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TGIS 415
Term Project Paper

In my project, I used GIS in order to locate potential sites where ski venues could be constructed in the state of Washington. To accomplish this task I created a list of criteria based on literature of ski resort planning and development, in addition to the features of existing resorts. A process of elimination then ensued to identify areas where ski resorts could be constructed. Once the potential sites were located, I proceeded to conduct a slope analysis in order to determine how conducive the site was to skiing and snowboarding, and digitized potential ski runs accordingly. The purpose of the project was to demonstrate how GIS could be used to identify potential sites for ski resort development companies.

The planning process for my project entailed creating a comprehensive list of criteria that would be useful for conducting ski venue site selection. I started with average snowfall, wind, topography, available land, and proximity to roads. However, in order to conduct all of the analyses I wanted to in my project, I would need not only a greater number of criteria but also more nuanced criteria. In order to achieve this I decided to change the purpose of the project slightly to not simply finding ski resort sites, but finding sites that would be the most successful, i.e. would generate the most business. Thus two more criteria would be added: the number and variety of slopes at the site (essentially a more nuanced version of my “topography” criteria), and reasonable accessibility (meaning within a reasonable proximity to major population centers).

Throughout my literature review and data collection process, I modified my criteria further. Snowfall and wind vary greatly by the specific location and thus aren’t available in GIS datasets. These would not have been particularly helpful anyway, however, because snowfall is generally reliable above 3,000 feet, and wind typically comes from the same direction. I also

wanted to include environmental factors, such as susceptibility to avalanches and harm to wildlife. However, not enough data has been collected on avalanche hazards, and this data would have to be site-specific. In terms of the environment, the U.S. Forest Service already has standards that must be met before a ski resort can be constructed. Resort planners must submit an environmental impact statement, which takes several years to complete, before a site is cleared for construction. I also modified my topographical criteria slightly; not only is it important for a site to have a variety of slopes, but the site should also be located on a north or east facing slope. At Washington's latitude the sun shines longer on south-facing slopes due to the earth's tilt, so north-facing slopes receive the least sunlight and consequently have the most snow. Also, an east-facing slope is important in order to take advantage of the prevailing winds (which come from the west).

After modification, my final set of criteria for ski area site selection were as follows: above 3,000 feet, on north or east facing slopes, features a variety of slope gradients, on available land (in terms of land use and land cover), reasonable proximity to major population centers, and close proximity to roads. Using this set of criteria I collected all relevant data, including roads, digital elevation models, land cover, and land use from numerous county GIS websites.

For the first phase of the project, I decided to narrow down usable land area as much as possible. I started by drawing rough lines around all areas where roads exceeded 3,000 feet in elevation. After locating these areas, I imported land use data and identified areas where ski resorts could be built. I looked through each of the attribute tables and found areas that were labeled as designated forest land, recreation, national and state parks, etc. I displayed all unusable designations in red and modified the lines I had drawn in order to exclude these areas.

Once this process was complete I could now begin a more specific site selection process within the boundaries I had created. I started by eliminating areas where there were too many roads (and hence not enough space for a resort to be built) and areas that were too far away from major population centers (such as Okanogan county). I then located areas where roads were in close proximity to north or east facing slopes. My search had now been narrowed down to 11 areas that potential ski areas could be constructed within.

Before I could continue the site selection process, I would need to analyze existing ski resorts in order to determine which specific geographic features were conducive to ski slopes. I decided to analyze just one of Washington's major resorts, Crystal Mountain, due to the extensive time it took to conduct the analysis. I digitized all of Crystal's ski runs and lifts, and classified then based on skill level (beginner, intermediate, advanced, and expert). I then imported the data into ArcScene, visualized it in 3D, and conducted a slope analysis. For each skill level of ski run I calculated a maximum grade (30 degrees for beginner, 35 for intermediate, 40 for advanced, and 45 for expert) and visualized them in a green-to-red color ramp. Slopes less than 30 degrees were green (conducive for any skill level), while slopes greater than 45 degrees were red (not conducive for any skill level). The best ski sites would need to have mostly green slopes near the bottom (where the parking and beginner areas would be), few red slopes, and plenty of intermediate slopes in the middle for varying skill levels.

