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# Explanation of Intro to IS Lab 1: Year-round Orienteering

## Speed Setting

Based on the pictures of different terrains and human jogging speed, the max speed at all types of terrains are decided in table 1. And changes in terrains caused by seasons are also included. The slope affects the speed is considered as a linear decrease, the relation is exhibited in figure 1. The moving pattern is considered as only four directions (up, down, left, right) is applicable at each movement between pixels.

Table 1. The max speed and color of different terrains. *updated terrains with different color and speed

| Terrain type | Color on map (RGB) | Max speed (m/s) |
|---|---|---|
| Open land | 248, 148, 18 | 2 |
| Rough meadow | 255, 192, 0 | 1.5 |
| Easy movement forest | 255, 255, 255 | 1.8 |
| Slow run forest | 2, 208, 60 | 1.4 |
| Walk forest | 2, 136, 40 | 1.2 |
| Impassible vegetation | 5, 73, 24 | 0 (unreachable) |
| Lake/Swamp/Marsh | 0, 0, 255 | 0 (unreachable) |
| Paved road | 71, 51, 3 | 2.5 |
| Footpath | 0, 0, 0 | 2.2 |
| Out of bounds | 205, 0, 101 | 0 (unreachable) |
| *Footpath (Fall) | 150, 150, 150 | 1.8 |
| *Ice (Water area in Winter) | 100, 200, 255 | 1 |
| *Mud area (Spring) | 0, 0, 100 | 0 (unreachable) |

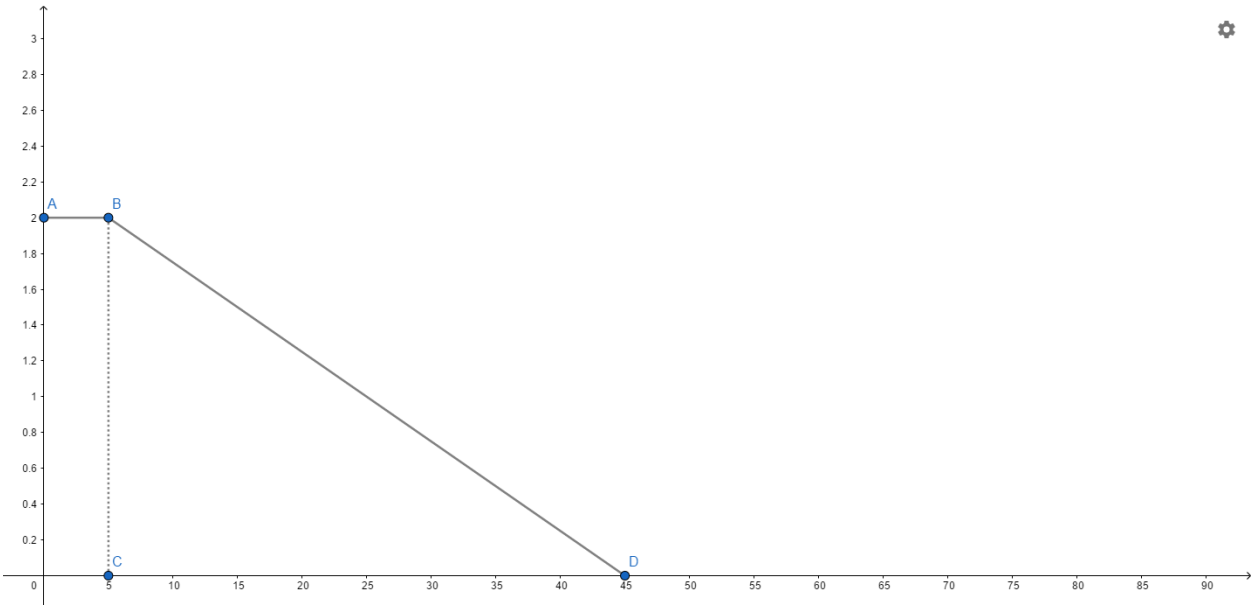

Figure 1. The pattern of speed decrease affected by slope. As an example of open land, the speed remains 2 m/s as the max speed when slope is less equal than 5°. The speed is considered as 0 when slope is greater than 45°. The speed is a linear decrease when slope is in between 5° and 45°. Uphill and downhill are considered as the same pattern

**Heuristic Function Implementation**

Each vertex represents each pixel in the map, the 3d-coordinate is the (x, y, z) in space. For A* Search, h(n) refers to the heuristic time cost, which is calculated as the straight line distance to the destination pixel divided by the max possible speed, the initial value is set as a max integer. g(n) refers to the cost time from the start pixel, which is calculated as the previous pixel's g(n) plus the real cost time from previous pixel to this pixel, the initial value is set as 0 (if the pixel is the start pixel, g(n) remains 0). f(n) refers to h(n) + g(n), the initial value is set as a max integer.

