼棒貫入異常，建築限界超え，その他（分岐部の異状，頂端切除，巻き根，治療痕等），その他特記事項等.
【樹木健全度調査／樹木医】
上記項目と併せて樹勢，樹形，活力判定，分岐部・付根の異状，胴枯れ等の病害，虫穴・虫フン・ヤニ，根元の揺らぎ，ルートカラー，露出根被害，不自然な傾斜，腐朽空洞率等.</td><td>◌東京国道事務所の例
【簡易診断／樹木医】
樹木形状（樹木番号，樹種名，樹高，幹周，枝張り），活力状況（樹勢，樹形，不自然な傾斜），被害・異状箇所の記録（枝の欠損，幹・根株の欠損），特記事項（記入項目以外で確認された異状），処置・対応（被害程度の評価，必要な処置の判断，対応方法），精密診断（腐朽・空洞等の測定（実施するケースはほとんどみられない））.</td><td>◌大阪市の例
【簡易診断／職員】
全木：樹勢，通行障害等.
異状が確認された樹木：樹体の異状（空洞，腐朽，亀裂，子実体，打診音異常，鋼棒貫入異常，樹体の揺らぎ，病虫害），活力状況（樹勢）.</td></tr>
</table>

点検・診断精度の確保として実施要領などの作成や講習会・研修会の開催，複数人による点検・診断等が行われていた．点検・診断結果を受けた措置は，主に剪定と伐採で，補植される場合もあった．実施の効果としては，倒伏などによる事故が減少したという回答があった．点検・診断結果は，倒伏・落枝を未然に防止する措置を決定するための根拠として利用されるほか，データベース化して新たな管理方針策定への活用などに展開したい意向があるものの，組織の人員や予算などの制約から実施までには至っていない現状がうかがえた．

Ⅳ．まとめと今後の課題

街路樹の点検・診断が実施されていることにより，倒伏・落枝による交通障害などは減少しているものの，点検・診断結果は伐採の可否を判断するためだけの根拠として活用されていることがほとんどであった．そのため，樹木医などの資格を持たない職員でも，点検・診断前の研修と試行経験により樹体の構造的な弱点（以下，弱点とする）を認識でき，街路樹の危険性を排除することが可能となっていた．

街路樹診断は，開始されてから20年程度経過するなかで，診断項目の固定化や診断機器の普及が進んでおり，樹木医などの有資格者に限らず行えるものになりつつある．そのなかで，景観向上，緑陰，環境保全などの街路樹の機能を発揮させるには大きいことも重要で，健康に長寿化させる管理方法の基礎データとして点検・診断結果を活用すべきである．さらに，蓄積された点検・診断データにより示すことが可能な不健全となりやすい樹種や樹齢などの特徴は，点検・診断の計画立案時における実施時期や優先樹種，診断項目等の設定に活用することで，街路樹の点検・診断の高度・効率化に繋げることが求められる．また，弱点というマイナス評価により伐採の可否に終始しがちな点検・診断に，弱点を補強する構造の評価や街路樹本来の機能などのプラス評価を加え，積極的な保全措置を検討すべきである．

引 用 文 献

国土交通省（2015）「道路土工構造物技術基準」の制定及び「道路標識設置基準」，「道路緑化技術基準」の改正について．http://www.mlit.go.jp/report/press/road01_hh_000495.html（2017年12月14日閲覧）

（2017年12月15日受理）

Site Fidelity in Lineages of Mixed-species Heron Colonies

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Abstract.—As heron and egret colonies are sometimes abandoned due to human activity and subsequently newly established at nearby locations, colony locations *per se* cannot represent colony fates. Here, "colony lineages" were traced by connecting short-distance location shifts between colony sites in consecutive years to quantify the site fidelity of heron colonies themselves rather than the breeding-site fidelity of individuals. Site fidelity of 61 colony lineages recorded from 1963 to 2013 in and around Ibaraki Prefecture, Japan, was evaluated by persistence periods with survival analysis and shapes of historical trajectories by applying the correlated random walk analysis. While 36% ($n = 22$) of colony lineages did not show site fidelity and lasted only 1 year or indicated untangled shapes of historical trajectories, 64% ($n = 39$) of colony lineages exhibited site fidelity by reusing the same locations for multiple years or by staying within a small area with entangled shapes of historical trajectories. Even though suitable breeding sites were abundant in the study area and site fidelity of colony members was low, a high rate of site fidelity in colony lineages may be achieved when a few faithful pioneer herons and egrets are followed by many others.

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Key words.—Ardeidae, colony lineage, correlated random walk, egret, heron, site fidelity, trajectory.

Waterbirds 41(4): 355-364, 2018

Breeding-site fidelity is common to most bird species that form colonial breeding sites (Cézilly *et al.* 2000; Bried *et al.* 2003). Colonial herons and egrets (Ardeidae) can form colonies on trees, bushes, reeds and the ground in inland areas, and their colonies often persist at the same locations for many years (Kushlan and Hancock 2005). However, some heron colonies exist for only one or at most a few years, and others shift to neighboring locations (Bancroft *et al.* 1988; Kelly *et al.* 2007). Such colony abandonment and relocation are sometimes caused by human disturbance because the noise and unpleasant odors of heron colonies can be disagreeable and annoying for residents when they are located near residential areas (Hafner 2000; Telfair *et al.* 2000; Parkes *et al.* 2012).

Solving such conflicts between human residents and avian breeding colonies requires knowledge of how these colonies are formed and persist at specific locations. Research on species distribution and habitat selection may provide insights into the development of appropriate ecological approaches for tackling these problems (Parkes *et al.* 2012), but research has conventionally focused on the philopatry or site fidelity of individuals within persisting colonies (Atwood and Massey 1987; Aebischer 1995; Vergara *et al.* 2006). However, avian colonies are often formed with individuals that are not highly philopatric. For example, the frequency with which individual herons and egrets return to their natal or previous breeding locations was 55% at most (Fernández-Cruz and Campos 1993; Melvin *et al.* 1999; Fasola *et al.* 2002). These colonies were annual, or only formed during the breeding season within a year. Thus, colonies with site fidelity are reformed with different members annually at exactly the same locations. Moreover, colonies can be relocated to nearby sites when human beings force the birds to evacuate former colony sites by completely destroying nesting resources. For such colonies, the site fidelity of colonies themselves rather than the breeding-site fidelity of individuals can be used to solve conflicts between human residents and colonial avian species.

As colonies are relocated due to human activity and other causes, colony locations *per se* cannot represent colony fates. Therefore, "colony lineages" can be traced by connecting multiple colony sites for each colony history (Garden 1958). Colony abandonment is often followed by the establishment of a new colony at a nearby location, and such new sites should be considered descendants of the abandoned colonies rather than new colonies (Mashiko and Toquenaga 2013). Site fidelity of moving colonies should be defined based on the frequency of relocation, persisting period of each colony site, and the shapes of the trajectories of relocation events.

Our objectives were to quantify the site fidelity of heron colony lineages based on their historical trajectory, or the consecutive movement path of colony sites within a lineage. We analyzed 51 years of colony data for the northern Kanto Plain, Japan. Since the breeding and foraging habitats are homogeneously distributed (Carrasco *et al.* 2014, 2015) and human disturbance occurs frequently in the area, we hypothesized that colony lineages with site fidelity should be characterized by: 1) not one-year but rather multiple-year persistence periods; and 2) not untangled but rather entangled shapes of historical trajectories.

