

Original Research

# Characterization Monitoring of *Alexandromys fortis* and *Apodemus agrarius* and the Relationship with Land Use in Dongting Lake, China

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## Abstract

Dongting Lake is a biodiversity hotspot and an important food production base. Small mammals in the area are mainly rodents, which not only pose a threat to food security but also to human health. *Alexandromys fortis* and *Apodemus agrarius* are the main rodents in the area. Previously, their habitats were relatively separated, but in recent years, with changes in environmental conditions, they have invaded each other. In order to achieve effective management of rodents in Dongting Lake, long-term monitoring of land use types and rodent communities was conducted for 20 years. The results showed that the construction land continued to increase, and the arable land and forest land remained stable. During this period, there was no significant relationship between the density of *A. fortis* and *A. agrarius* and the area of different land use types, but the fatness of *A. fortis* was significantly correlated with water body area and construction land area. The research suggests that fatness is more suitable and sensitive than population density during the rodent monitoring.

**Keywords:** rodent management, remote sensing monitoring, fatness, population density, *Microtus fortis*

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## Introduction

Rodents are widely distributed due to their high adaptive capacity and are thought to be able to respond quickly even when faced with changing environments [1]. In the context of global climate change and intensified human activities, the environment in which rodents live has also changed dramatically. A review on the ecological response of rodents in the world's arid zones showed that the effects were different at the population and community levels [2]. Rodents are an important component of ecosystems and contribute importantly to ecosystem function, using the concept of "ecosystem engineering" [3]. Rodents are also closely related to humans and may not only spread diseases but also cause biological disasters in agricultural and forestry production [4]. Exploring the patterns of rodent population changes and identifying driving factors is the foundation for achieving rodent management.

Land use type is an important environmental factor influencing changes in rodent communities and has been noted early [5]. Relationships between land use types and rodent communities vary across ecosystems [6]. A study on rodent communities in Kalahari savannah rangelands revealed that long-term heavy grazing threatened the diversity of rodent communities in arid environments [7]. The analysis of rodent community composition and diversity in relation to landscape structure in the city of Buenos Aires revealed that diversity, richness, and representation of native species decreased with increasing urbanization [8]. The knowledge may be useful for planning decisions of rodent management inferred from the landscape structure. Predicting spatial and temporal habitat use of rodents in a highly intensive agricultural area indicated that special attention has to be paid to the protection of natural habitats such as kettle holes, because they can act as source habitats facilitating rodent conservation [9]. In urban ecosystems, especially patches with tall vegetation cover and low canopy cover, are important habitats for small rodent communities, providing conservation options in heavily altered landscapes [10]. Wetlands are important habitats for many rodent species, and rodent community structure is also an important indicator for evaluating the health of wetland ecosystems [11]. Most wetland ecosystems are characterized by periodic inundation, which in turn causes more significant effects on land use types and further affects rodent community structure [12].

Long-term monitoring of rodent communities and their environments is a prerequisite for exploring the relationship between land use types and rodent communities. Land use types can be retraced using, for example, remote sensing techniques, while long-term rodent monitoring is an important challenge. Until now, there have been a few case studies on land use types and rodent communities based on long-term monitoring [13]. Analyses of long-term time series of *Microtus agrestis* and *Myodes glareolus* indicate good synchrony of population abundance associated with damage in

forestry [14]. Pellet data were employed to assess rodent populations for a long time and showed that increased temperatures and dry summers would challenge most of the analyzed species and most likely lead to decreased abundances [15]. Monitoring of lemming populations in Traill Island, Northeast Greenland, over a period of more than 20 years has shown a strong correlation between land use types and rodent populations [16]. Dongting Lake is an important wetland ecosystem in China and a global biodiversity hotspot [17]. The land use types of Dongting Lake have changed dramatically in recent years, and the study further confirms that the changes in land use types have an important impact on macroinvertebrate diversity [18]. Rodents are the main vertebrates in the Dongting Lake wetland ecosystem, where *Alexandromys fortis* and *Apodemus agrarius* are the dominant species [19]. *Alexandromys fortis*, which was formerly known as *Microtus fortis*, mainly inhabits beach habitats and can cause serious agricultural disasters [20]. *Apodemus agrarius* mainly inhabits farmland habitats, but in recent years, with changes in the environment, it has also continuously invaded beaches [21]. Although more and more attention has been paid to the impact of land use types on biodiversity in recent years, there has been no study on the impact of land use types on rodent communities in Dongting Lake. *Alexandromys fortis* poses a greater threat to agriculture [20], while *A. agrarius* is more likely to threaten human health [22]. There are significant differences in the biological characteristics between *A. fortis* and *A. agrarius*, and the management measures for the two species are different. The study hypothesized that there is a significant relationship between land use type and rodent community structure in Dongting Lake. In order to further clarify the relationship between rodent community characteristics and land use types, the study analyzes the relationship between rodent population size, fatness, and land use types in Dongting Lake based on 20 years of long-term monitoring data. The results of the study are not only beneficial for exploring the relationship between rodent community succession and the environment, but also for the management of rodents in Dongting Lake.

