

## Spatial Behavior and Population Ecology: The Role of Territoriality

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**Abstract** This study introduces the definition and research history of territoriality, elaborates on the core position of territorial behavior in animal ecology and behavioral science, as well as its mechanism of action on population density regulation, reproductive success and individual fitness. Meanwhile, it was explored how territorial behavior affects niche differentiation, predator-prey relationships, and community stability and diversity in community structure. Through the analysis of typical cases of birds (such as songbirds), mammals (such as wolves and lions), fish and reptiles (such as cichlids and lizards), the different manifestations and ecological significance of territoriality are demonstrated. This study also discusses the methods of incorporating territoriality into population dynamic models, including the combination of spatial heterogeneity and individual-based models, as well as the significance of territoriality for long-term population succession prediction. From an application perspective, this paper clarifies the implications of territorial behavior research for habitat protection, species restoration and human disturbance management. Territoriality is not only an individual's behavioral strategy but also an important mechanism for regulating population structure and maintaining ecosystem stability. Integrating behavioral ecology with population dynamic models is conducive to enhancing ecological prediction capabilities and the scientific nature of conservation management.

**Keywords** Territory behavior; Territoriality; Population ecology; Population regulation; Community structure

## 1 Introduction

Territorial behavior refers to the phenomenon where individuals or communities occupy and defend a specific spatial range through fighting, demonstrations and other actions to prevent individuals of the same or different species from entering. The classic definition regards a territory as an exclusive part of an individual's range of activities, that is, the "territory" is the core area of active defense (Sells and Mitchell, 2020). The study of animal territories can be traced back to the early 20th century, and observations of bird territory singing and fighting laid the theoretical foundation. In the era of modern behavioral ecology, scholars such as Brown have linked territorial behavior with resource allocation and suitability, and proposed the theory of "economic defensibility" to explain when territoriality evolved. In recent years, with the development of telemetry and molecular technology, researchers have been able to track in detail the spatial utilization and social interaction of animals, promoting the study of territorial behavior into a new stage.

Territoriality is widely distributed among birds, mammals, reptiles, amphibians and fish, and is one of the core topics in behavioral ecology research. By defending specific areas, individuals can monopolize key resources such as food, mates or nest sites, thereby increasing survival rates and reproductive success rates. Its evolution mechanism depends on the balance between defense benefits and costs: When resources are moderately distributed and defensible, territorial behavior can enhance fitness and thus is more likely to evolve (Both and Visser, 2003; Lopez-Sepulcre and Kokko, 2005). If resources are extremely concentrated or too sparse, the cost of maintaining the territory is too high, and such behavior is usually difficult to form.

At the population level, territoriality is regarded as an important mechanism for regulating density and shaping spatial patterns. Species with territory often exhibit density-constrained effects, that is, each individual needs to occupy a certain range, thereby limiting the overall population (Balluffi-Fry et al., 2025). In a community, the overlap or mutual exclusion of territories among different species can promote niche differentiation, a process that helps maintain community diversity. Territorial behavior is also closely related to social systems. For instance,

when defending territory requires the collaboration of partners, it often promotes the evolution and maintenance of monogamy (Weiner et al., 2019; Moura and Menezes, 2021; Wang et al., 2022).

This study will explore the mechanism and significance of territorial behavior in population ecology, introduce the biological basis of territorial behavior, and analyze how territoriality regulates population density, reproduction, and individual fitness, as well as how it affects species coexistence and interaction in community structure. The diverse manifestations and ecological consequences of territoriality are deeply illustrated through typical cases (songbirds, wolves and lions, cichlids and lizards). Meanwhile, the progress of incorporating territoriality into population dynamic modeling is discussed. From the perspective of conservation biology, the implications of territorial behavior research for habitat protection, species restoration, and human-wildlife conflict management are explored, hoping to deepen the understanding of the important role of territoriality in maintaining population and community stability.

