Research on accuracy of field patrol data based on GIS

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Abstract. Field patrol is the main method of wildlife protection, which plays a very important role in the protection and management of natural resources and biodiversity in nature reserves. However, it is difficult to completely evaluate the patrol accuracy, because it is impossible to preset the animal site in advance. Based on patrol data collected from the First Ecological Guard Competition, the accuracy of patrol route, animal site and geographical factor of animal site and GIS method are evaluated and analyzed. The results show that: (1) the patrol route has the highest accuracy, and the average accuracy is 87.91%, which indicates that ranger could basically patrol according to the preset patrol route; (2) the accuracy of animal site is not as good as that of patrol route, and the average accuracy is 51.10%, mainly because recorded animals are not right, standardized and complete; (3) the altitude accuracy is high, the slope accuracy is very low. It is recommended that slope data would no longer be recorded in the future and be directly obtained by GIS method. The results are helpful to improve the patrol accuracy evaluation system.

1. Introduction

Field patrol is the most important and basic work in management of nature reserves. It is the most direct and effective protection and management measure for natural resources and biodiversity in nature reserves, especially the main methods of wildlife protection [1]. Therefore, regular daily patrols in the nature reserve are very important for the protection and management of nature reserves [2].

In the world, the long-term patrol of wildlife population has been a set of standardized and repeatable work [3-4]. Domestic scholars have studied the field patrol mode [1], management system [5], technical regulations [6] and accuracy [7-8]. In the field patrol work, the patrol route can be preset, but it is impossible to preset animal site in advance, so there are few studies on patrol accuracy, and the evaluation system is not complete and systematic.

Based on actual and preset patrol data, the accuracy of field patrol from patrol route, animal site and geographical factor of animal site, and GIS method are analyzed in this paper, and the accuracy of patrol results is quantitatively evaluated.

2. Methodology

2.1. Study areas and data

The study area is Shaanxi Louguantai State owned Experimental Forest Farm in China, which is located in the northern middle part of Qinling Mountains and Zhouzhi County. There are 241 species of wild animals[9]. Study area is shown in Figure 1.
Altitude, slope and other geographical factors have a significant impact on the spatial distribution of animals [10]. Therefore, the data used in this paper includes two parts; route and animal site data, and geographical factor data such as altitude and slope.

Patrol route and animal site data: data are obtained from the First Ecological Guard Competition held in Shaanxi Louguantai State owned Experimental Forest Farm, China in November 2020. Thirty teams from nature reserves or forest farms in Shaanxi province participated in the competition and these players are all rangers. The patrol route and animal site data include preset data and actual patrol data, respectively. (1) Patrol route: according to the terrain of the forest farm, considering the actual situation of field patrol work, the preset route is based on the principle of "using the shortest distance to cross the most habitat types, and taking into account different terrain and landform", and ten patrol routes are preset, which is called “preset patrol route”, and each length is controlled at about 1 km. The actual patrol route obtained by each team is called “actual patrol route”. (2) Animal site: firstly, the organizer evenly and randomly arranges animal site on each preset patrol route, which is called “preset animal site” and records the longitude and latitude. The animals are common wild animals in the area. About 20 animal sites were set up on each route, and 227 animal sites are set on 10 routes. During patrol process, each team records the actual animal site which is called “actual animal site”.

There are 30 teams and 10 preset patrol routes, so each patrol route is completed by three different teams successively and independently, and 30 actual patrol routes and 590 actual animal sites are obtained. Preset patrol routes and preset animal sites are shown in Figure 1 and Table 1.

Geographical factor data: altitude and slope data. (1) Based on digital elevation model (DEM), the altitude and slope of animal site are extracted: DEM is from the Geospatial Data Cloud of Computer Network Information Center of Chinese Academy of Sciences [11], the spatial resolution is 30 m. Altitude and slope are extracted by DEM, which is called “altitude and slope calculation value of animal site”. (2) Altitude and slope of animal site recorded in the actual patrol: during the actual patrol process, each team records the altitude of animal site based on Ovital Map. In the field patrol, the slope is usually estimated by ranger according to their experience, which is called “altitude and slope recorded value of animal site”.

2.2. Methodology
(1) Methods used to measure patrol route accuracy: that is to evaluate the consistency level between actual patrol route and preset patrol route. Because actual and preset patrol routes are line data and cannot be compared directly, in research of wildlife protection and patrol, line data is usually changed into area data for comparison. A 30 m buffer zone is generated on both sides of a preset patrol route, which is called “preset patrol belt”. Preset patrol belt areas are shown in Table 1. Similarly, “actual patrol belt” is generated. Proportion of actual patrol belt area to preset patrol belt area is calculated (referred to as "proportion of patrol belt area"). The higher the proportion is, the more consistent the actual patrol belt is with the preset patrol belt, and the more accurate the patrol route is.