## Materials and Methods

### Field Survey of Rodent Communities in Dongting Lake

Dongting Lake is located in the northeastern part of Hunan Province, China, in the middle reaches of the Yangtze River (Fig. 1). Dongting Lake not only has important ecological functions, but is also an important food production base [23]. Due to the influence of rainfall and rivers, there are significant dry and high water periods in Dongting Lake, which means that the Dongting Lake beaches are periodically flooded every year. Consistent with the pattern of water level changes

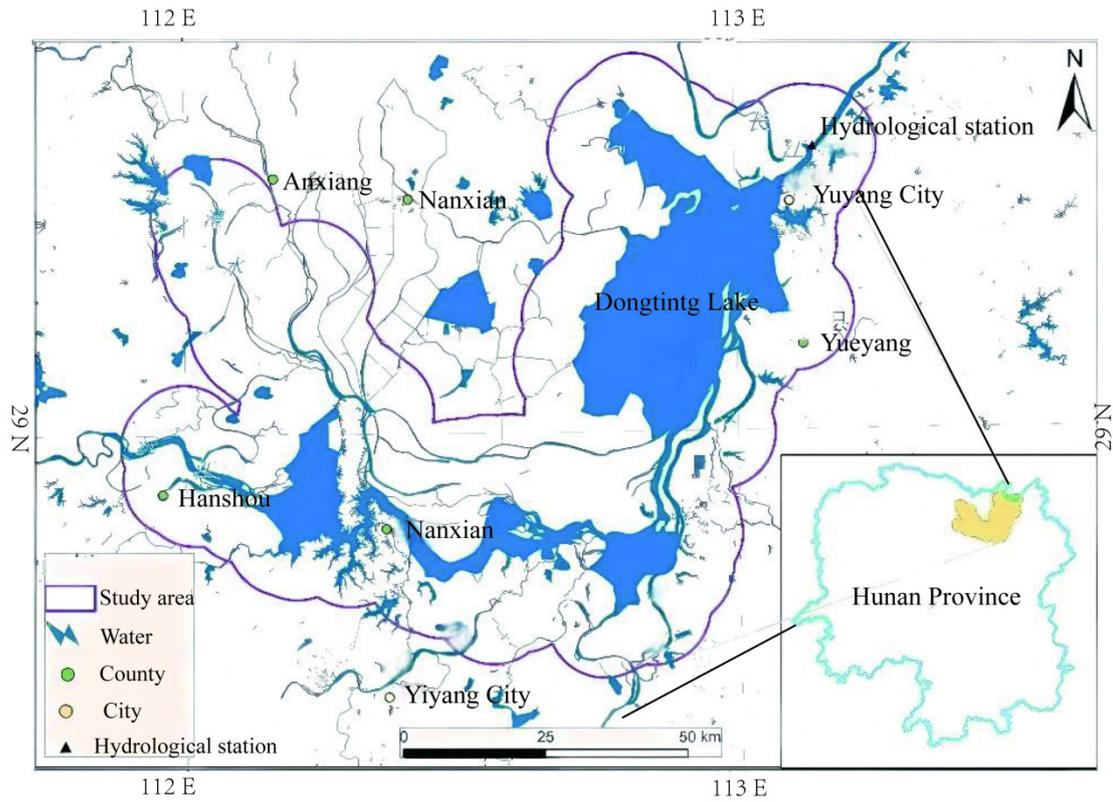


Fig. 1. Location of Dongting Lake and the extent of the study area.