Before conducting slope analysis on each of my potential sites, I collected DEMs and orthophotos of each site by exporting to the extent of the data frame in order to work with smaller file sizes (3D visualization in ArcScene consumes a lot of RAM, so smaller file sizes are needed). After collecting this data I proceeded to conduct slope analysis on northeast-facing slopes within each boundary I created and located areas that had slopes conducive to ski areas.

Using land cover data I marked out the boundaries of each individual site, thus completing the site selection process.

For the final phase of the project, I imported the slope data I had created in ArcScene into ArcMap and placed a transparent orthophoto on top of it in order to digitize the locations of parking, ski lifts, and ski runs at each site. I placed lifts in areas where multiple ski trails could branch off from them, and placed parking areas adjacent to roads on relatively flat surfaces. I tried to emulate the features of trails at Crystal Mountain while digitizing ski runs. After creating all of the sites I imported them into ArcScene and visualized them in 3D with an orthophoto, then calculated stats for each site, including the number of lifts, runs, total miles of trails, and the total vertical drop (highest trail point minus the lowest trail point). Sites were named based on the mountain they were located on or near (obtained in Google Earth).

Five sites were located in total, all located within the Cascade mountain range (two sites were found in the Olympics, but did not pass slope analysis). Skagit, Snohomish, and Lewis counties each had a site, and King County had two sites. The best of these sites was Hurricane Peak in Skagit County, with 46 runs and over 25 miles of trails (almost as large as Crystal Mountain), and the highest vertical drop of the selected sites. Skagit County currently has no major ski areas, so this would be a prime location for a ski resort. Snohomish County's Long John Mountain also makes for a decent location, with 37 runs and over 18 miles of trails.

Some potential problems with this project are that some of the most important analyses must be site-specific. GIS data is not nearly extensive enough to conduct an in-depth study of each individual site, which would be necessary in order to construct a ski resort in real life. Factors like snowfall and wind strength vary considerably by the specific location. Snowfall data is only collected at a few specific sites located several miles away from one another,[1] so it is

virtually useless for this project. In general, however, snowfall is reliably high during ski season above 3,000 feet, which is the criterion I used for the purpose of my project. Wind data is problematic because it is also scarce; no data is provided for each individual site, and wind strength varies greatly from location to location.

Another vital consideration for constructing ski resorts is the environmental impact. A considerable amount of construction must be done on ski sites in order to make the slopes conducive to skiing and snowboarding, which, as cited in several articles, has a negative impact on the local wildlife.[2] This data is not relevant to my project, however, because environmental impact studies are carried out by the U.S. Forest Service only after resort designs have been submitted.

Although the ski industry is growing as the population increases, it probably isn't feasible to build many more ski areas in developed countries due to the negative environmental impacts and the effects of climate change. As global warming worsens ski seasons will become shorter and snow lines will become higher.[3] This can be mitigated to some degree by snowmaking, snow grooming, and building resorts at higher elevations where snowfall is more reliable and the ski season is longer.[4] However, the environment is more sensitive at higher elevations, so this must also be taken into consideration.[5]

Endnotes:

1. Jordan A. Silberman & Peter W. Rees, "Reinventing mountain settlements: A GIS model for identifying possible ski towns in the U.S. Rocky Mountains," *Applied Geography,* vol. 30 (2010): 39.
2. Katja Kangas, et. al., "Ecological Impacts of Revegetation and Management Practices of Ski Slopes in Northern Finland," *Environmental Management*, vol. 44 (2009): 408-419.
3. Silberman & Rees, 40.
4. Daniel Scott & Geoff McBoyle, "Climate change adaptation in the ski industry," *Mitig Adapt Strat Glob Change*, vol. 12 (2007): 1414-1419.
5. Scott & McBoyle, 1419.

Bibliography

Kangas, Katja, et. al. "Ecological Impacts of Revegetation and Management Practices of Ski Slopes in Northern Finland." *Environmental Management*, vol. 44 (2009): 408-419.

Scott, Daniel and Geoff McBoyle. "Climate change adaptation in the ski industry." *Mitig Adapt Strat Glob Change*, vol. 12 (2007): 1411-1431.

Silberman, Jordan A. and Peter W. Rees. "Reinventing mountain settlements: A GIS model for identifying possible ski towns in the U.S. Rocky Mountains." *Applied Geography,* vol. 30 (2010): 36-49.