Figure 1. Study area and preset patrol routes.
(2) **Methods used to measure animal site accuracy:** actual animal site location (longitude and latitude) should not only be within 30 m of preset animal site location but also have the same name in order to be considered as a valid site. The more effective the number is, the higher the accuracy of animal site is.

(3) **Methods used to measure geographical factor of animal site accuracy:** altitude and slope calculation value and recorded value of animal site are compared. The closer the two values are, the higher the accuracy is. In order to measure the difference between calculation value and recorded value, deviation is used here. The larger deviation absolute value is, the lower the accuracy is.

Deviation is calculated by:

\[
d = \frac{\sum_{j=0}^{i} \left(\frac{a_j - b_j}{b_j} \times 100\%\right)}{i}
\]

Where \(d\) is deviation, \(a_j\) is recorded value of the \(j\)-th altitude or slope, \(b_j\) is calculation value of the \(j\)-th altitude or slope, and \(i\) is the total number of animal sites.

### 3. Results and analysis

#### 3.1. Patrol route accuracy analysis

Consistency level between actual patrol route and preset patrol route, that is, the proportion of patrol belt area, is shown in **Table 1**. In general, the proportion of patrol belt area of each team is close to 100%, which indicates that actual patrol routes fit preset patrol routes well, and patrol route accuracy is high. The average proportion of patrol belt area is 87.91%, and the highest proportion is 98.32%, which is almost coincides with the preset patrol route. The lowest proportion is 51.44%. The overall accuracy of patrol route is high. At present, ranger could basically patrol according to the preset patrol route.

| No.  | Preset patrol route length (m) | Preset animal sites number | Preset patrol belt area (km²) |
|------|-------------------------------|---------------------------|-----------------------------|
| No.1 | 1036.92                       | 21                        | 0.061                       |
| No.2 | 972.40                        | 22                        | 0.057                       |
| No.3 | 1379.52                       | 24                        | 0.071                       |
| No.4 | 1268.55                       | 24                        | 0.071                       |
| No.5 | 1192.12                       | 24                        | 0.069                       |
| No.6 | 931.87                        | 22                        | 0.059                       |
| No.7 | 1038.59                       | 22                        | 0.059                       |
| No.8 | 966.25                        | 22                        | 0.052                       |
| No.9 | 1007.24                       | 22                        | 0.060                       |
| No.10| 1276.70                       | 24                        | 0.068                       |

#### 3.2. Animal site accuracy analysis

The accuracy of animal site is shown in **Table 2**. The overall accuracy of animal site is not as high as that of patrol route. The average accuracy of animal site is 51.10%, the highest is 85.71%, the lowest is 16.67%.

There are several factors affecting the accuracy of animal site. One is that ranger does not know the animals, or the animal’s name records are not standardized, incomplete, or accurate. Second, because ranger is not proficient in using Ovital Map. Third, there are errors in recorded data of animal location, such as the incorrect record of longitude and latitude value, and the insufficient reservation of decimal numbers.
3.3. Geographical factor of animal site accuracy analysis

The deviation results of geographical factors (altitude and slope) of animal site are shown in Table 2. In general, the altitude deviation is small, the average deviation of altitude is -3.95%, indicating that altitude accuracy is high, and recorded value is slightly less than calculation value. The maximum positive deviation of altitude is 14.97%, the minimum is 0.42%, while the maximum negative deviation is -0.50%, the minimum is -12.46%. In general, the slope deviation is large, the average deviation is 79.29%, indicating that the accuracy of slope is low, and recorded value is much larger than calculation value. The maximum positive deviation is 364.35%, the minimum is 2.27%, while the maximum negative deviation is -2.00%, and the minimum is -28.66%.

According to the deviation of geographical factor of animal site, the altitude deviation is not big, but the slope deviation is very large. This indicates that there is no problem with the altitude record. Because the slope is the estimate in the field according to the ranger’s experience, the deviation is very large. It is recommended that slope data would no longer be recorded in the future and be directly obtained by GIS method.