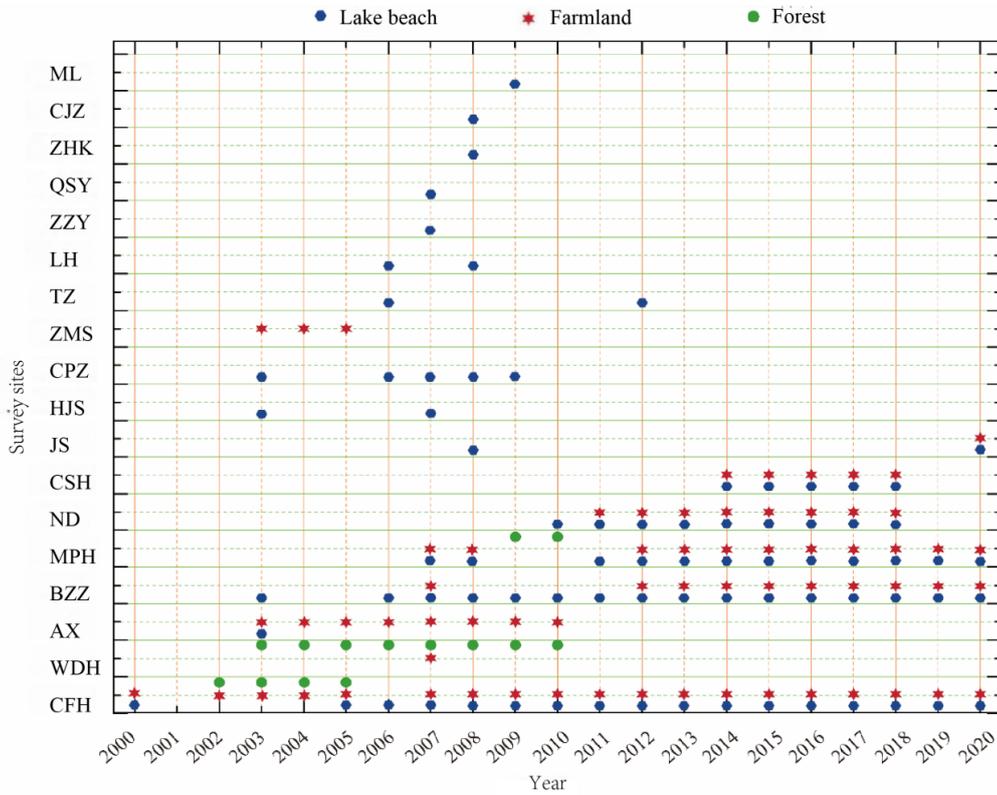


Fig. 2. Infographic of survey sites in the study area.

Note: Vertical coordinates are abbreviations of the initials of the Chinese names of the different investigation sites, and more detailed information can be found in the previous reports of the research group [19].

in Dongting Lake, the rodents on the Dongting Lake beach also periodically migrate between the beach and nearby farmland every year [20]. During the migration of rodents into agricultural land, if the rodent population is too high, it can cause a serious biological disaster [24]. Previous studies have shown that the migration distance of the rodent population on the Dongting Lake beach does not exceed 10 km [20], so the study was conducted with a 10 km buffer around Dongting Lake as the research area of this study.

Between 2000 and 2020, 18 survey sites were selected to monitor characteristics of the rodent community in the Dongting Lake area, and the locations of the survey sites were based on our previous report [19]. The snap trap method was employed to investigate the rodent community, and rat clamps (150 mm × 80 mm) were bought from Guixi Mousing Tool Factory, Jiangxi, China [24]. Traps, baited with fresh sunflower seeds, were placed on the ground in the afternoon, and then collected the next morning [25]. During each survey, approximately 300 rodent traps were placed, with a 5-meter interval between each trap and a distance of at least 20 m between different survey lines. The community surveys were primarily focused on the lake beach, farmland, and forest habitats (Fig. 2). The surveys were designed to be conducted once per season, but water levels and other factors made it difficult to achieve this. Fig. 2 displays the survey frequency for surveys of different habitats at each site each year. More details of the survey sites and survey methodology, as part of a series of studies, are given in our previous reports, which are fully consistent [19].

### Land Use Types Change Monitoring

The data on land use types used in the study were obtained from China's Multi-Period Land Use Land Cover Remote Sensing Monitoring Dataset (CNLUCC) of the Resource and Environmental Science Data Platform (<https://www.resdc.cn>, accessed on 20 July 2025) [26]. This dataset is based on Landsat series satellite remote sensing images. It employs remote sensing information extraction methods and combines them with field surveys to continuously monitor the changes in China's land use types with reference to the current mainstream land use type (LUCC) classification system. The dataset has a long-time span and good classification accuracy (the overall accuracy is more than 85%), which can satisfy the research's demands for land use in the Dongting Lake area.

Land use type change is a gradual process, and the study selects remote sensing images of land use types in the Dongting Lake area at five time points: 2000, 2005, 2010, 2015, and 2020, respectively. The spatial resolution of the remote sensing data is 30 m. Referring to other research results and the actual situation of land use types in the Dongting Lake area [27], the study divides the land use types in the Dongting Lake area into six categories: arable land, forest land, grassland,

water, beach land, and construction land. In order to investigate the change characteristics of land use types in the Dongting Lake area over the past 20 years, the land use transition matrix and the land use dynamics were calculated, respectively [28]. The land use transition matrix can reflect the structural change characteristics of land use types over time, and land use dynamics can reflect the quantitative change of a land use type in the study area at different times and spaces [28].

### Correlation Analysis and Statistical Analysis

Rodent communities in the Dongting Lake area are characterized by two typical features: one is the periodic inundation of Dongting Lake's beaches, and the second is the reciprocal migration of rodent communities between the beaches and farmland [19, 20]. Surveys show that *A. fortis* and *A. agrarius* are the main rodent species in the Dongting Lake area. In the study, the characteristics of rodent communities in the Dongting Lake area were calculated by the proportion of rodents in different habitats at different sites and in different seasons. At the same time, rodent density and fatness were also calculated to analyze the correlation between rodent communities and land use types [19]. The proportion of different land use types was calculated with a 10 km buffer for each survey site, and a correlation analysis was done with rodent density and fatness.

In the study, land use type analysis was performed in ArcGIS 10.0, and correlation analysis was performed using SPSS 18.0. The rodent investigation process was authorized by Dongting Lake Station for Wetland Ecosystem Research, Institute of Subtropical Agriculture, the Chinese Academy of Sciences, and conducted under their supervision.