## 2 The Biological Basis of Territorial Behavior

### 2.1 Classification of territorial behavior

The territorial behavior forms of animals and animals are diverse and can be classified according to dimensions such as function and duration. Take birds as an example. The classic classification divides the territory into six types: Class A territory is a "fully functional territory", covering all activity Spaces such as mating, nesting and foraging; Class B territory is limited to mating and nesting and does not include the main feeding areas. Class C territory only includes the nest site and a small area around it (commonly seen in waterfowl that breed in groups). Class D territory is only used for pairing and courtship (such as species with a mating field); Class E territory refers to the nocturnal habitat territory. Category F territories are seasonal territories, such as the foraging range of migratory birds defending their wintering grounds (Ord, 2021). Although the territorial forms of different species are not the same, the core feature is to occupy - defend a certain space to exclusively enjoy the key resources within it (Juarez et al., 2020).

In addition to classification by function, territorial behavior can also be divided based on the actor and stability. For instance, some species have their territory defended by a single individual (such as most solitary male birds); There are also species that jointly defend territory in communities or families. For example, wolves patrol boundaries in family groups (Sells et al., 2021). The duration of the territory also varies: some animals retain a fixed territory throughout the year, which is called a permanent territory; Some others only form temporary territories during the breeding season, and the territorial relations become loose after the breeding season. These differences reflect the adaptation strategies of different species to resources and the environment (Mayer et al., 2020).

### 2.2 Establishment and maintenance mechanism of territory

The establishment of territory usually begins with an individual's repeated inspection and marking of a certain area, making the surrounding peers aware of their possession. Different groups of animals use their own specific ways to mark the boundaries of their territories and maintain territorial stability: Among mammals, many carnivores leave signals at the edge of their territories through odor markers (urine, anal gland secretions, etc.) to act as "odor fences" (Candolin and Voigt, 2001; Zubizarreta et al., 2020). A study on African wild dogs shows that the social structure of the group can affect their odor marking strategies. Factors such as the number of pups in the group and the number of adjacent competing communities can all change the patterns in which they choose marking locations and frequencies. This reflects the important role of olfactory signals in territorial maintenance: Territorial owners regularly patrol the border and add odor markers to convey the message of "this is occupied" to potential intruders, thereby reducing frontal conflicts (Sells et al., 2021; Hansen et al., 2025).

In addition to chemical signals, sound and visual signals are also important means for animals to declare their territory. Male songbirds often stand in prominent positions within their territory and sing loudly, using auditory signals to mark their territory and attract mates. For instance, studies have found that urban birds such as the dark-eyed raven had reduced singing activities and lower movement distances during pandemic lockdowns ("quiet periods"), suggesting a decrease in territorial intrusions (Walters et al., 2022). For instance, in visual display,

reptiles such as lizards will make exaggerated body movements (such as bright-colored laryngeal pouch dilation, nodding up and down, etc.) to warn their own kind to stay away (Ord, 2021). A study by some scholars on tropical parrots in the Americas found that their response intensities to territorial neighbors and unfamiliar intrusions were significantly different. This phenomenon of "neighbor-stranger discrimination" (also known as the "affinity effect") is also common among mammals (Niaskiewicz et al., 2024).

### 2.3 Factors affecting the size and strength of territory

The size and defense intensity of an animal's territory are not fixed but are influenced by a variety of internal and external factors. The distribution and abundance of resources are the key ecological factors determining the size of a territory: when resources are sparsely scattered in space, individuals need a larger area to meet their demands, and the territory is often larger. Conversely, if resources are abundant and concentrated, animals can obtain sufficient resources in a smaller territory (Keeley, 2000; Mayer et al., 2020). For example, studies on free-moving dogs in urban environments have found that in urban areas where food is highly dense and predictable, the activity area (which can be regarded as territory) of dog packs is significantly smaller than that in rural areas where food is scarce (Thanapongtharm et al., 2021).