METHODS

Study Area

This study focused on 11,865 km^2 in Japan in a region that included the Ibaraki Prefecture and bordered on the regions of Fukushima, Tochigi, Saitama and Chiba Prefectures in the northeastern part of the Kanto Plain, Japan (35° 53′ N to 36° 54′ N, 139° 41′ E to 140° 49′ E; Fig. 1). The north is mountainous and not suitable habitat for herons and egrets. The remainder of the region is flat lowland with large areas along rivers used for rice production and lotus fields scattered near Lake Kasumigaura. The flooded fields and irrigation ditches support large numbers of foraging herons and egrets (Lane and Fujioka 1998). Breeding habitat was homogeneously distributed here; when we gridded the entire study area into 915-m x 915-m cells, 94.5% of the cells contained at least one pixel (45.7 m x 45.7 m) of trees or bamboo, primarily moso bamboo (*Phyllostachys pubescens*), Simon bamboo (*Pleioblastus simonii*) or dwarf bamboo (*P. chino*), thickets that are potential breeding sites for herons and egrets (Carrasco *et al.* 2014, 2015; Fig. 2). Residential areas were also scattered throughout the lowland, and human disturbance occurs frequently where heron and egret colonies are located adjacent to residential areas (Fig. 2).

Every year, the herons and egrets breed mainly in mixed-species colonies from March to August: Grey Heron (*Ardea cinerea*) arrives first in March; Great Egret (*A. alba*), Little Egret (*Egretta garzetta*) and Black-crowned Night-Heron (*Nycticorax nycticorax*) arrive in April; Intermediate Egret (*A. intermedia*) arrives in late April; and finally, Cattle Egret (*Bubulcus ibis*) arrives by early May. Colony size varied considerably, from approximately four to over 3,000 individuals (Environmental Agency of Japan 1994; Mashiko and Toquenaga 2013). Intermediate and Cattle egrets are summer migrant species, but the other four species are a mixture of residents and migrants in the area, and some individuals winter in this area. Until the early 1990s, some colony sites were also used for roosting by wintering Great and Little egrets from September to February (Anzai 1990); however, since 1995, all colony sites have been used only for breeding by the six species, and all colonies become vacant by October.

Colony Data

Colony sites in the study area from 1963 through 2013 were included. The most intensive surveys were conducted from 1999 to 2013 (annual number of colony sites = 22.0 ± 1.1) during which we obtained colony location data from region-wide aerial and ground-based searches. Aerial censuses were conducted from 1999 to 2000 using aircraft (Fujioka *et al.* 2001) and from 2002 to 2013 with aerial photography using a radio-controlled paraglider (Mashiko and Toquenaga 2013). For ground-based searches, colony sites were found by checking the places in which colonies had been located in previous years, and all colony sites were surveyed at least once in a breeding season. When a colony was abandoned, searches were made to determine whether other colonies had formed nearby. From 1983 to 1998 (annual number of colony sites = 17.5 ± 0.9), we obtained colony location data from ground-based searches (Koshida 2007). We obtained colony location data from local literature and personal communications with local amateur avian observers before 1983 (annual number of colony sites = 3.3 ± 0.5). We also complemented the data with literature and interviews from 1983 and later to minimize the number of colony sites not detected.

Our focus was on colony lineages, and we needed as much documented history for each colony as possible over a long period. Thus, we included all known colony sites since 1963 even though some colonies prior to 1999 may have been undetected. Preliminary examination showed that the results of analyses excluding data prior to 1999 did not differ from those using the entire dataset.

Confirmation of Colony Lineages

To determine colony lineages, first we documented the year and location of establishment, persistence, and abandonment of each constituent colony site. A colony site was deemed abandoned when it was confirmed that no breeding activities were conducted in the following year at the location of the previous year's colony site. A colony site was deemed newly es-

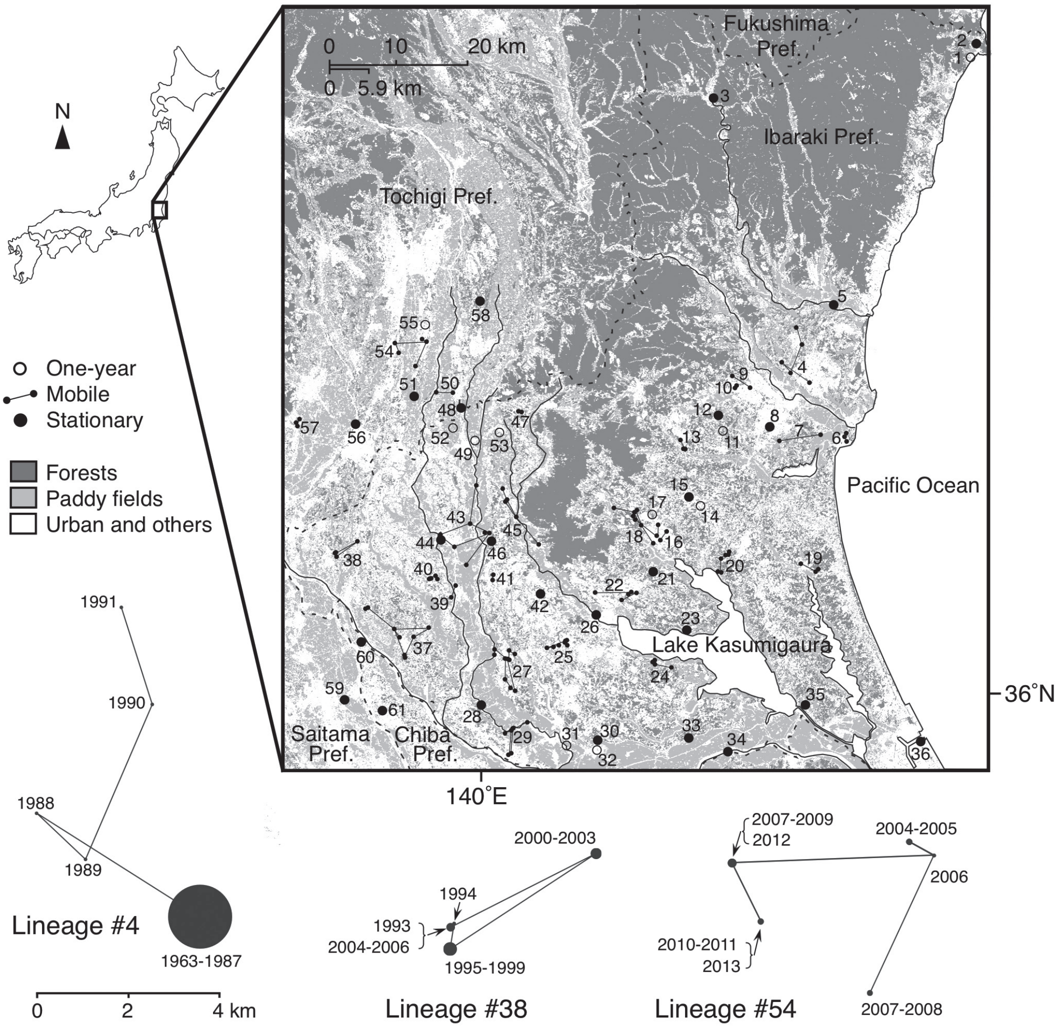

Figure 1. Map showing the location of 61 colony lineages in the study area around Ibaraki Prefecture, Japan, from 1963 to 2013. Broken lines represent prefectural boundaries, and continuous lines represent the main rivers in the study area. Enlarged figures of mobile lineages (no. 4, 38, and 54) showing different shapes of trajectories are included below the map. The diameters of the circles reflect the persistence period of each colony site. Pref. = Prefecture.