## Result

### Seasonal Dynamics of Rodent Proportion

In long-term rodent surveys, the main rodents in Dongting Lake include *M. fortis*, *A. agrarius*, *Rattus norvegicus*, *Micromys minutes*, *Niviventer confucianus*, *Niviventer fulvescens*, *Rattus tanezumi*, and *Rattus losea*. *Alexandromys fortis* and *A. agrarius* are the dominant rodent species, the proportion of which is much higher than that of other rodent species [19]. There are significant differences in the proportion of rodents on the beach and in farmland at different locations (Fig. 3). In CSH, the proportion of rodents on the beach has always been higher than that in farmland. Except in summer, CFH also has a higher number of rodents on the beach than in the farmland. In ND, the number of rodents on the beach is higher than in the farmland during winter and spring, but in autumn, the number of rodents in the farmland is higher than on the beach (Fig. 3a)). For *A. fortis*, it has a typical distribution pattern, that is, in all locations and seasons except for CFH

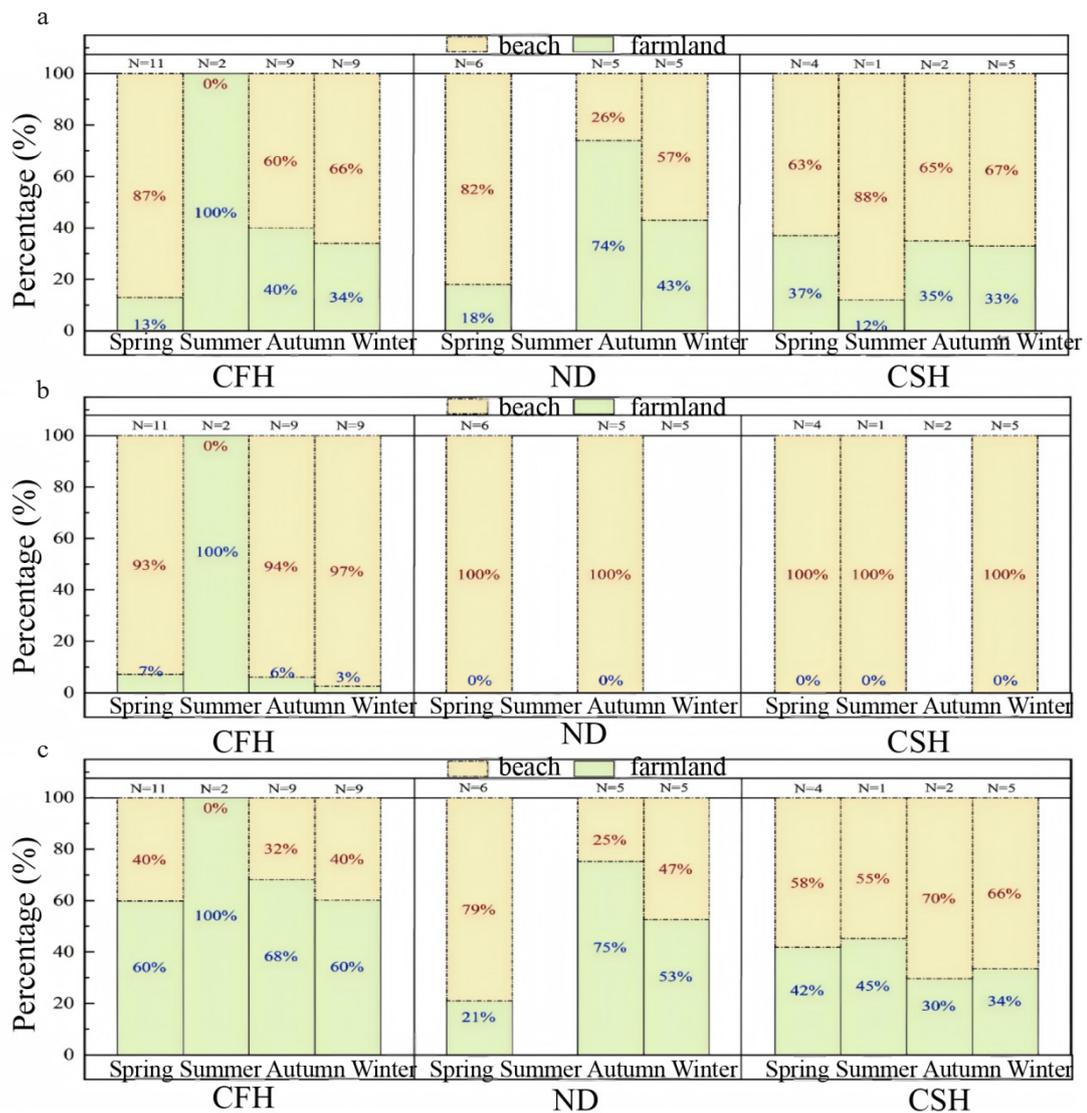


Fig. 3. Proportion of rodents in different habitats in different survey sites and seasons. Note: a) All rodent species; b) *Alexandromys fortis*; c) *Apodemus agrarius*

summer, the number of *A. fortis* on the beach is higher than that in farmland (Fig. 3b)). In CFH and ND, the distribution characteristics of the number of *A. agrarius* are similar. Except for the ND spring, the number of *A. agrarius* in farmland is higher than that on the beach, which is opposite to the pattern of *A. fortis*. In CSH, the distribution pattern of the number of *A. agrarius* is consistent with that of *A. fortis*, that is, the number on the beach is higher than on the farmland throughout the year (Fig. 3c)).