Population density and social environment also profoundly influence territorial dynamics. When the density of individuals of the same species increases and competition is intense, the number of territories that can be accommodated in a unit space increases, and individuals are often forced to reduce their territories to achieve spatial sharing (Mayer et al., 2020). Long-term studies on red squirrels have shown that the territory size of squirrels has a significant negative density dependence: in years of high population density, the territory of each squirrel decreases on average compared to years of low density, and the territory overlap rate increases (Berlusconi et al., 2025). Furthermore, individual characteristics (such as gender, body type, age and physiological state) can also affect the size of their territory and defense capabilities (Asensio et al., 2018). For example, the odor marking behavior of the Eurasian beaver (*Castor fiber*) on territorial boundaries, which uses odor information to maintain territorial integrity and social interaction (Figure 1) (Mayer et al., 2020). Generally, adult males have the largest territory and devote the most energy to defense during the breeding season. This is because males need territory to attract mates and ensure space for raising their offspring.

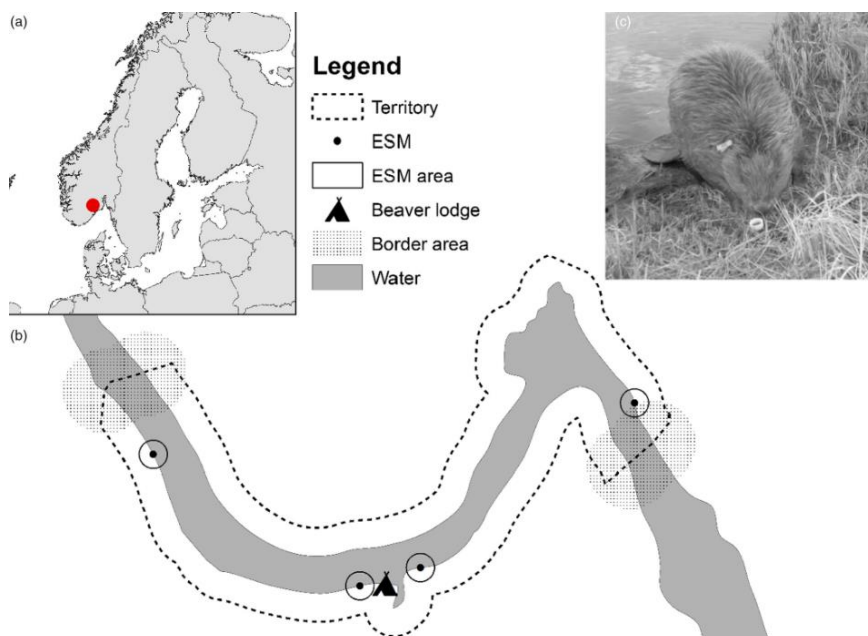


Figure 1 Spatial distribution of beaver territories and scent marking behavior in southeastern Norway (Adopted from Mayer et al., 2020)

Image caption: south-east Norway (red dot, a) and (b) a schematic representation of a beaver territory, the main lodge, the location of the experimental scent mounds (ESM), ESM areas and border areas. The picture (c) shows a Eurasian beaver (*Castor fiber*) sniffing an ESM (Adopted from Mayer et al., 2020)

### 3 Territoriality and Population Regulation

#### 3.1 Territorial role in population density regulation

Territoriality, as a spatial competition mechanism, has a significant self-regulating effect on animal population density (Rueda et al., 2021). In highly territorial species, the number of breeding individuals that a habitat can accommodate is often limited by the number of territories that can be divided in that area. This phenomenon is also manifested in social animals such as wolves: Wolf packs occupy a fixed-size territory. Once the available space is insufficient, newborn cubs have to leave the pack and become wandering individuals when they grow up until they find a vacant territory (Sells et al., 2021).

Territorial behavior not only limits the maximum density but also affects dynamics at low densities. Theoretical research shows that territorial spatial structure may bring about the Alli effect: when the population density is too low, lacking the interactive stimulation of neighboring individuals, territorial owners encounter unfamiliar invasions more frequently instead, the cost of territorial defense increases, resulting in further reduction of reproductive success and survival rate (Mayer et al., 2020). Model simulation also supports this complex effect: Population models of spatial structure show that territory competition can spontaneously generate multiple stable states and a minimum necessary population size, that is, if the number of individuals is lower than a certain threshold, the population is difficult to maintain (Alli effect) (Weiner et al., 2019).

