GEOS9016 - Consultancy Brief
Expansion of the Smiths Lake field station - 2021

The University is investigating the expansion of facilities at the Smith's Lake Field Station. This is primarily for accommodation but advice will be appreciated on expansion of other existing uses.

Google Earth view (Left): an overview of the Smiths Lake area with a red circle marking the location of the Field Station area. Right: multi-spectral airborne image of UNSW Smiths Lake Field Station (the square buildings, metallic top).

Your company has been engaged to identify where such expansion should take place.

You must identify a location or locations that will, in relation to the general area:

1. Minimise any construction costs.
2. Maximise the aesthetics.
3. Minimise the impact on any conservation issues at the site.
4. Minimise any impact arising from the construction (e.g. soil sediments, chemical and organic pollutant loads into the waterways). (see figures 2 and 3 that show closeness of the UNSW station to the lake)
5. Minimise the hazard from bushfires. (see Figure 1, wildfire of January 2021)

The project must be completed in two stages. Stage 1 is to develop a GIS database that will be used in the second stage. In Stage 2 you will use your database to identify the optimal location or locations for any expansion.

Stage 1. The data sets must be constructed such that they can be used in any future analyses. They must be geographically consistent. To indicate successful completion of this stage you are to provide a report on the development of your digital elevation model (DEM) of the area. You are also to provide metadata for the DEM using the ISO format. [This is the individual report to be submitted on the 7th July 2021, instructions have been posted in moodle]

Stage 2. The analyses that you implement in stage two must be fully documented and any relevant interpretations and recommendations given.

For further information please contact Graciela Metternicht through email (g.metternicht@unsw.edu.au) or by MS Teams.

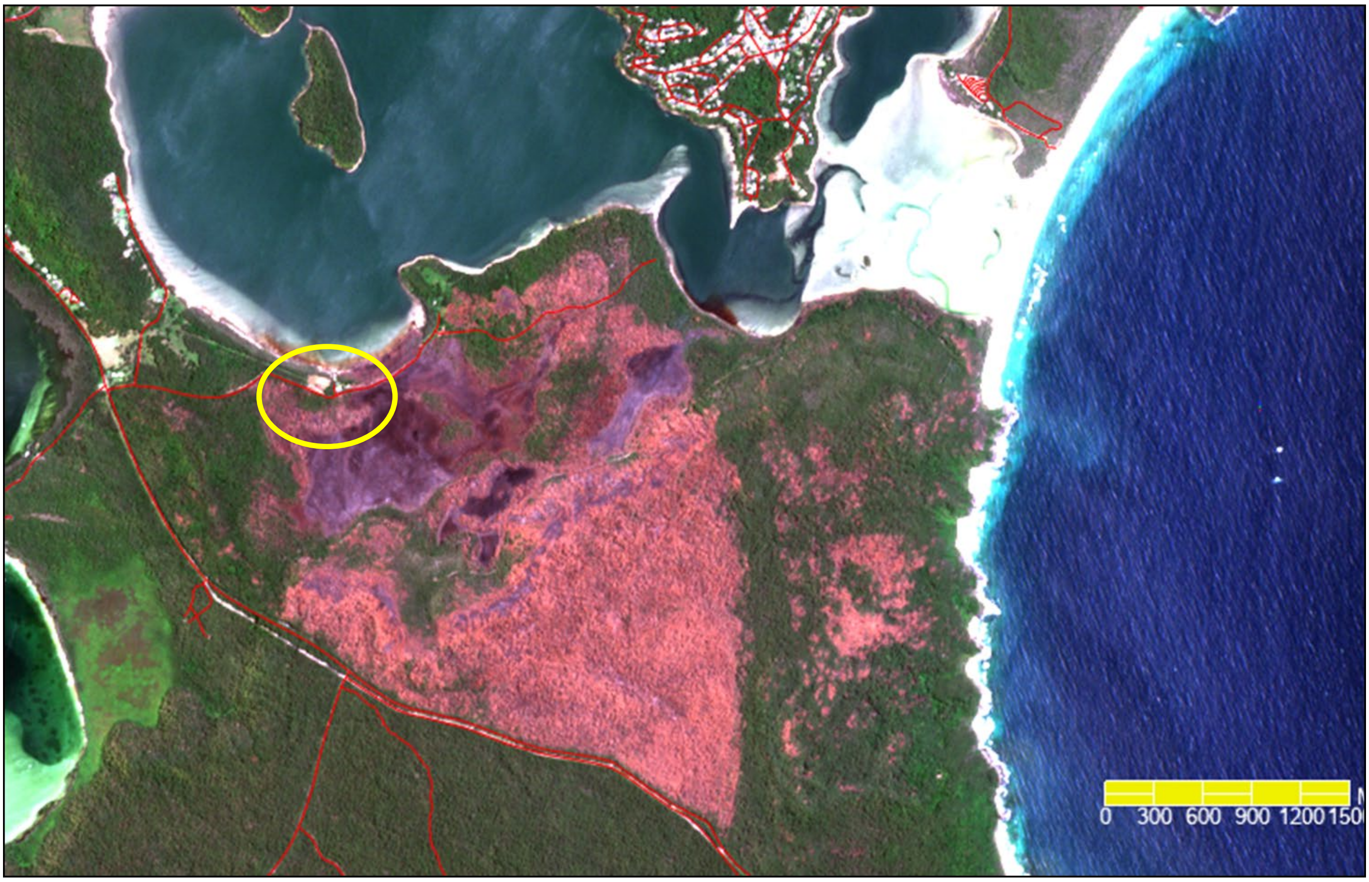

Figure 1 Satellite image showing the aftermath of a wildfire in mid- January 2021 (pinkish colours); the yellow circle shows the location of the Smiths Field Station building. Source: Sentinel-2 satellite image, 25.01.2021.