### Seasonal Dynamics of Rodent Fatness

Overall, in most survey sites, the winter fatness of *A. fortis* and *A. agrarius* is higher than in other seasons, but the seasonal variation pattern of fatness varies among different survey sites (Table 1). In the beach habitat, the fatness variation pattern of *A. fortis* and *A. agrarius* in BZZ is the same, with winter > autumn > spring >

summer, and the fatness in winter is significantly higher than the other three seasons ( $p < 0.05$ ). In the beach habitat of CFH, the fatness of *A. fortis* and *A. agrarius* showed the same trend as BZZ, but the difference was not significant ( $p > 0.05$ ). In the farmland habitat of CFH, the fatness of *A. fortis* and *A. agrarius* is the highest in winter ( $p < 0.05$ ). Regardless of whether it is a beach or farmland habitat, the fatness of *A. agrarius* in winter is significantly higher than in other seasons ( $p < 0.05$ ). In the ND lake beach habitat, the fatness of *A. fortis* in autumn and winter is maintained at a relatively high level ( $p < 0.05$ ). The fatness of *A. agrarius* in the farmland of CSH is highest in autumn and lowest in spring, with no significant seasonal difference ( $p > 0.05$ ). The fatness of *A. agrarius* on the beach is significantly higher in spring and winter than in autumn ( $p < 0.05$ ). The fatness of *A. agrarius* in the farmland of MPH is highest in winter, while it is highest in summer and lowest in autumn in the beach habitat, with significant differences ( $p < 0.05$ ).

Table 1. Seasonal dynamics of fatness of *Alexandromys fortis* and *Apodemus agrarius*.

Habitat	Species	Survey sites	Fatness (g/cm <sup>3</sup> )				p
			Spring	Summer	Autumn	Winter	
Farmland	<i>Alexandromys fortis</i>	BZZ	—	2.099±0.230 (N=9)	—	—	—
		CFH	2.701±0.584 (N=49)	2.448±0.446 (N=89)	2.470±0.214 (N=4)	—	<0.05
		ND	—	2.859±0.268 (N=2)	—	—	—
		MPH	—	2.474±0.403 (N=37)	—	—	—
	<i>Apodemus agrarius</i>	BZZ	—	2.631±0.600 (N=91)	—	—	—
		CFH	2.750±0.700 (N=47)	2.872±0.738 (N=36)	3.105±0.639 (N=60)	3.450±0.833 (N=18)	<0.05
		ND	2.987±0.689 (N=31)	2.826±0.589 (N=29)	2.705±0.443 (N=107)	3.175±0.792 (N=20)	<0.05
		CSH	2.927±0.648 (N=30)	2.977±0.778 (N=16)	3.247±0.879 (N=21)	3.155±0.589 (N=20)	0.375
		MPH	2.800 (N=1)	2.516±0.436 (N=44)	3.161 (N=1)	3.660±0.604 (N=3)	<0.05
		CPZ	—	—	—	—	—
Beach	<i>Alexandromys fortis</i>	BZZ	2.905±0.691 (N=399)	2.611±0.492 (N=186)	2.819±0.521 (N=10)	3.286±0.538 (N=83)	<0.05
		CFH	2.642±0.512 (N=567)	2.697±0.439 (N=76)	2.690±0.480 (N=50)	2.750±0.418 (N=40)	0.453
		ND	2.424±0.401 (N=147)	—	3.072±0.712 (N=8)	2.685±0.320 (N=23)	<0.05
		CSH	2.760±0.414 (N=45)	—	—	2.541±0.205 (N=2)	0.462
		MPH	—	2.453 (N=1)	—	3.001±0.430 (N=2)	—
		CPZ	2.561±0.375 (N=24)	2.323±0.296 (N=23)	—	2.527±0.096 (N=2)	0.066
	<i>Apodemus agrarius</i>	BZZ	2.889±0.700 (N=303)	2.508±0.535 (N=464)	2.782±0.733 (N=116)	3.153±0.621 (N=158)	< 0.05
		CFH	2.812±0.660 (N=18)	2.626±0.384 (N=11)	—	2.864±0.670 (N=20)	0.676
		ND	2.791±0.494 (N=122)	—	2.501±0.481 (N=41)	3.108±0.463 (N=39)	< 0.05
		CSH	3.272±0.845 (N=49)	—	2.314±0.369 (N=48)	3.283±0.887 (N=22)	< 0.05
		MPH	3.155±0.722 (N=65)	3.590±0.763 (N=4)	2.843±0.453 (N=48)	3.210±0.560 (N=49)	< 0.05
		CPZ	2.643±0.222 (N=2)	2.303±0.390 (N=9)	—	2.764 (N=1)	0.347

### Changes in Land Use Types

Between 2000 and 2020, the proportion of land use types in the Dongting Lake area remained relatively stable, with the largest being arable land and the second being water bodies, accounting for over 70% of the total area (Fig. 4). The proportion of arable land is the largest and fluctuates relatively little, basically stable at around