Empirical studies also show that territorial behavior does indeed play the role of a regulator in the actual population dynamics. For instance, in the field experiment of red squirrels, by supplementing food to enrich the resources in certain areas, the squirrels reduced their respective territories, accommodated more individuals, and the coexistence density increased (Berlusconi et al., 2025). Territoriality affects the distribution of reproductive opportunities through spatial exclusivity, thus becoming one of the important mechanisms for regulating the intrinsic density of a population. When conducting population dynamics prediction and management, considering the existence of territoriality can more accurately evaluate the population growth trend and density feedback effect (Marques et al., 2024).

#### 3.2 The influence of territoriality on reproductive success rate

Obtaining and defending a high-quality territory is usually one of the prerequisites for an animal to achieve reproductive success. In many species, only individuals with territory can successfully mate, build nests and raise offspring, while the "landless" without territory often lack reproductive opportunities (Rueda et al., 2021). Research shows that the reproductive success rate of territory owners is significantly higher than that of non-territory individuals: owning a territory is equivalent to having resources and the right to mate. Apart from whether reproduction occurs or not, the quality of the territory also affects the reproductive output. Rich in resources and vast in area, territories often offer more food and shelter, thereby benefiting the spouses and offspring of the landowners and achieving a higher reproductive success rate (Ord, 2021).

A study on the white-browed robin (hypothetical species) found that male birds occupying high-quality territory had significantly higher numbers of chicks hatched and survival rates from their mates than those in low-quality territory breeding pairs (Lopez-peinado et al., 2024). Similar cases also exist in fish: Studies have found that in the Texas endemic Leon Springs pupfish, the territorial male fish protect the ovipositor by continuously patrolling (rather than simply attacking intruders), and eventually retain more eggs (Snekser et al., 2024). On the other hand, territoriality can also bring about cost trade-offs in reproduction. Continuous defense of territory requires time and energy, which may reduce the energy animals devote to foraging and caring for their young, thereby affecting reproductive input to a certain extent (Ord, 2021).

#### 3.3 Territoriality and individual suitability

Individual fitness refers to an individual's relative ability to pass on their genes to their offspring, which is usually determined by both survival and reproduction. Territorial behavior can enhance an individual's survival and reproductive success through multiple channels, thereby improving their fitness. Individuals who hold territory usually have more opportunities to obtain resources: an adequate and stable food supply helps maintain good physical condition and increases survival rates during the overwintering and breeding periods. Suitable territorial

environments (such as hidden nest sites and Spaces for avoiding enemies) reduce the risk of being preyed upon or harmed by bad weather (Ord, 2021). Territoriality grants reproductive priority to individuals. Males occupying territory can usually mate with females earlier or more frequently, and territorial females can also have exclusive rearing space, thereby directly increasing the number and quality of offspring (Lopez-peinado et al., 2024).

Territorial behavior can also enhance the indirect components of fitness. Territorial defense promotes the establishment of "familiar neighbor" relationships - a certain tacit understanding is formed among neighbors through repeated interactions (the so-called "intimate enemy" effect), reducing unnecessary conflicts (Nieskiewicz et al., 2024). On the other hand, territorial behavior may also incur certain fitness costs. Continuous territory defense increases energy consumption, injury risk, and the probability of exposure to predators (Ord, 2021). In most cases, the net effect of territorial behavior on fitness remains positive: territorial landowners have a higher survival probability and reproductive success than those without territory, thus leaving more offspring in the population (Lopez-peinado et al., 2024).

## **4 Territorial Behavior and Community Structure**

### **4.1 Territorial overlap and niche differentiation among species**

In multi-species coexisting ecosystems, territorial behavior can promote spatial differentiation among species by reducing niche overlap, thereby maintaining the stability of community structure (Berlusconi et al., 2025). When different species utilize similar resources and meet spatially, territorial interactions between heterospecies individuals often occur, which is called interspecific territoriality (Drury et al., 2020). Heterologous territorial behavior promotes niche differentiation. Through territorial exclusion, different species each occupy specific microhabitats or spatial blocks, reducing direct conflicts in resource utilization. Recently, an experiment on five closely related species of the Eurasian Tit family was carried out in Italy: Researchers observed that these tit species excluded each other by forest type during the breeding season, and different species communities were spatially separated in the vast woodlands (Berlusconi et al., 2025). Of course, the intensity of territorial exclusion between species varies greatly depending on the paired species. Generally speaking, species with close kinship and highly overlapping ecological niches tend to have the most intense territorial conflicts. Conversely, if the ecological demands of species vary greatly, there will be few territorial interactions (Drury et al., 2020).