tablished when breeding activities were confirmed at a location where there had been no colony in the previous year. When we could not determine the existence of a colony at a specific site in one year (year *t*), we first confirmed its presence in previous years ($t - k$, $0 < k$) as well as in the subsequent year ($t + 1$). If the site's presence could be confirmed both before and after year *t*, it was considered present in year $t - i$ as well where $0 \leq i \leq k$. Conversely, even if the colony was confirmed both before and after the year *t*, when we were able to positively confirm that a colony site did not exist in year *t*, we treated the colony that lasted until $t - k$ and the colony established in $t + 1$ as separate. To determine the persistence period for each colony site, the number of years from the first establishment at a location was counted.

We evaluated colonies based on lineage, rather than the observed colony sites themselves, to account for short-distance location shifts. When abandonment and new establishment occurred in neighboring locations in successive years, the new site was assumed to be a descendant of the abandoned one. This is supported by the behavior of heron and egret individuals at the beginning of their breeding season when they choose their colony site: if a site has become unsuitable for nesting through the natural death of vegetation or human-induced disturbances, herons and egrets first circle above the location of the colony site it had used in the previous year. They sometimes fly away, but at other times they stay on trees nearby and, finally, this nearby location becomes a new colony site (M. Mashiko and Y. Toquenaga, pers. obs.; Fig. 2). To determine a reason-

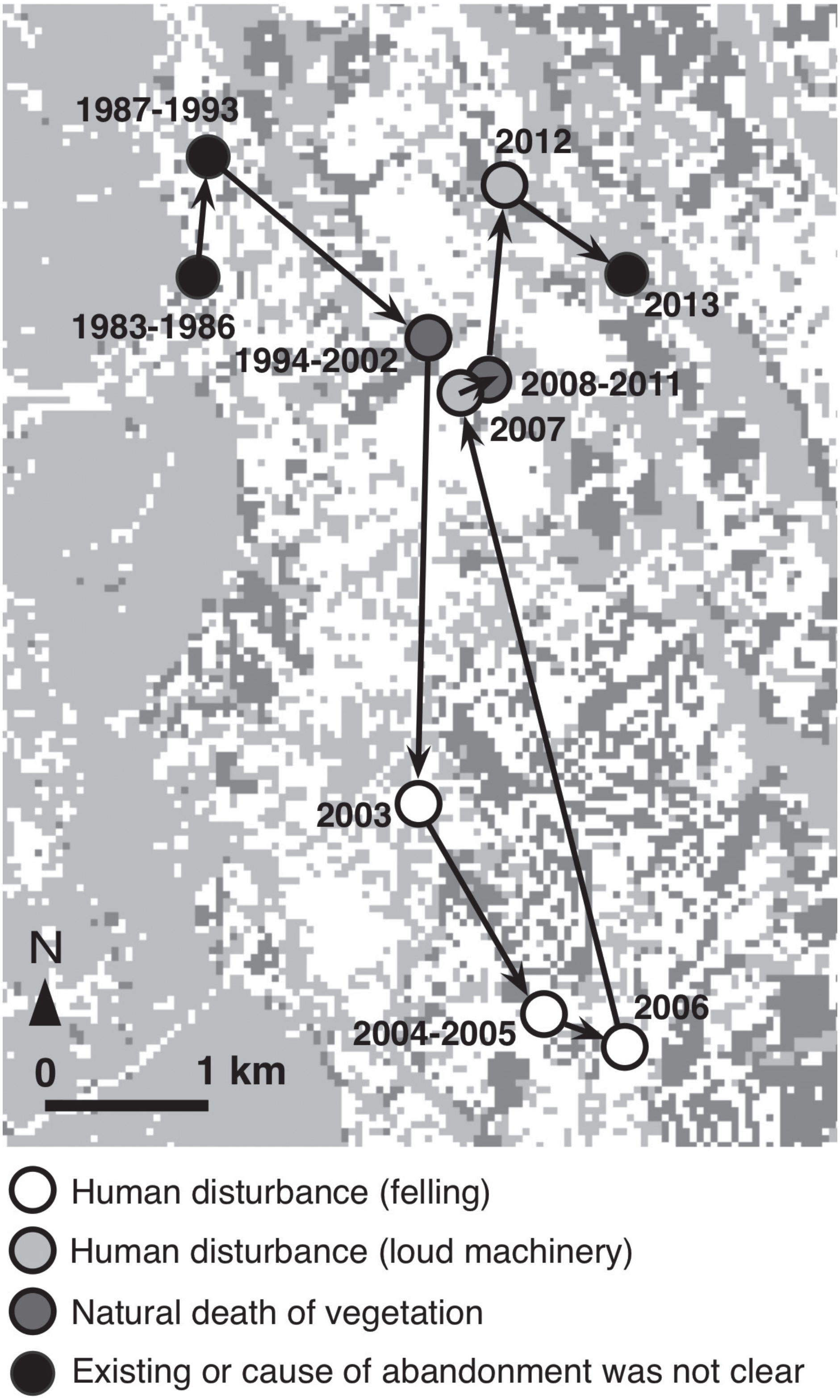

Figure 2. Enlarged map showing trajectory of lineage no. 27 with its observed causes of abandonment of constituent colony sites.

able maximum distance for colony-site shifts included within a single lineage, we calculated mean nearest-neighbor distance from the center of observed colony sites (11.85 ± 1.76 km; 1999-2013), and it was assumed that each colony had a circular domain within which foraging herons and egrets belonged to the colony. The radius of the domain of attraction was set to be half the average nearest-neighbor distance (5.93 km; Mashiko and Toquenaga 2013). Since our focus was site fidelity at the colony level, we defined colony lineages regardless of whether the colony site at year t was composed of the same or different birds at year $t - 1$.

To detect which lineages exhibited site fidelity, we first focused on the persistence periods for lineages and classified them into two categories: "one-year" and "multiple-year". For multiple-year lineages, which may indicate site fidelity, we focused on the number of colony sites that the lineage had used and classified them into two categories: "mobile", which includes at least one location shift, and "stationary". To determine how many lineages in these two categories exhibited site fidelity, we performed the following analyses.