Since the orienteering is a time-oriented sport, the purpose is to find a route which takes the least time. Therefore, the f(n), also determined as the priority in queue of A* Search, should be a function of cost time instead of cost distance. And the g(n) is implemented as a cost time as well. However, the heuristic function should still be imaged as a direction to the destination pixel, which indicating the straight line distance, hence the least possible cost time is implemented as the heuristic function.

In addition, another back-up heuristic speed function which returns the max speed in terrains that the "straight line" crossed was tested as well, and it turned out that the final organized route did not show significant differences.

**Map Modification by Season**

Since the graph building function only connects vertices with a speed greater than 0, water area is not in the graph at the beginning. Thus, the condition of different season is applied and the map is updated before building the graph in order to optimize the efficiency. In fall, the "change_fall" function finds all footpath that near an easy movement forest and change it to grey color that keys of the speed in easy movement forest. In winter, the "winter_terrain" function determines whether a pixel is within 7-pixel range to any land. The "change_winter" function finds all pixels in water area and changes it to light blue if they are in range. In spring, the "spring_terrain" function collects all pixels within 15-pixel range near the water edge and marked it as mud area. The "change_spring" function checks if any pixel in mud area has an elevation less than 1 m and changes it to dark blue. After proper modification of the map image depending on different seasons, the updated map can be used for graph building and A* Search.

**Sample Output**

The optimal route(path) is shown in red color.

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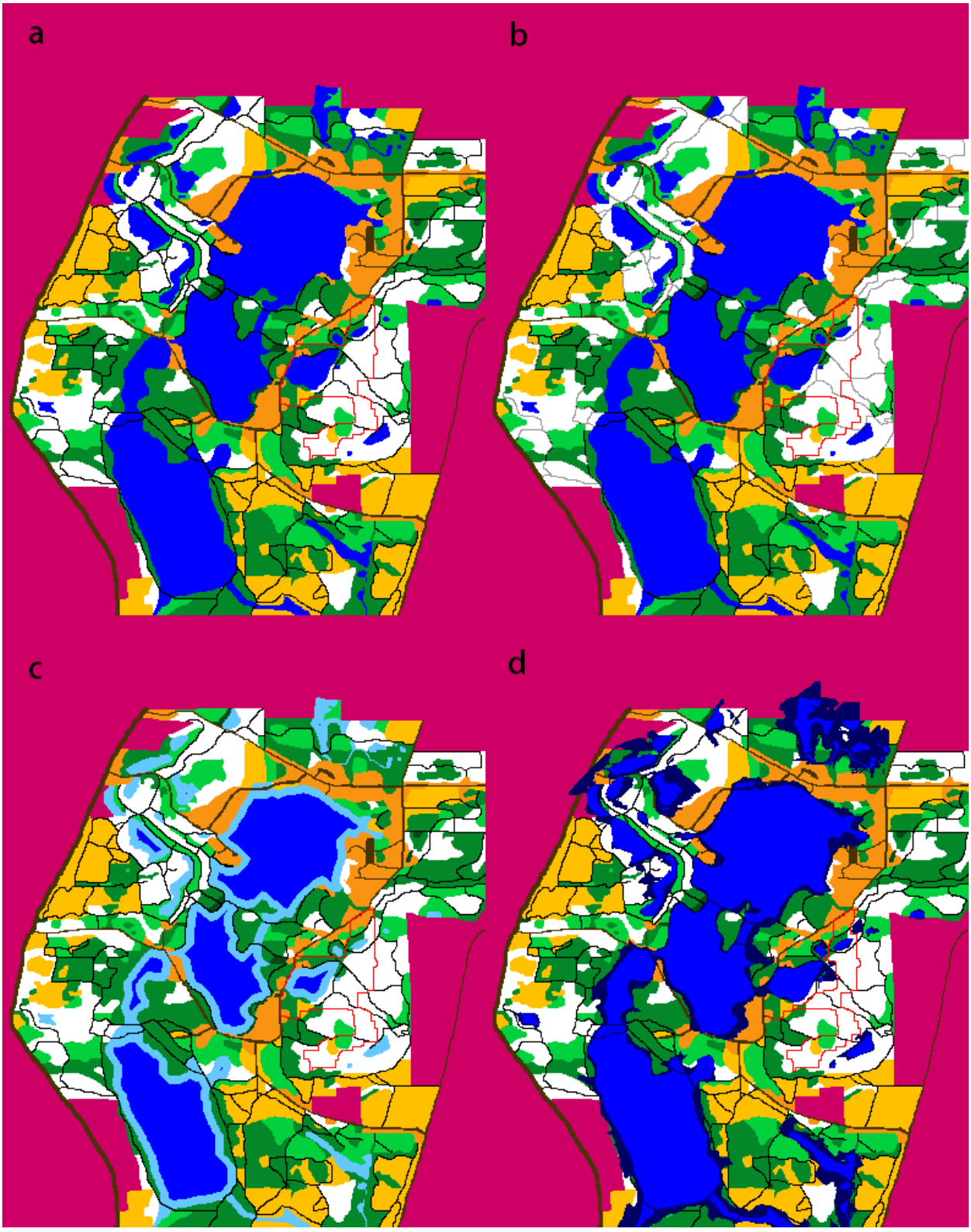