### **4.2 The regulatory role of territoriality in the interaction between predators and prey**

Territorial behavior plays a crucial role in the relationship between predators and prey, capable of altering predation stress under specific conditions and shaping the spatial distribution of prey (Clermont et al., 2025). The territory of predators is often equivalent to a "buffer zone" or "refuge" for prey: due to the repulsion among predators, each individual only controls a limited area, so the risk of prey in boundaries or vacant patches is relatively reduced.

Furthermore, territoriality also determines the way predators exploit their prey. Generally, the size of a territory is closely related to the abundance of prey resources, and predators adjust their activity range according to the density of prey (Sells et al., 2021). Theoretical research indicates that this "expansion-contraction" mechanism helps stabilize the system: when the number of prey decreases, predators are forced to expand their territory, and the density drops accordingly, providing the prey with recovery space. When the number of prey increases, the territory shrinks and the number of predators increases. The increased predation pressure then inhibits the unlimited growth of prey (Weiner et al., 2019).

The ecological outcomes of territoriality, however, depend strongly on context. Inside a predator's territory, prey face higher risks, yet "super predation" by multiple predators is avoided, since intruders are excluded. On the other hand, if territorial defense limits the predator's patrol range too strictly, some prey may exploit overlooked areas to evade capture and continue reproducing (White et al., 2020).

### **4.3 The impact of territorial behavior on community stability and diversity**

Territorial behavior changes the stability and diversity of communities by shaping competition within species and among different species (Weiner et al., 2019). This influence is bidirectional. In many cases, land division helps

species to coexist, keeps species numbers stable, and makes communities stronger (Berlusconi et al., 2025). But sometimes, if a species has too much land and strong defense capabilities, it may instead reduce overall diversity (Hata et al., 2020).

How a community eventually develops depends on factors such as the strength of its defense capabilities, the traits of each species, and how resources are disseminated. Incorporating land behavior into community studies helps explain coexistence in ways that old models cannot account for. For instance, studies on forest birds have shown that strong territorial habits can create clear spatial patterns. Even if the competition is unfair, diversity can remain stable. Clear land demarcation enables many species to survive in the same location, even if their competitiveness varies greatly (Weiner et al., 2019). This indicates that conservation should maintain the stability of the territorial system of important species.

## 5 Typical Case Analyses

### 5.1 Territorial nature and reproductive ecology of birds

Under the background of urbanization, the territorial behavior of songbirds also shows a certain degree of behavioral plasticity. Research on the dark-eyed lampshade finch in campus environments shows that when "human interference is reduced", their territorial aggressiveness decreases and their range of activity also narrows. Specifically, during the period of pandemic lockdowns (referred to as the "anthropostatic period" when human activities decreased), the chirping responses of these birds to territorial invasions weakened, and their movement distances were significantly shortened compared to the normal period in 2019 (Walters, 2022).

### 5.2 Territorial cases of mammals

Among mammals, wolves and lions are classic representatives of territorial behavior research. The Gray Wolf (*Canis lupus*) lives in small family packs (Wolf packs) led by core breeding pairs. Each Wolf pack occupies a certain area of territory and defends territory boundaries by howling, scent marking and patrolling (Sells et al., 2021; Hansen et al., 2025). The size of a Wolf's territory can range from tens to hundreds of square kilometers, depending on the density of prey and terrain conditions. The results show that Wolf packs select important foraging patches within their territory in an economically efficient way to maximize food acquisition while reducing conflicts with neighboring Wolf packs (Sells et al., 2021).