48%, mainly distributed around the periphery of the embankment. The water bodies mainly include lakes, rivers, reservoirs, etc. The area reached its maximum in 2005, reaching 2532.18 km<sup>2</sup>, accounting for 29.56%, and has been continuously decreasing since then. Among them, the East Dongting Lake has the largest reduction in water body area. The grassland area grew rapidly from 7.4% to around 10% during the period of 2005-

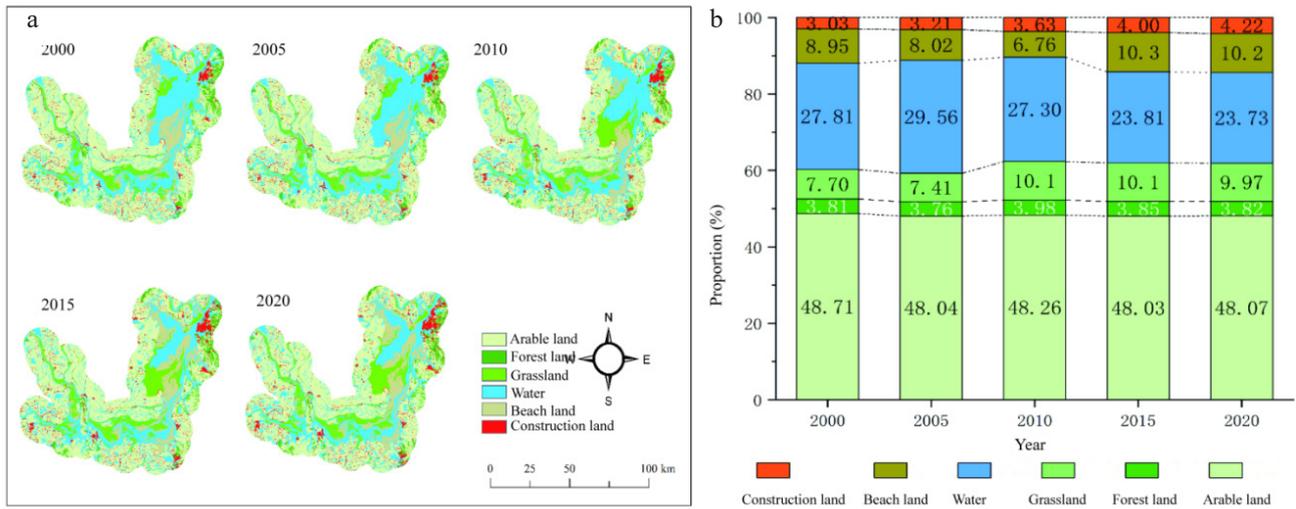


Fig. 4. a) Distribution and b) proportion of land use types in the Dongting Lake area from 2000 to 2020.

2010. The significant increase in grassland area was mainly distributed in the East Dongting Lake. From 2010 to 2020, the proportion of grassland area remained stable at around 10%. The proportion of beach area shows a trend of decreasing first and then increasing, with the smallest proportion of 6.76% in 2010, and an average of around 10% in 2015 and 2020. Forest land is mostly distributed in the hilly areas of the northeast of the region, with the smallest proportion in 2005 and the largest in 2010, and then slowly decreasing from 3.98% to 3.82%. Construction land continues to increase, from 259.17 km<sup>2</sup> in 2000 to 261.76 km<sup>2</sup> in 2020, with the proportion growing from 3.03% to 4.22%.

#### Transfer Matrix of Land Use Types

The main habitat of rodents on the beach is grassland. Between 2000 and 2010, the grassland area grew rapidly, increasing by 202.75 km<sup>2</sup>, mainly from the water bodies and beaches, with the most significant increase in the East Dongting Lake area (Fig. 5). But between 2010 and 2020, the grassland area decreased by 8.29 km<sup>2</sup>, mainly converted into arable land (8.97 km<sup>2</sup>). During the study period, the grassland area increased

by 194.24 km<sup>2</sup>, mainly coming from the water bodies and beaches. The main habitat of rodents outside the embankment is the farmland. During the research period, the arable land area continued to decrease by 54.67 km<sup>2</sup>, mainly converted into water bodies and construction land. From 2000 to 2020, the order of land use dynamics from large to small is: construction land > grassland > water > beach land > arable land > forest land (Table 2). The land use dynamics of arable land and water are negative, while forest land, grassland, beach land, and construction land are positive, with the fastest growth rate being 1.98%/a for construction land.

#### The Relationship between Land Use Type, Population Density, and Fatness

Considering that BZZ and CFH have the best continuity in rodent surveys (Fig. 2), the study chose the two locations mentioned above to analyze the relationship between rodent density, fatness, and land use types. There is no significant relationship between the population density of *A. fortis* and *A. agrarius* and land use type in the two locations mentioned above (Table 3,  $p > 0.05$ ). The relationship between fatness

Table 2. Dynamic attitude of land use in the Dongting Lake area during 2000-2020.

Land use types	Land use dynamics (%)		
	2000-2010	2010-2020	2000-2020
Arable land	-0.09	-0.04	-0.07
Forest land	0.44	-0.40	0.01
Grassland	3.07	-0.10	1.47
Water	-0.18	-1.31	-0.73
Beach land	-2.45	5.09	0.70
Construction land	2.01	1.62	1.98

Table 3. Statistical correlation between population density and land use in different survey points.