Figure 2. The route of "brown" in (a) summer, (b) fall, (c) winter, and (d) spring.

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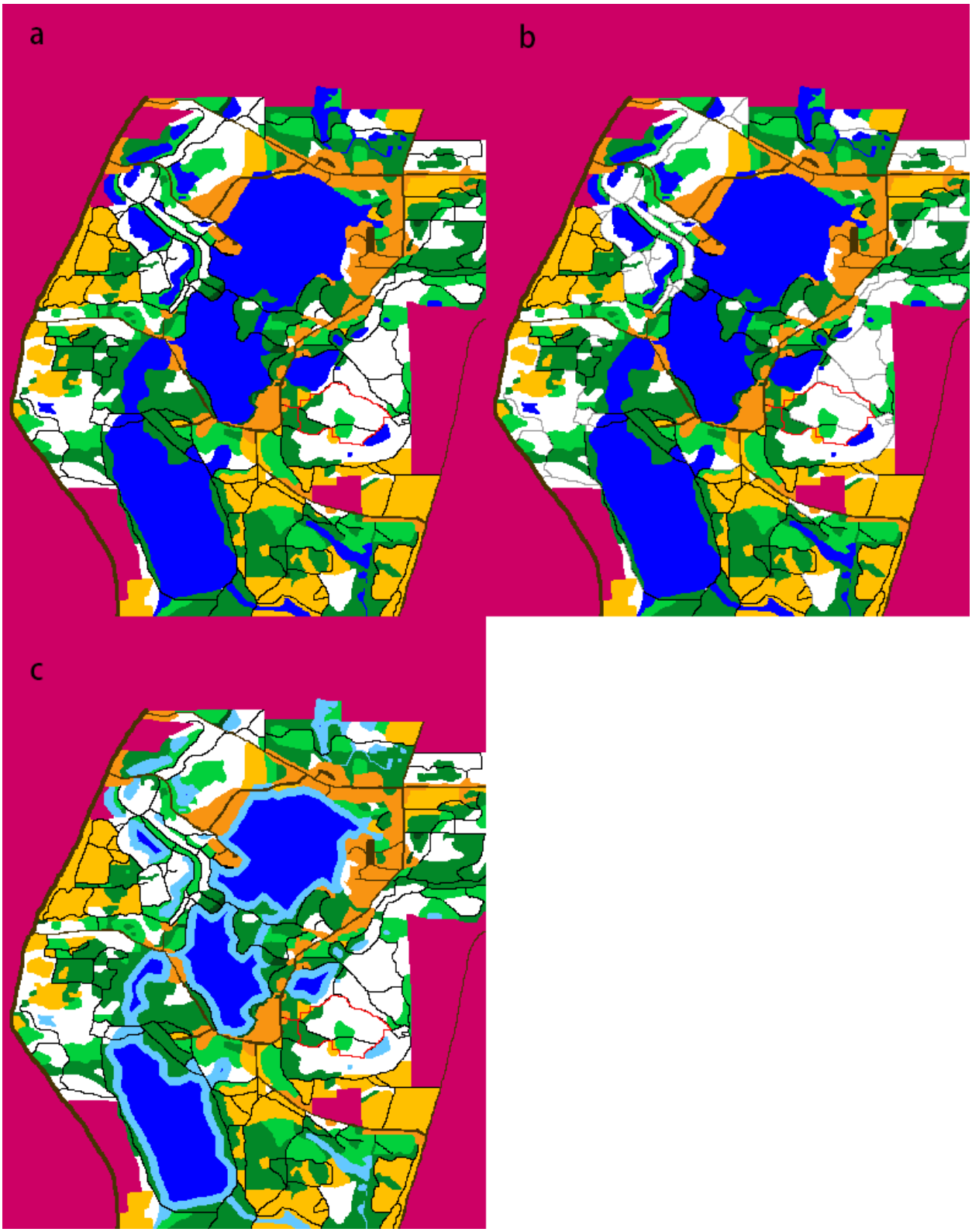


Figure 3. The route of "white" in (a) summer, (b) fall, and (c) winter. Spring is not applicable since one destination is in mud area.