The social organization and territorial behavior of African lions (*Panthera leo*) are different from those of wolves. Lions adopt a group structure with separated sexual behavior: A pride of several blood-related female lions and their cubs occupies a shared territory, while adult male lions usually form small alliances, patrol and defend a certain area to monopolize the female pride within that area (Clermont et al., 2025). The territory of the Lion Alliance varies from tens of square kilometers to hundreds of square kilometers depending on the abundance of prey on the grassland and the number of competing lions.

The cases of wolves and lions demonstrate the diversity of mammalian territoriality: wolves' territories are based on family units, focusing on maximizing foraging resources and avoiding cross-group conflicts; The territory of lions is divided by gender roles. The male territory protects the right to reproduce, while the female territory corresponds to the range of cooperative hunting.

### 5.3 Research on territorial behavior of fish and reptiles

In fish and reptiles, there are also obvious territorial behaviors, but the ways and ecological backgrounds are different. Many tropical freshwater fish (especially cichlids) are known for their strong territorial nature. Take the cichlids in African lakes as an example: During the breeding season, male cichlids will clear a specific area at the bottom of the lake as their spawning territory, show off their bright body color and drive away invading male fish of the same kind, attracting female fish to enter the territory to spawn. Male fish not only have to protect their spawning pits from being occupied by other male fish, but also need to guard against the invasion of foreign species that feed on eggs. Frequent patrols by male fish were more effective in reducing the risk of egg predation than direct attacks. Eventually, these actively patrolling male fish achieved higher reproductive success (Snekser et al., 2024). Ecological factors such as nesting and defense behaviors of male fish play an important role in

reproductive success. The structural complexity of the habitat environment may affect territory selection and reproductive strategies (Figure 2) (Yamazaki et al., 2025).

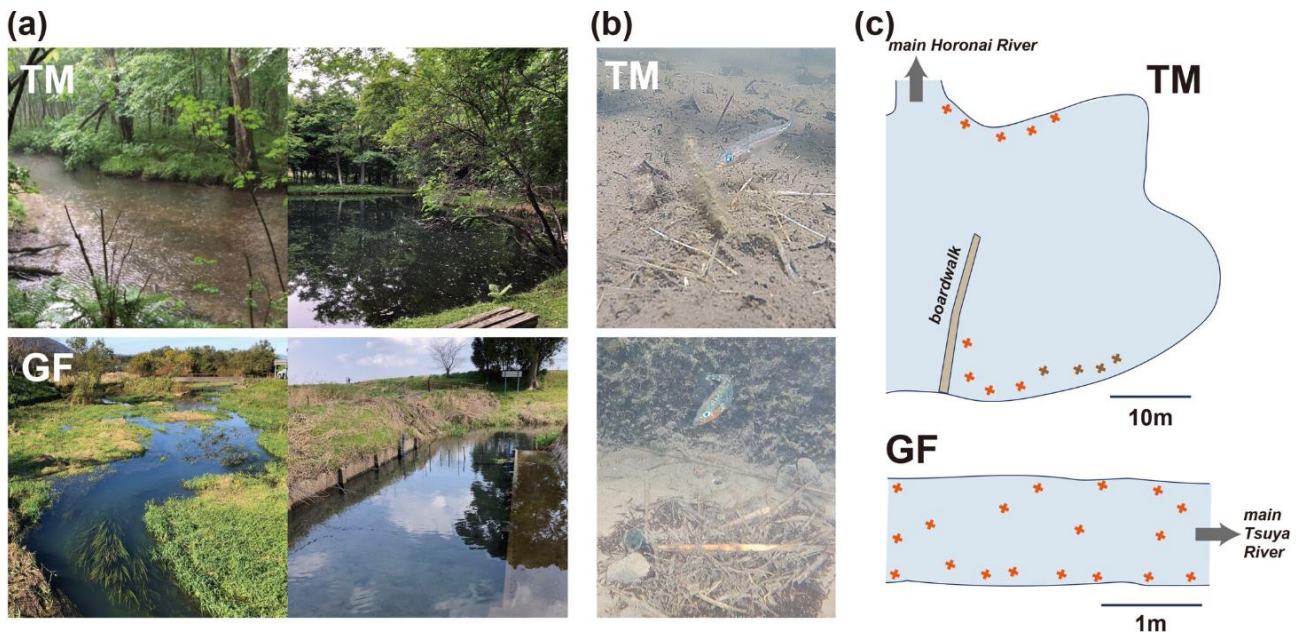


Figure 2 Impact of river ecosystems under different environmental conditions on fish reproductive behavior (Adopted from Yamazaki et al., 2025)