Table 2. Statistics accuracy of patrol routes, animal sites and geographical factor of animal sites.

| Patrol route number | Proportion of patrol belt area (%) | Animal sites accuracy (%) | Altitude deviation (%) | Slope deviation (%) | Patrol route number | Proportion of patrol belt area (%) | Animal sites accuracy (%) | Altitude deviation (%) | Slope deviation (%) |
|--------------------|-----------------------------------|--------------------------|-----------------------|--------------------|--------------------|------------------------|------------------------|-----------------------|--------------------|
| No.1-1             | 91.33                             | 85.71                    | -12.32                | 102.50             | No.6-1             | 86.22                   | 27.27                  | -8.88                 | 99.18              |
| No.1-2             | 91.35                             | 42.86                    | -8.92                 | 364.35             | No.6-2             | 85.91                   | 59.09                  | -8.47                 | 187.31             |
| No.1-3             | 95.88                             | 47.62                    | -9.54                 | 191.53             | No.6-3             | 91.48                   | 63.64                  | -12.46                | 219.27             |
| No.2-1             | 95.74                             | 50.00                    | -1.36                 | 62.27              | No.7-1             | 90.16                   | 50.00                  | -1.80                 | 88.97              |
| No.2-2             | 96.07                             | 27.27                    | -0.50                 | -25.43             | No.7-2             | 93.55                   | 68.18                  | -2.40                 | 53.29              |
| No.2-3             | 93.44                             | 50.00                    | -0.88                 | 2.27               | No.7-3             | 94.73                   | 68.18                  | -2.71                 | 70.41              |
| No.3-1             | 94.92                             | 45.83                    | -4.25                 | 126.98             | No.8-1             | 91.70                   | 68.18                  | -3.57                 | 118.25             |
| No.3-2             | 95.92                             | 62.50                    | -4.95                 | -2.00              | No.8-2             | 51.44                   | 50.00                  | -5.25                 | 84.70              |
| No.3-3             | 91.19                             | 58.33                    | -3.64                 | 146.86             | No.8-3             | 98.32                   | 72.73                  | -4.41                 | 37.63              |
| No.4-1             | /                                 | 58.33                    | -4.91                 | 49.51              | No.9-1             | 97.34                   | /                      | 14.97                 | -18.04             |
| No.4-2             | 93.88                             | 58.33                    | -3.48                 | /                  | No.9-2             | 97.16                   | 68.18                  | 0.42                  | -19.23             |
| No.4-3             | 90.15                             | /                        | -1.54                 | 19.43              | No.9-3             | 95.17                   | 59.09                  | 2.19                  | -21.11             |
| No.5-1             | 95.82                             | 16.67                    | -2.65                 | 102.68             | No.10-1            | 92.47                   | 58.33                  | -6.75                 | 11.91              |
| No.5-2             | 93.94                             | 62.50                    | -4.76                 | 208.83             | No.10-2            | 83.28                   | 45.83                  | -5.74                 | -17.14             |
| No.5-3             | 95.21                             | 66.67                    | -3.81                 | 82.94              | No.10-3            | 73.67                   | 41.67                  | -6.20                 | -28.66             |

Note: No.1-1 represents the first preset patrol route obtained by the first group, No.2-1 represents the second preset patrol route obtained by the first group, and the rest are named in a similar way. "/" indicates that the data is lost.

4. Discussion

Through field patrol, it could be fully understood the population status and distribution of wild animals [2]. In the field patrol work, the patrol route can be preset, but the animal site cannot be preset in advance, so it is difficult to make a complete and systematic evaluation of the patrol, especially the animal site accuracy. Based on the First Ecological Guard Competition, using actual and preset patrol data to quantitatively evaluate and analyze, which helps to improve the patrol evaluation system and provide reference for future field patrol work.

The methods and data of GIS provide help for patrol research. In this paper, several tools such as buffer analysis and extraction analysis are used in ArcGIS software, which not only provides a method
for the accuracy evaluation of patrol but also is fast and visual way. In the future research, GIS method could be used to analyze patrol data and make more contributions to theoretical research of patrol systems, such as scientific planning and management of nature reserves based on GIS.

5. Conclusions
(1) The patrol route has the highest accuracy, and the average proportion of patrol belt area is 87.91%, which indicates that ranger could basically patrol according to the preset patrol route.

(2) The accuracy of animal site is not as good as that of patrol route, and the average accuracy rate is 51.10%, mainly because recorded animals are not right, standardized and complete.

(3) The altitude deviation is small, the altitude accuracy is high, and recorded value is slightly less than calculation value. The slope deviation is very large, the slope accuracy is very low, and recorded value is far greater than calculation value, which indicates that ranger generally overestimate slope value according to ranger’s experience. It is recommended that slope data would no longer be recorded in the future and be directly obtained by GIS method.

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