Measuring Site Fidelity of Colony Lineages

For stationary lineages, being stationary alone did not indicate site fidelity. For instance, when we compared site fidelity of a stationary lineage that persisted for 2 years with a mobile lineage that included two colony sites that existed for only 1 year and that persisted for 3 years, it could not simply be determined that the stationary lineage that persisted for 2 years exhibited site fidelity. To examine whether stationary lineages exhibited site fidelity, we compared persistence periods for sites of stationary lineages with those for sites of mobile lineages. Persistence periods for sites of mobile lineages were used as the null expectations for this comparison because if the persistence periods of stationary lineages were shorter than the average of those of mobile lineages, it would be difficult to assert that stationary lineages exhibited site fidelity. Since the datasets for persistence periods contained censored data (an abandonment event of a colony site was not observed before the end of our study period), non-parametric survival curves were estimated for each category with the Kaplan-Meier method in the survival analysis (Kleinbaum 1996). Differences between the curves were evaluated with the log-rank test.

To investigate whether the mobile lineages exhibited site fidelity, we examined colony trajectories (i.e., the consecutive movement path of colony sites within a lineage) by applying a correlated random walk method (Kareiva and Shigesada 1983) at the colony level. Since the shapes of trajectories are considerably different among lineages even if those lineages are composed of the same number of colony sites and movements (e.g., lineages #4 and #38 in Fig. 1), we considered a mobile lineage to exhibit site fidelity if the trajectory remained within a small area (entangled), and to not exhibit site fidelity if the trajectory was increasingly distant (untangled) or intermediate between entangled and untangled (border). To clarify which trajectories were entangled and which were untangled, we developed an index of the distance between a focal point and the last site of a trajectory (DFL), and compared those values to the observed and expected trajectories. DFL is inspired by net squared displacement, which is widely used for analyzing the movement patterns of mammals (Bergman *et al.* 2000) and insects (Brouwers and Newton 2010), as well as growth in plants (Cain 1990).

We calculated the DFL of observed trajectories. The focal point was a location at which the weighted sum of the distances from all given colony sites in a trajectory were minimized. We obtained this point using the *zsummin* function in the statistical program R package *orloca* (Fernandez-Palacin and Munoz-Marquez 2012), which deals with the Fermat-Weber location problem. Weighting was based on the persistence period of each colony site. For each observed trajectory, we constructed 100 expected trajectories by choosing a length and turning the angle randomly from all segments of all mobile trajectories as many times as the length of persistence period of the observed trajectory ($n = 517$, length: ranged from 0 to 5,908.6 m (482.7 ± 53.5 m), turning angle: ranged from −177° to 167.5° (0 ± 1.9°)). When a sampled length or turning angle forced the movement into a body of water or mountainous region (gray regions in Fig. 3), we sampled another length or turning angle so as to construct expected trajectories within a geographical range where colonies could be formed (white regions in Fig. 3). Finally, we compared the observed DFL

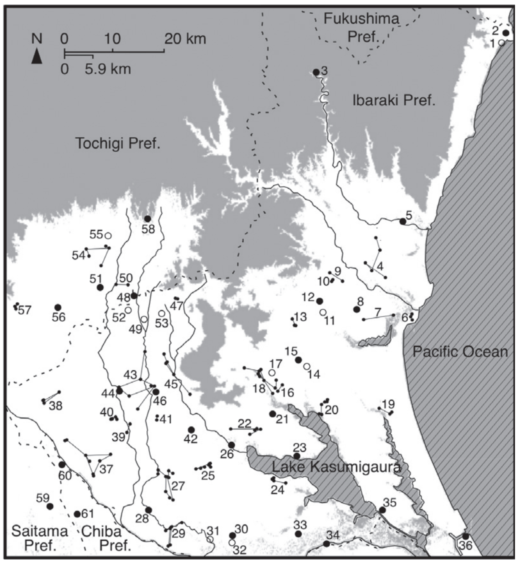

Figure 3. Map showing a geographical range where heron colonies could be formed. For constructing expected trajectories of mobile lineages, white areas indicating lowlands with an altitude of 0 m to 100 m, where heron colonies could be formed in trees and bamboo thickets, were used but gray areas indicating mountainous regions (> 100 m) or deep bodies of water were not used. Pref. = Prefecture.

with the mean DFL of randomized trajectories to examine the entanglement of observed trajectories. We identified entangled and untangled trajectories when the DFL of the observed trajectory was respectively smaller and larger than the 95% confidence limits of those of the randomized trajectories. Trajectories that fell within the 95% confidence limit were classified as border.

Some colony lineages may have multiple trajectories: when a lineage contained more than one colony site in the same year, the trajectory diverged into different paths (e.g., lineage #54 in Fig. 1). Similarly, originally unique trajectories could be joined when colony sites from two trajectories were abandoned in the same year and, in the following year, a single colony site was newly established in a location near both the abandoned sites. However, even if a lineage contained more than one colony site in the same year, we used the larger, major colony site to make a single trajectory so as to avoid making too many trajectories when reliable data for the colony sizes of those sites were available (Mashiko and Toquenaga 2013). We examined the entanglement for all trajectories using DFL, but judgment of entanglement of multi-trajectory lineages was made for each colony lineage rather than each trajectory: the lineage was categorized as untangled, border, or entangled when the judgment of all trajectories was the same, and it was deemed border when the judgment differed among trajectories. All statistical analyses were conducted with statistical program R (R Development Core Team 2013). Where appropriate, we report mean ± SE.

RESULTS

During the 51-year period from 1963 to 2013, a minimum of 163 colony sites were used for at least one breeding season in the study area (Fig. 1). This included seven colony sites that were re-established at exactly the same location after their abandonment. The recorded 163 colony sites were categorized into 61 lineages. While 10 out of 61 lineages (16.4%) existed for only 1 year (open circles in Fig. 1), the remaining 51 lineages persisted for more than 1 year (Fig. 4A). These 51 multi-year lineages were composed of 26 mobile and 25 stationary lineages (Fig. 4B). Mobile lineages were composed of 127 colony sites. Stationary lineages were composed of 26 colony sites because one lineage had two colony sites within a 5.93-km