Image caption: Photographs of (a) riverscapes (left) and breeding habitats (right) in which our field survey was conducted (TM: Tomakomai, GF: Gifu) and (b) breeding of territorial orange-throated males. (c) Distribution of male nests across breeding habitats for TM and GF populations (Adopted from Yamazaki et al., 2025)

Among reptiles, lizards are one of the most studied groups in terms of territorial behavior. The arboreal *Anolis* lizard is a classic example: male *Anolis* lizards demarcate a fixed small area on tree trunks or hedges as their territory, and repeatedly perform the "nodding and prostrating" gesture with their colorful laryngeal sacs to show their territorial possession (Ord, 2021). When other male lizards invade, the Lord male immediately rushes towards them, confronting and competing in size and color. If the other party does not back down, a scuffle and fight will break out until one party escapes. In an environment rich in food and sunlight resources, a large tree can even accommodate multiple *Anolis* lizards, each occupying a branch as their territory. They become familiar with each other through sight and behavior, thereby reducing direct conflicts (Nasse kiewicz et al., 2024). Experiments have found that if the dominant male lizard in a certain area is removed, its territory is quickly filled by the neighboring secondary male lizards. The next day after occupation, they start to show off and drive away the adjacent ones, indicating that lizards are highly sensitive to territorial space opportunities. Once the landowner disappears, other individuals will immediately adjust their spatial distribution to expand their territory.

## 6 The Application of Territoriality in Population Dynamics Modeling

### 6.1 Population distribution model under territorial constraints

Traditional models of population distribution often assume that individuals use space evenly. For species with clear territorial behavior, this assumption is not correct. Newer models with territorial constraints bring in land area and spatial exclusivity, so the results are closer to real conditions. For example, adding extra parameters to a habitat suitability model can limit the number of breeders in an area by setting the maximum number of territories that can be defended. This helps predict both spatial spread and the upper limit of density more accurately.

These models work well in the conservation of large raptors. One case is the endangered Polynesian falcon (hypothetical species). Researchers built an individual-based model that considered territory dynamics to simulate how it spreads in its habitat network (Marques et al., 2024). In the model, every falcon pair was given a clear territory, and the repulsion from nearby pairs was also included. Compared with traditional methods that ignore territory, this model gave better predictions on breeding pairs, population size, and cross-area distribution.

## 6.2 The combination of spatial heterogeneity and the individual-based model (IBM)

Modern population dynamics modeling tends to use Individual-Based models (IBM) to simulate the impact of complex behaviors on populations. Among them, territorial behavior has been incorporated into several IBM for exploring the long-term dynamics of populations in spatially heterogeneous environments. IBM allows behavioral rules (such as territory establishment, intrusion and defense rules) to be set for each individual, and "gradually" simulates the interactions of a large number of individuals in space over time in the computer, thus giving rise to patterns at the population level. Case of onelli's eagle (*Aquila fasciata*): Researchers constructed an IBM to explore the long-term effects of electric shock death on the eagle population (Marques et al., 2024). The model sets each pair of adult eagles to occupy a territory for breeding, and when the young eagles grow up, they search for vacant territory in a limited space. In addition to birds and raptors, there have also been instances of incorporating local behavior into IBM in the infectious disease ecosystem. A model of disease transmission in felines introduced the territorial formation mechanism of "odor pheromone-guided movement" (White et al., 2020).