Population characteristics	Survey sites	Species	Arable land		Forest land		Grassland		Water		Beach land		Construction land	
			r	p	r	p	r	p	r	p	r	p	r	p
Population density	BZZ	<i>Alexandromys fortis</i>	0.841	0.364	0.606	0.586	-0.111	0.929	0.743	0.467	-0.766	0.445	-0.450	0.703
		<i>Apodemus agrarius</i>	-0.542	0.636	-0.796	0.414	-0.994	0.072	-0.670	0.532	0.644	0.554	0.894	0.296
	CFH	<i>Alexandromys fortis</i>	0.060	0.924	-0.270	0.660	0.168	0.788	-0.480	0.413	0.538	0.349	0.424	0.476
		<i>Apodemus agrarius</i>	-0.300	0.624	-0.198	0.750	0.313	0.608	-0.502	0.389	0.445	0.453	0.609	0.276
Fatness	BZZ	<i>Alexandromys fortis</i>	-0.499	0.392	0.186	0.764	0.832	0.081	-0.979	0.004	0.695	0.193	0.968	0.007
		<i>Apodemus agrarius</i>	-0.250	0.686	0.692	0.195	0.856	0.064	-0.684	0.203	0.199	0.748	0.063	0.253
	CFH	<i>Alexandromys fortis</i>	-0.493	0.399	-0.659	0.226	-0.425	0.487	0.166	0.790	0.272	0.658	-0.146	0.815
		<i>Apodemus agrarius</i>	0.650	0.235	0.169	0.785	-0.381	0.527	0.610	0.275	-0.654	0.231	-0.557	0.329

and land use types varies among different survey sites and rodent species (Table 3). In BZZ, there is a highly significant negative correlation between the fatness of *A. fortis* and water bodies ( $p < 0.01$ ), and a highly significant positive correlation with construction land ( $p < 0.01$ ). There is no significant correlation between the fatness of *A. agrarius* and all land use types ( $p > 0.05$ ).

## Discussion

From 2000 to 2020, the arable land and water area in the Dongting Lake region continued to decrease, while the construction land continued to increase. This may be related to factors such as the construction of the Three Gorges Project, the rapid development of local urbanization, and the balance between cultivated land occupation and compensation, which is consistent with the research results of Deng Chuxiong et al. [29]. Sedimentation is an important reason for the reduction of water in Dongting Lake [30]. Therefore, planting trees and preventing soil erosion around Dongting Lake are important measures to prevent further shrinkage of Dongting Lake. The Three Gorges Project is another important reason for changing the land use types in the Dongting Lake area [31]. The increase in grassland and beach areas during the research period is related to the changes in the hydrological characteristics of Dongting Lake since the operation of the Three Gorges Project. In addition, the project of returning farmland to lakes during the research period also promoted the transformation of arable land into wetlands [32].

A series of studies were conducted on the land use types and the quantity and species of rodents in Dongting Lake, while these studies often only focus on individual land use type factors. The study on the area of beach and the population density of *A. fortis* shows that the continuously expanding beaches are conducive to an increase in the density of *A. fortis*, providing a huge source of rodents for rodent disasters in the region [33]. This study systematically analyzed the correlation between rodent density and all land use types for the first time, and the results showed no significant relationship, which contradicts our experience and some previous results. The reasons may mainly include the following aspects. Firstly, it is closely related to the monitoring method of rodent density. Although the snap trap method is the most commonly used method for rodent investigation, it is easily influenced by various factors, including the experience of the implementing personnel, external environment, etc., especially when the absolute number of rodents is not large. Based on this, more rodent monitoring methods have been applied, such as intelligent monitoring, eDNA [34, 35]. The absolute number of rodents in the Dongting Lake area is usually not high, lower than the environmental capacity. They mainly gather in limited spaces under flooding pressure, ultimately leading to rodent disasters [20]. Therefore, the occasional errors in daily monitoring are relatively