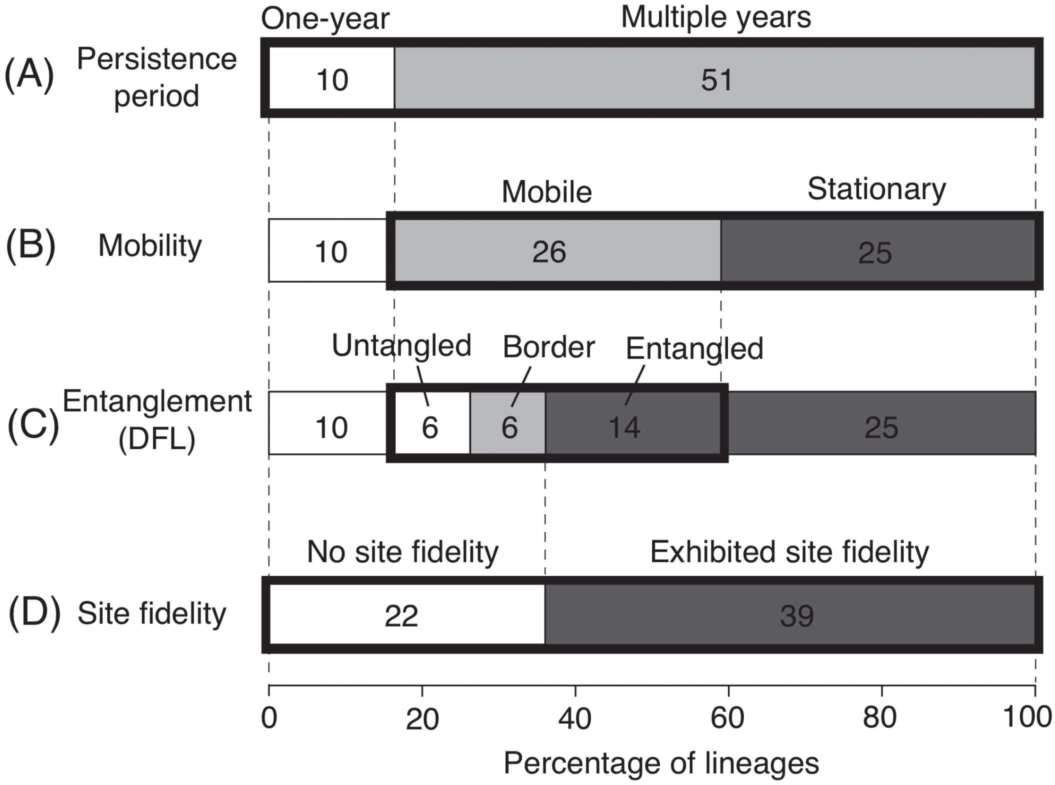

Figure 4. Summary of the classification of 61 lineages. Values represent the number of lineages. White, light gray and dark gray sections represent no site fidelity, border, and site fidelity, respectively.

radius in the same year. Survival curves differed between colony sites of stationary lineages and null expectations: persistence periods of colony sites in stationary lineages were much longer than those in mobile lineages ($\chi^2 = 14.4$, $P < 0.001$; Fig. 5). Thus, the stationary lineages exhibited site fidelity by reusing the same site for many years.

The 26 mobile lineages were composed of 39 trajectories because five out of 26 lineages had multiple trajectories. The number of colony site shifts in a lineage ranged from one to nine (3.1 ± 0.29). Results of entanglement of trajectories evaluated based on DFL revealed that six lineages were above the line of equality for observed and expected DFL, six were border, and 14 were below (Fig. 6). Hence, four lineages were untangled, but 14 lineages (53.8%) were entangled (Fig. 4C). When those results were combined with one-year and stationary lineages, 22 lineages (36.1%) did not exhibit site fidelity, but 39 lineages (63.9%) did (Fig. 4D).

Discussion

Lineages of heron and egret colonies demonstrated that these species had a preference for reusing the same or nearby sites as in previous years even though breeding sites are widely available throughout the study area. One possible explanation of the mechanism behind site fidelity is that herons and egrets have fidelity to foraging sites as well as to colony sites (Yamada 1994), and thus subsequently select certain locations as colony sites. Food availability, measured as the area of potential foraging habitat around the colony, has often been thought to be the most important factor affecting the location and size of a heron colony (Fasola and Barbieri 1978; Gibbs 1991). However, variables related to foraging sites did not have a major impact on locations and sizes of colonies in our study area (Fujioka *et al.* 2001; Tohyama 2005; Carrasco *et al.* 2014, 2017). Thus, the site fidelity of colony lineages is not merely caused by individuals' preferences for foraging habitats.

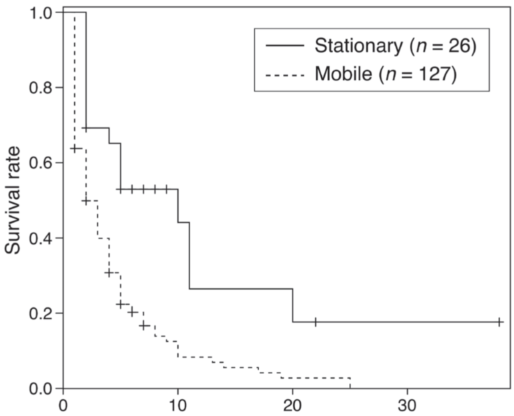

Figure 5. Survival curves of the persistence period of the colony sites using the Kaplan-Meier estimate. The broken line represents colony sites that constituted mobile lineages (*n* = 127), and the solid line represents those that constituted stationary colony lineages (*n* = 26). Vertical bars represent censored observations.

The frequency of return to natal or previous breeding locations has been well studied in colonial seabirds (Atwood and Massey 1987; Spendelow *et al.* 1995), but only three studies have assessed it in herons and egrets. Fernandez-Cruz and Campos (1993) banded Grey Heron fledglings (*n* = 319) at a colony in Spain over 5 years, with an 11.6% return to the colony the following year, 5.6% return after 3 years, and 3.1% return after 4 years. Melvin *et al.* (1999) measured natal site fidelity in the USA from a dataset spanning from 1914 to 1994 with 16.2% for Great Blue Herons (*A. herodias*), 23.8% for Great Egrets, 18.0% for Snowy Egrets (*E. thula*), 7.9% for Little Blue Herons (*E. caerulea*) and 12.5% for Tricolored Herons (*E. tricolor*). Fasola *et al.* (2002) investigated the dispersal rate of Little Egrets in colonies in the Camargue in southern France. They marked 6,618 chicks and 504 adults over 16 years and found an average estimated dispersal rate among colonies of 45%; in other words, 55% of individuals seemed to exhibit natal- or breeding-site fidelity. These low average individual site fidelities seemingly contradict our results showing that nearly two thirds of heron colony lineages exhibited site fidelity.

A high degree of site fidelity at the colony level may occur when a few faithful individuals return to a colony site and many others follow them. Generally, frequency of breeding-site fidelity is higher in males than in females