## 6.3 The significance of territoriality for long-term population succession prediction

Incorporating a territorial perspective can make our predictions of the long-term dynamics and succession trends of species more reliable. Whether it is the rate of species climate migration, the recovery time of released populations, or the direction of community structure changes, territorial behavior will play a "hidden thread" role in all of them. For this reason, future ecological modeling and conservation planning should attach importance to territorial parameters, such as the constraint of territorial size on diffusion distance, the influence of territorial vacancy rate on reproductive output, etc. (Rueda et al., 2021). Some scholars have called for more cross-scale research to combine the habitat heterogeneity obtained by remote sensing with field behavior experiments to improve the estimation of territorial parameters, thereby enhancing the predictive ability of models for biological responses under rapid environmental changes (Ord, 2021). It can be foreseen that with the accumulation of relevant data, we will be able to answer more accurately: "In the era of global change, how fast can animals run and how far can they spread?" Does territoriality slow them down or speed them up?" These issues are crucial for formulating effective strategies for biodiversity conservation.

## 7 Application Perspective

### 7.1 Spatial requirements assessment in habitat conservation

In habitat conservation work, the issue lies not only in "how much land needs to be protected", but also in "how much territory animals can actually utilize". This process involves several steps. Field investigations can reveal the average size and layout of the species' territory. When establishing protected areas, the land should be large enough not to be divided into too many small plots, so that each patch can accommodate at least one complete territory (Lopez-peinado et al., 2024). After that, a long-term test is needed to verify whether the plan is effective. For instance, the nesting usage and breeding success rate of raptors can be used to determine whether their territory is sufficient. If high-quality habitats are left vacant or reproduction decreases due to fierce competition, it may indicate that the protected area is too small in scale or under excessive external pressure. Territorial behavior can clearly reflect habitat quality and help guide spatial planning (Chen et al., 2023; Probst and Probst, 2025).

### 7.2 Behavioral adaptation issues in release and habitat restoration programs

Territorial demands usually determine whether release or habitat restoration projects are effective. Before releasing animals, managers should check how much free space is available in the area, including new Spaces created by new resources, and then set the number of releases based on the situation (Rueda et al., 2021). The same rule also applies to habitat restoration. When new plants bring new space, before adding animals, it is crucial to check how much territory the space can accommodate (Marques et al., 2024). Behavior and genes also play a role. Captive animals may not know how to set up or defend their territory. Training them in semi-natural enclosures, allowing them to meet opponents and practice defense, can help them get ready before being released.

### 7.3 Behavioral response and management strategies to human interference

With the spread of human activities, wild species are under pressure from land erosion, noise and direct disturbance. Understanding how territorial behavior changes under these pressures is crucial for planning (Walters, 2022). The response patterns of species vary, but their goals are the same: to maintain stable space utilization and normal territorial cycles. Stable space utilization can enhance the success rate of reproduction and reduce abnormal behaviors, such as aggression towards humans or abnormal nocturnal activities. Through meticulous management, a balance can be achieved between human land use and the territorial needs of animals, opening up a coexistence path that is both conducive to protection and sustainable utilization.

### 8 Concluding Remarks

Animals take and defend areas to live in. This helps them get food, mates, and safe space. It also shapes how groups are built and keeps nature in balance. By marking and guarding places, animals cut down on fights and create order between groups of the same or different species. At the population level, territorial behavior controls how many animals can breed. This stops too many from living in one area, which would waste food and space. It also prevents numbers from dropping so low that breeding cannot continue. In this way, territory helps manage population size.

In ecological communities, keeping areas can push species into separate roles. This often makes systems more diverse and stable. In some cases, one species may take over and reduce variety. But most of the time, territorial rules help different species live side by side. Learning about territory is important to understand how groups and communities change. Future studies should link behavior with population ecology to explain why these strategies formed and what results they bring.

Adding space limits into models makes predictions clearer. For example, adding territory size to climate models can improve forecasts of animal movement and spread. Connecting territory space with breeding success also shows more about growth and the smallest group size needed for survival. In real protection work, looking at territorial needs is helpful. Protected areas, animal release projects, and human-wildlife conflict plans all work better when space use is included. Tools such as GPS, satellites, and computer models now give new ways to study territories across scales.

Work between different science fields is key. Joining field data with models can show how territorial behavior changes when the environment shifts fast, and how this affects populations. In the end, studying territory from both behavior and population views builds a stronger base for saving biodiversity and managing ecosystems.

### Conflict of Interest Disclosure

The authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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