Figure 2: Satellite Image of early January 2021, prior to the wildfires. Red vectors are main rodas, vegetation greenness changes according to type of vegetation.

Figure 3: Higher spatial resolution images of Smiths Lake, the right image shows the location of the current buildings from UNSW (YELLOW circles)

Some notes

Now that the formal part is covered, here are some points to remember when reading the brief and doing the project work (in no particular order):

- People cause more problems than technology
- Everything changes faster than you would like, e.g. user expectations
- Uncertainty is always with us
- Everything interacts with everything else
- Users often have very imprecise ideas of what they want – even if they say otherwise
- There is no single best solution – usually there are several equivalent solutions
- If you encounter a problem then the chances are that someone else has already solved it, or has solved something similar.

Additional points:

- You **do not need** to provide metadata in stage 2. Only the DEM metadata is needed, and that is for stage 1.
- The marking criteria and expectations are included in the 'structure of the major report document' (access through Moodle).

Project overview

The major project consists of two main sections – collation and correction of the base data sets, followed by analysis for the purposes of identifying which locations are most suitable for a field station expansion.

The notes below are very general. The specifics are given in the lab instructions, or need to be worked out by you.

Initial references to the literature are given in the relevant lab instructions and the lecture notes.

Collection and collation of base data sets

Key steps:

1. Copy data from source location
2. Define projections (coordinate systems)
3. Ensure all layers are in a common coordinate system
4. Interpolate a digital elevation model (DEM) using the topographic data *(you have done that in the individual report; if you are not happy with the results you can produce a new DEM for this project).*

Main analysis

There are four principal parts of the main analysis. These are divided into conflicts and constraints. The conflicts are building costs and conservation, as they are conflicting land uses. The constraints are waterway pollution and fire, and only constrain the building locations in this project. The ideal site at which to locate the field station extension is one that minimises both the cost of building and any conflict with conservation values, while also minimising both the potential for waterway pollution and the risk from fire. Aesthetics are part of the brief, but these can be assessed as a final ranking step once you have identified a set of candidate sites.

These four analyses are developed as separate models and described below. The final combination is given at the end, albeit only generally since you need to work much of that out yourselves. We are also using a fuzzy logic framework for these analyses to allow for the inherent uncertainty and error in the models. The fire and pollution models are built first and then fuzzified, while the conservation and building models are developed entirely within a fuzzy framework.

Keep in mind that these are landscape scale analyses. Site specific analyses within any locations identified for building can be left to further work (i.e. you do not need to do site level analyses in this course).

Pollution (erosion) model

The pollution model is also called the erosion model, as it is using a simple soil erosion model under the (reasonable) assumption that pollutants move with the sediment flux through a catchment. This is either attached to sediments, or as particles in the sediment flux.

The erosion model we use is the Universal Soil Loss Equation (USLE). This is a commonly used algorithm devised originally for agricultural landscapes. It has many limitations, for example it is a temporally static model, but it is simple to implement. It has five inputs which we will calculate.

Erosion = R * K * S * L * C * P

Where:

R is rainfall (spatially constant over the study area)
K is the soil erosivity index
S is the slope gradient (from the DEM)
L is the slope length (from the DEM),
C is the cropping factor (vegetative resistance to erosion, from the vegetation map), and
P is the practise factor due to erosion control measures (we will assume a value of 1 for no controls)

Fire model

This uses the MacArthur fire model which we have as a series of equations. Given this, we can implement it using a GIS because each term is either a spatial constant or a geographic layer. It is then a case of using map algebra to implement it.

It has the following inputs:

- Fuel loads (derived from the field survey). These determine the rate of spread across flat ground.
- Slope gradient (from the DEM). This modifies the rate of spread, as fire spreads faster up steep slopes.
- Any other factor is a spatial constant which you can take from the instructions, or develop your own.

Conservation model

The conservation model consists primarily of developing buffer distances around threatened flora and fauna, and possibly drainage lines. It is up to you to determine how far to buffer. An important point is that these distances are inherently uncertain, which is why we are using a fuzzy logic approach based on distance analysis, and not the buffer tool.

Building model

The building model consists entirely of identifying sites that are good (cheap) for building. Any issues of conservation that are not in the local environment plan do not need to be considered within this model. They will be incorporated into the site selection when we combine the building and conservation models.

You need to identify locations that satisfy at least the following criteria:

- Low slope gradient (from the DEM)
- Close to existing vehicle access
- Not too close to any high voltage power lines
- Not too far from normal power lines

It is computationally simpler to incorporate the views in the final combination as a ranking criterion rather than at this stage.

The final combination

In the final combination you are attempting to identify a location with sufficient space to locate your building.

You are looking for areas that have a good building suitability score, while also having a low fire hazard and pollution risk. At the same time they must not be a location that is also of high conservation value. This is a two-step process, and need not be complex. You first exclude any areas from the building model that have too high a hazard, and then compare it with the conservation model to identify areas with low conflict.

Once you have identified a set of potential building sites you need to identify those that are of the correct extent and rank them. This will involve calculating areas (as per the coordinate systems lab), and possibly changing the combination weightings or being less stringent about what constitutes an acceptable site. This is inevitably an iterative process.

You may even decide to present multiple scenarios, for example one where conservation is valued highly and one where it is not.

Site ranking

Once you have your set of candidate sites you can then rank them based on their aesthetics. You are looking for areas with better passive solar characteristics (using the DEM) as well as areas with nice views and/or privacy (also derived from the DEM).