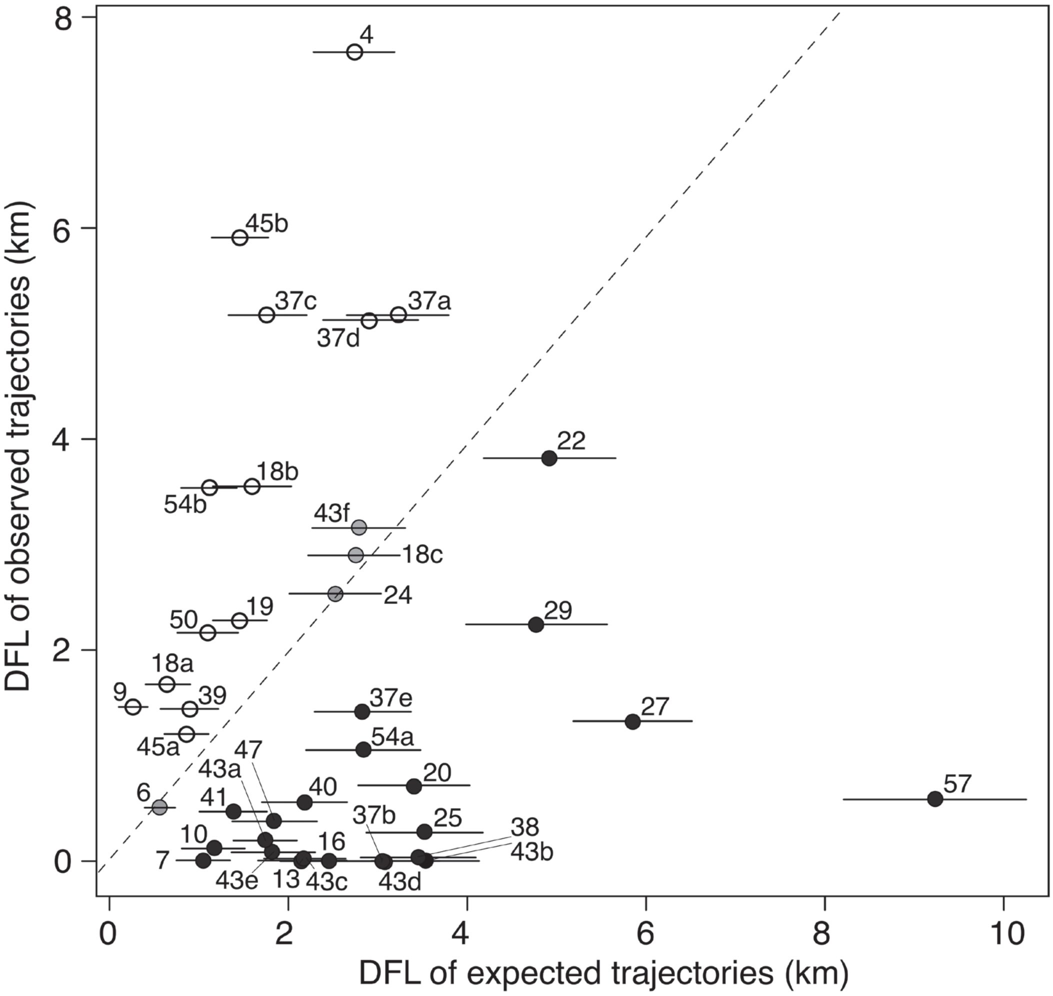

Figure 6. Comparison of observed and expected trajectories by distance between focal point and last colony site (DFL) of 26 mobile lineages. Each circle represents a trajectory. ID of the lineage and trajectory corresponds to Figure 1. Letters represent multiple trajectories in a lineage: lineage #18, 37, 43, 45 and 54 had 3, 5, 6, 2 and 2 trajectories, respectively. The broken line represents the line of equality. Trajectories were categorized into untangled (open), entangled (filled), and border (gray). Each circle with a line represents the exact value for observed trajectory and mean with a 95% confidence interval for the expected trajectory.

among bird species (Greenwood 1980; Shields 1982), the rate of nest- or colony-site fidelity is higher in adults than in juveniles (Haymes and Blokpoel 1978; Aebischer 1995), and the experience of breeding success at a colony site could also enhance fidelity to that location (Vergara *et al.* 2006). In our case, a proportion of male, adult or resident herons and egrets may have been familiar with colony locations. Those individuals may have exhibited colony-site fidelity and taken the initiative in the colony site selection at the beginning of every breeding season.

While other nomadic individuals, such as females, juveniles, dispersive adults and migrant species, may not exhibit fidelity to a specific colony site, they may be cued by the presence and abundance of conspecifics or hetero-specifics when choosing where to settle and thus contribute to a high degree of site fidelity at the colony level. This mechanism is expected to operate broadly in the breeding-habitat patch choice of social animals like colonial birds (Forbes and Kaiser 1994; Toquenaga *et al.* 1995; Serrano *et al.* 2003). Herons and egrets also refer to the presence of other species as a source of information for choosing their colony sites (Belzer and Lombardi 1989). Site fidelity or dispersal of individuals may be influenced by the status of their colonies, as with allee effects of colony size in colony site selection of individuals (Serrano *et al.* 2005).

Conversely, about one third of colony lineages did not exhibit site fidelity. There is a positive correlation between an individual's reproductive success and its subsequent nest- or colony-site fidelity (Vergara *et al.* 2006), and first-year breeders or immature birds rely on the reproductive successes of nesting adults to assess their own chances of breeding successfully in a given patch and to make settling decisions (Danchin *et al.* 1998; Schjørring *et al.* 1999; Calabuig *et al.* 2008). Heron and egret individuals that had bred at single-year colonies may be less likely to recruit follower individuals because they may have suffered lowered reproductive success, due to any number of factors including human disturbances, and moved to different colonies the following year.

Site fidelity was observed in more than half of mobile lineages, and it could have originated from a few faithful pioneer individuals with many others following them. Even when heron colonies shift their locations to alternative sites, mobile colony lineages tend to stay within a small area rather than moving far away unless some unsuitable condition, such as human disturbances, overrides the ecological advantages of site fidelity. For mobile colony lineages with an entangled trajectory, management techniques should be developed to retain colonies at locations where conflict with neighboring humans can be minimized. A historical perspective of colony lineages is necessary so as not to become trapped in a vicious circle of conflict, and the application of random walk models by considering the trajectories of mobile bird colony lineages as movement paths of an individual looking for suitable locations is useful for examining the site fidelity of gregarious animals at the colony level.

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2.2 学会・シンポジウム要旨

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P-19

全国における街路樹の現況と推移

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1.はじめに

国土交通省では，道路において沿道環境の改善をすることで通行の快適性の向上や良好な生活環境を創出していくことを目的とした道路緑化の整備を推進している．なかでも景観向上や環境保全，緑陰形成，交通安全，防災等の諸機能を大きく発揮できる街路樹は，戦後の急速な都市開発とともに本数が増加し，多様な樹種が植栽されてきた．国土技術政策総合研究所においては，時代の流れとともに社会や経済状況が大きく変化し国民ニーズも多様化している情勢に応じた道路緑化整備を持続していくため，基礎資料として道路緑化現況を把握するための全国調査を1987年以降5年毎に行っている．

ここでは，最新となる2017年3月31日現在供用済み道路における道路緑化現況調査結果から全国における街路樹の現況と推移を報告する．

2.調査方法

調査は，2017年8月に各道路管理者（国，都道府県，市町村，地方道路公社，高速道路会社）に対してアンケート形式で行った．調査項目は，各道路管理者が管理している道路緑化樹木（2017年3月31日現在供用済み道路を対象）の樹種別本数とした．このうち，高速道路会社を除く道路管理者が樹高3m以上で使用する樹種を街路樹として本数の集計を行うとともに樹種の傾向と推移を併せて把握した．

3. 調査結果と考察

街路樹本数は，2017年3月31日現在で約670万本であった．都道府県別では道路延長の長い北海道が最多となり，次いで東京都，兵庫県，愛知県，大阪府といった大都市圏域が続いた．大都市では道路交通や歩行者が多く，道路緑化の持つ機能が強く求められているため，積極的な道路緑化が行われた結果と考えられる．このような状況の中で道路延長あたりの本数では，沖縄県がこれらの都道府県を大幅に上回る本数となり，観光地を演出するための緑化が積極的であることがうかがえた．

樹種別本数では，イチョウが最も多く，次いでサクラ類，ケヤキ，ハナミズキ，トウカエデの順となった．これらの樹種が多用される理由としては，都市部の車道横という植物の生育環境には不適な場所であっても比較的良好な生育が望めること，生育空間にあわせて行われることがままある強剪定後の萌芽力を有することなどの強健さや，花の美しさや紅葉の彩りにより都市景観に華やかさが付加されることなどが考えられる．また，ハナミズキにおいては，樹形がコンパクトで限られた道路空間に収まるサイズであることが考えられる．