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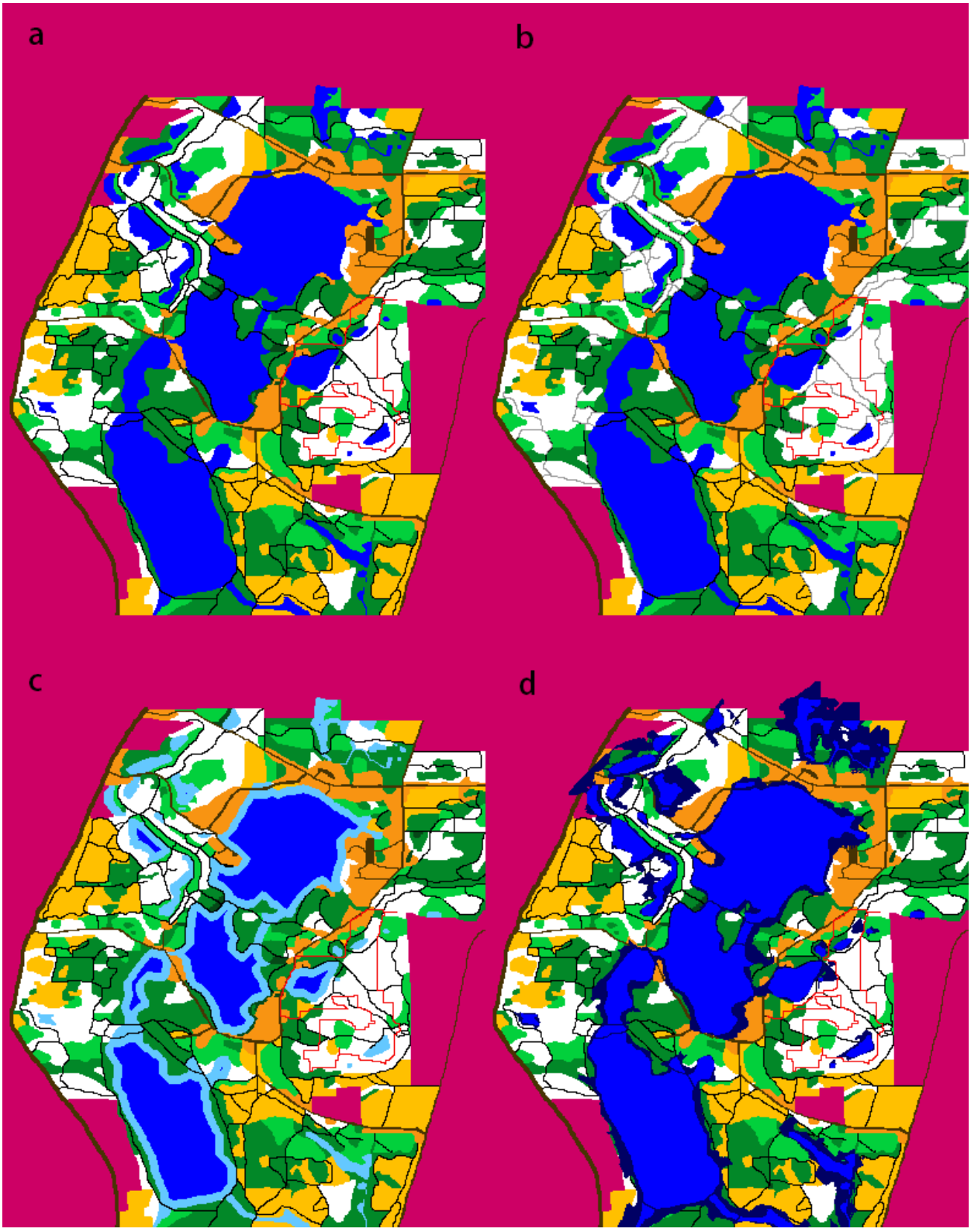


Figure 4. The route of "red" in (a) summer, (b) fall, (c) winter, and (d) spring.