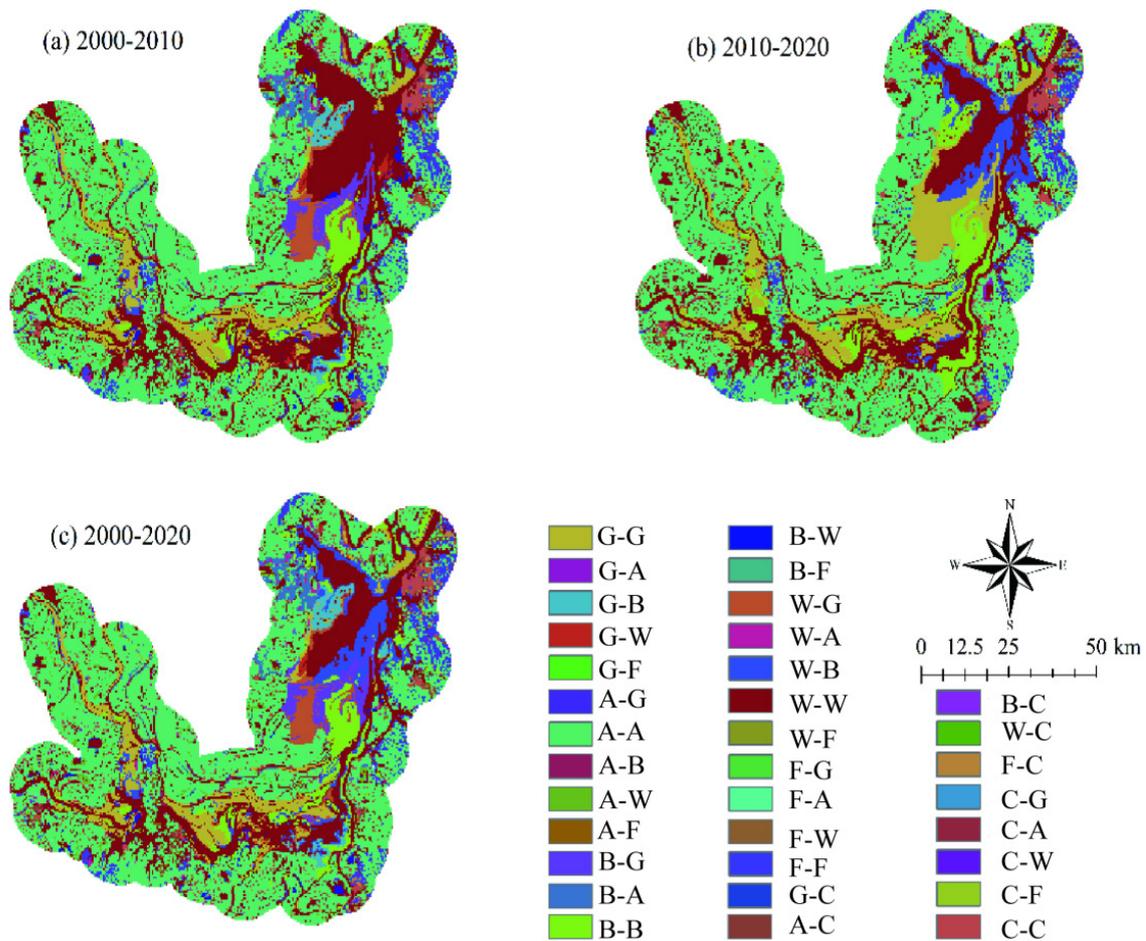


Fig. 5. Land use type transfer in the Dongting Lake area from 2000 to 2020  
 Note: A: Arable land, B: Beach land, C: Construction land, F: Forest, G: Grassland, W: Water

large. In the practice of rodent pest management, rodent outbreak risk assessment can be carried out based on land use types [20], but the correlation analysis of daily monitoring may be masked by errors. The second reason is that the number of rodents is significantly related to more characteristics of land use types, rather than just to the proportion of land use type area. Previous studies have shown a significant correlation between vegetation coverage and rodent density [19], and vegetation coverage is the result of the combined effects of land use type and vegetation type. The analysis of the landscape pattern characteristics of land use types in Dongting Lake shows that an increase in water fragmentation is beneficial for an increase in the number of *A. fortis*, while the closer the shape of construction land patches is to a square or circle, the lower the capture rate of rodents in houses, and the larger the patch area, the greater the impact of its shape on the overall rodent capture rate in the region [36]. The rodents' fatness is the most commonly used comprehensive physiological indicator to measure their adaptation to the ecological environment, which can provide a more specific understanding of their growth and development, and plays an important role in analyzing population dynamics. Previous research results showed that the

female *A. fortis* are more sensitive to environmental factors than the males and habitat and food available may affect the fatness of the female *A. fortis* and then explain the population increasing [37]. In this study, the fatness of *A. fortis* was significantly correlated with water bodies and construction land, which is consistent with previous research results. Comparing population density and fatness, research suggests that fatness is more suitable for monitoring rodent populations. Research has shown that as land use changes, the structure of rodents also undergoes changes [38]. Therefore, it is necessary to choose appropriate monitoring methods to continue long-term rodent monitoring in response to the current situation of rodent management in the Dongting Lake area.

### Conclusions

The changes in natural elements and the implementation of various regulations and policies have led to significant changes in land use in the Dongting Lake area. During the period of 2000-2020, the main activity areas of rodents in the Dongting Lake region were farmland and water bodies, followed by beaches,

grasslands, construction land, and forests. During this period, the construction land continued to increase, and the arable land and forest land remained stable. The *A. fortis* and *A. agrarius* are currently the dominant mouse species in the Dongting Lake area, but there are spatial and seasonal differences. During this period, there was no significant relationship between the density of *A. fortis* and *A. agrarius* and the area of different land use types, but the fatness of *A. fortis* was significantly correlated with water body area and construction land area. Research suggests that land use types can be used to assess the risk of rodent outbreaks in the Dongting Lake area, but at the same time, more effective methods for monitoring rodent populations should be developed to explore the characteristics of land use types in order to achieve effective management of rodent populations in the region.

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### Conflict of Interest

The authors declare no conflict of interest.

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