街路樹本数の推移は，1987年から2002年まで順調に増加したものの2007年以降は減少と増加を繰り返しており，当分の間はこの傾向が続くものと推察される．

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Site fidelity in lineages of mixed-species heron colonies

As heron and egret colonies are sometimes abandoned due to human activity and subsequently newly established at nearby locations, colony locations per se cannot represent colony fates. Here, “colony lineages” were traced by connecting short-distance location shifts between colony sites in consecutive years to quantify the site fidelity of heron colonies themselves rather than the breeding-site fidelity of individuals. Site fidelity of 61 colony lineages recorded from 1963 to 2013 in and around Ibaraki Prefecture, Japan, was evaluated by persistence periods with survival analysis and shapes of historical trajectories by applying the correlated random walk analysis. While 36% (n = 22) of colony lineages did not show site fidelity and lasted only 1 year or indicated untangled shapes of historical trajectories, 64% (n = 39) of colony lineages exhibited site fidelity by reusing the same locations for multiple years or by staying within a small area with entangled shapes of historical trajectories. Even though suitable breeding sites were abundant in the study area and site fidelity of colony members was low, a high rate of site fidelity in colony lineages may be achieved when a few faithful pioneer herons and egrets are followed by many others.

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Resolving human-bird conflict in urban areas in Japan

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Many people recognize that urban green spaces are important to support biodiversity; however, they may be displeased when those originally comfortable spaces for human residents are crowed with nuisance bird flocks. In Japan, crows, starlings, herons and cormorants sometimes form their roosts and colonies on trees in urban and suburban areas. Local people often disturb the birds using firecrackers and loud machinery because noise and unpleasant odors of bird flocks can be disagreeable and annoying for them. But those temporal measures to scare birds away from a site may cause the same problem at another, neighbor urban green space because those birds exhibit site fidelity to the areas. To develop strategies to avoid trapping in a vicious circle of negative interactions between human and birds, conditions under human disturbances at mixed-species colonies of herons and egrets around Ibaraki Prefecture, suburban of Tokyo, were examined from the colony data during 1983 and 2017. Average distance between colony location and nearest houses were shorter in colonies with human disturbances than those without them. Colonies located distant enough from residential district at greenbelt of riverside or industrial areas prone to persist longer years. Thus, reasonable way to resolve conflicts between human residents and heron colonies would be: 1) drive away birds thoroughly from an original colony location where human-bird conflict occur, and 2) attract birds to a new, alternative location far enough from residential district. Further practical studies are needed to examine details on how to drive away and attract birds.

日本鳥学会
日本鳥学会 2018 年度大会講演要旨集（2018）：84

P029

鷺山との適度な距離とは

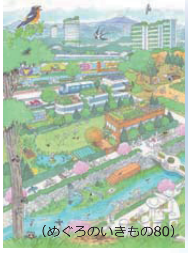
益子美由希（国総研）

白鷺城，白鷺の舞，白鷺神社。シラサギ類は昔から人々に愛され，祀られてもいる存在だが，それが鷺山（繁殖コロニー）となると厄介者とされがちである。特に，鷺山が住宅地に隣接する樹林に形成された際，その臭いや騒がしさに対する住民からの苦情を受けて地権者等が樹林を伐採し，翌年また近隣の樹林で同じ問題が生じる，という軋轢の連鎖が後を絶たない。一方で，鷺山が河川敷等の住宅地からある程度離れた樹林に形成された際には，長年存続し，愛鳥家も集まるスポットとなることがある。軋轢のない状態で鷺山が存続するには，鷺山と人との間に，両者が自然な営みができるような適度な距離があることが主要な条件のひとつと予想される。

本発表では，鷺山との軋轢問題の解決に資するため，インターネット上から収集した情報等をもとに，鷺山と最寄り住宅地との間の距離について，軋轢有無の鷺山間で比較分析した結果を紹介する。また，全国で手探りで行われている軋轢対策について，成功・失敗事例の具体的な内容を整理し，効率的な対策実施に向けて行政や関係者に求められる役割等について論じる。

国総研
国土交通省
国土技術政策総合研究所
National Institute for Land and Infrastructure Management

都市の生物多様性の確保を目的としたモニタリングとその活用手法に関する調査研究


（めぐろのいきもの80）

世界人口の半数以上が
都市に居住している
↓
「都市住民が生物多様性の
重要性を理解することが、
都市だけでなく、
地球全体の生物多様性の
保全に重要」

（国土交通省 H22 都市と生物多様性パンフレット）

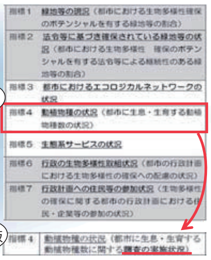
国土交通省 生物多様性条約10回締約国会議（COP10）での決議等を踏まえ、
自治体における都市の生物多様性の確保に向けた取組を支援

- ●H23『緑の基本計画における生物多様性の確保に関する技術的配慮事項』
- ●H25『都市の生物多様性の指標（素案）』

「主要な地域の生態系が存在する地点に生息又は生育する種を
リファレンス種（指標種）として設定し、その変化を算定する」

しかし！ **「動植物の生息・生育状況に関する十分なデータを有する自治体が極めて少ない」**（国土交通省 H26･27調査結果）

- ●H28『都市における生物多様性の指標（簡易版）』



素案

指標1	緑地等の現況（都市における生物多様性確保のポテンシャルを有する緑地等の割合）
指標2	法令等に基づき確保されている緑地等の状況（都市における生物多様性　確保のポテンシャルを有する法令等による継続性のある緑地等の割合）
指標3	都市におけるエコロジカルネットワークの状況
指標4	動植物種の状況（都市に生息・生育する動植物種数の状況）
指標5	生態系サービスの状況
指標6	行政の生物多様性取組状況（都市の行政計画における生物多様性の確保への配慮の状況）
指標7	行政計画への住民等の参加状況（生物多様性の確保に関する都市の行政計画における住民・企業等の参加の状況）

簡易版

指標 4	動植物種の状況（都市に生息・生育する動植物種数に関する調査の実施状況）

課題 自治体における動植物の生息・生育状況に関するモニタリングを普及させる必要がある

市民と協働で行う生物モニタリングに注目し、その効果的な実施・活用方法を調査中

調査 1 指標種の設定手法

全生物対象の網羅的調査は容易でない
⇒指標種となりうる生物は？

《自治体等の資料で指標種とされていた生物》

1位　ツバメ(22件) ※1
2位　カワセミ(18件)
3位　シジュウカラ、ミナミメダカ(17件)
⋮

しかし、個別の指標種の選定理由は不明瞭だった

指標種の設定のしかたは活用目的に応じて
複数ありうる

- ●環境を反映する指標種
- ●都市化傾度に応じた指標種
- ●身近でわかりやすい指標種　等

（目黒区生物多様性戦略）
環境ごとに市民調査の対象種となる指標種を設定している例

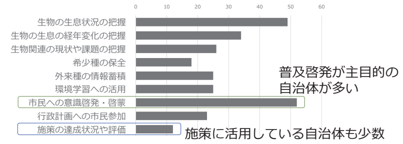
☞選定の考え方や手順を明らかにするため、
事例の詳細調査や過去データの分析を実施中

『市民参加型生物調査』

目（観察者）の数が多い
⇒業者委託よりも
- ●広域で
- ●長期的に
- ●安価に　調査しうる

《調査実施状況のアンケート結果》※2

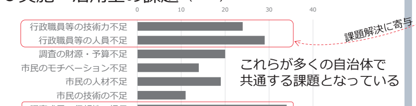
●ねらい・活用実態 (n=58)



普及啓発が主目的の
自治体が多い

施策に活用している自治体も少数

●実施・活用上の課題 (n=62)



課題解決に寄与

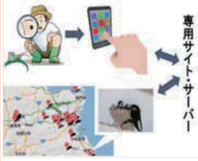
これらが多くの自治体で
共通する課題となっている

調査 2 新技術の導入可能性

生物情報の取得・蓄積には労力がかかっており、記録ミスも起こりがち
⇒高精度で効率よくデータを得るには？

《特に有用と考えられる2つの技術》

●スマホと連動した
ウェブGISツール



（小串・鎌田2017より改変）

写真から位置情報を読み取り
自動でマップ化する例

(現地での生物データの簡便な取得からデータの収集・管理までの一元化につながる)

●AIによる生物種の
識別補助ツール

(http://www.lupines.net/)

写真から植物種名を自動
判別するソフトの例

(現在は精度に課題があるが、将来的にデータの信頼性確保に役立つ可能性がある)

☞これらの技術を活用している事例を対象に、
導入の際の工夫、課題等の詳細調査を実施中

※1：自治体の緑の基本計画や生物多様性地域戦略に指標種又は調査対象となる生物種名の記載があった資料等39件を対象

※2：緑の基本計画や生物多様性地域戦略に市民参加型生物調査の記載があった自治体の62件の調査を対象

調査 3 市民参加型生物調査の効果的な実施・活用方法

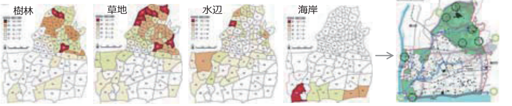
各自治体が手探りしている現状 ⇒地域の生物多様性の確保に結びつくやり方とは？

《2つのタイプ》

●普及啓発が主目的

誰もが参加できるわかりやすい調査を
継続している例

●施策検討が主目的



確認された指標種数から評価マップを作成し、保全上重要な緑地を位置づけている例

☞先進事例を詳細調査し、目的に応じた調査の実施体制・
仕組みや実施上の手順・ポイント等を整理中

(整理イメージ)

施策検討が主目的
STEP UP
普及啓発が主目的

高 ↑ 要求されるデータ精度 ↓ 低

実施体制

自治体 ― 学識者 ― 市民：
現場調査やとりまとめの際に
学識者の支援を得る
信頼性あるデータ取得のため
生物の識別力のある地元NPO
等が中心となる

自治体 ― 市民：
将来のSTEP UPも視野に市民参加の
仕方を工夫する
・誰もが識別できる指標種に限定
・観察イベント等で人材育成

今後の展望

市民参加型生物調査のコーディネート役となる自治体担当者向けの手引きの公表（H31年度末目処）
⇒先進事例のノウハウの共有による取組の推進
⇒自治体が実際の生物の生息状況を踏まえて、都市の生物多様性の確保のための取組を
適切かつ持続的に実施できる社会の実現へ

研究成果や技術支援情報などをお届けする
国総研メールサービスの登録はこちらから
http://www.nilim.go.jp/lab/bcg/mailmag/

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一般講演（ポスター発表） P2-249 （Poster presentation）

都市域の緑地の量・質・配置と生物多様性の関係 【B】
Urban biodiversity in relation to the amount, structure and network of urban green space 【B】

*益子美由希（国総研・緑化生態）, 守谷修（国総研・緑化生態）, 舟久保敏（国総研・緑化生態）, 上野裕介（石川県立大）
*Miyuki Mashiko（NILIM）, Osamu Moriya（NILIM）, Satoshi Funakubo（NILIM）, Yusuke Ueno（Ishikawa Pref. Univ.）

都市人口が世界的に増加する中、都市においても生物多様性の確保が課題となっている。都市内の樹林地、草地、水辺地等の緑地は、都市住民にとって身近な自然とのふれあいの場であるとともに、生物の生息場所としても貴重な空間である。わが国の都市では、人口減少・少子高齢社会に対応した都市のコンパクト化の動きの中で、新たに発生した空き地の緑地化や既設公園の集約・再編など緑地空間が大きく変容する可能性があるが、その際に都市の生物多様性の確保に結び付く緑地の保全・創出を推進するには、どの程度の規模で、どういった構造の緑地が、どのように配置されれば生物多様性保全に寄与し得るかといった知見を整理し、緑地計画に活用することが有効と考えられる。

そこで本研究では、東京都内の都市化の程度の異なる範囲において、緑地の量、質、配置が生物多様性にどのように影響するか明らかにするため、生物種の出現傾向と環境要因との関係を分析した。対象地は東京23区内から多摩地域にかけて位置する様々な規模（0.1～10ha以上）の61公園とし、生物データはこれら公園において2013～2014年に調査した鳥類（樹林性・水辺性）、飛翔性昆虫類（トンボ類・チョウ類・バッタ類）及び地上徘徊性昆虫類の各種の出現有無の記録を用いた。環境データは、緑地の量については公園内の緑地面積等を、質については公園内の植物種数やビオトープ、サンクチュアリの有無等を、配置については公園周辺の一定範囲に存在する緑地の面積や連結性指標値等を用いた。

分析の結果、分類群による多少の出現傾向の違いは見られたものの、概ね、公園内の緑地の面積が大きく、その構成要素として多様な植物種やビオトープ等が存在し、周辺の緑地との連結性が高い公園ほど、種多様性が高い傾向があった。本発表では、これらの分析結果を紹介するとともに、結果を踏まえた都市緑地の保全・創出・管理の方向性について論ずる。

一般講演（口頭発表） G01-10　（Oral presentation）

A Study on the Selection Method of Indicator Species for Biodiversity Monitoring in Urban Areas

*Keita Aragane, Miyuki Mashiko, Satoshi Funakubo（NILIM）

The conservation of biodiversity in urban areas has become important topics in urban environmental policy, and that contributes not only to improve urban living environment but also to enhance of people's awareness of biodiversity. For this purpose, it is necessary to assess regional ecosystem continuously by biodiversity monitoring. However, there are few municipal governments which have implemented continuous biodiversity monitoring, due to mainly financial restrictions. Selecting indicator species is considered to be an effective way to implement continuous biodiversity monitoring and assess regional ecosystem within budget constraints. In this study, we surveyed 30 municipal governments which have conducting biodiversity monitoring in the Tokyo metropolitan area for clarifying the selection method of indicator species. As a result, it was revealed that selected indicator species tended to differ depending on the purpose of the monitoring, species identification skills of observers, and degree of urbanization. It was also found that collaboration with diverse stakeholders (such as scientists, engineers, public administrators, and citizens) is an effective way to select the appropriate indicator species for biodiversity policies promotion.