Landfill Closures
Spatial Assessment (Group 3)
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Problem Statement

No spatial data exists for these 59 landfills, other than their coordinates. Since each landfill is a potential stressor, in order to assess risk it must invoke pressure on one or more receptors. These receptors could be rivers, groundwater wells from houses and municipalities, agriculture or other infrastructure. Ecological communities, such as standing fresh water in ponds and lakes, are also potential receptors.

Justification

Without understanding a landfill’s orientation with the rest of the landscape, a risk assessment of closed landfills would be incomplete. In this case, there is a risk of human exposure to contaminants in groundwater and leachate, as well as off-gasses (methane in particular) from landfills. Also of concern are vulnerable aquatic ecosystems connected to surface waters and contaminated groundwater plumes. In order for exposure to occur, the stressor (landfill contaminants) and receptor (ecological systems and people) must occur within the same time and space. If they are disconnected by either exposure is assumed to be unlikely, invalidating risk assessments blaming said stressor for any response.

The Vermont Agency of Natural Resources has provided water quality data dating back 20 years, landfill coordinates, landfill characteristics (e.g. lined or un-lined, capped or uncapped), tonnage of waste, and detailed engineers reports from the time of decommissioning for 59 landfills. Among this data for some sites are detailed topographic maps including testing wells, groundwater elevations, and other landscape features. These maps will serve as layers in geospatial analysis, and allow us to analyze whether specific sites are at risk due to the landfills presence.

Just because a site is located adjacent to the stressor does not mean that the site is a potential receptor. Leachate and groundwater contamination follow gradients of both gravity and water pressure. Upwellings, pools and drainage exist in the subterranean environment complicating the movement of contaminated groundwater. For example, a small pond located next to a landfill but above the groundwater elevation around the landfill is unlikely to be impacted by leachate contamination. However, data analyzed by consultants can more accurately confirm this upwards gradient of groundwater. In this regard our analysis is only a piece of the overall risk assessment, complemented by the data from water-quality wells on each site. Similarly, until the site has been analyzed we cannot assume that there is no risk based off map gradients alone. The test-well contaminant levels will be cross examined with surrounding land use types, and perhaps locate stressors where the maps would not initially indicate.

In order to add these parameters to our risk assessment calculator, we must quantify the co-occurrence of a receptor, to which landfill leachate, gas emissions or odor are a stressor. Group-Two of the closed landfill group will primarily be assessing the stressor aspect of landfill risk, while Group-Three will assess spatial association of stressors with receptors, especially anthropogenic infrastructure and resources.
This article will provide us with valuable techniques and methods in image analysis and interpretation, even though the authors were searching for illegal waste sites, and not evaluating the conditions of closed sites. In their methodology, the authors discuss the importance of a landfills proximity to public roadways as well as surrounding environment.


This paper discusses the use of GIS and geospatial technologies to find suitable locations for municipal landfills. The authors took a two-pronged approach in their work: first by analyzing existing maps, and then running potential sites through a multi-criteria decision making tool. Our analysis will follow a very similar approach only we will be working backwards from the paper in a sense, trying to highlight bad location of landfills that could pose a threat to the surrounding environment. An interesting takeaway from this paper was how the authors converted all vector polygon files into raster files, which will make data analysis easier.


This paper is very similar to the previous one written by Chang et al. The authors used a decision-matrix with a variety of variables to determine the best landfill sites. Again, we can use this paper by working backwards in our analysis to determine which Vermont closed landfill sites would have gotten a low (negative) score in this system. What sets this paper apart from the Chang et al. paper is a series of formulas and algorithms, which we can apply to our project.


In their paper, Jensen et al. used a four-branched geospatial system to monitor a series of hazardous waste sites. One of these branches consisted of analyzing raster and aerial image files to identify and investigate abnormalities in each site’s surrounding environment. Our analysis will consist of a similar technique when we interpret land cover rasters and aerial images.

Sumathi, V.R., Usha Natesan, and Chinmoy Sarkar. "GIS-based Approach for Optimizing Siting
This article is again, very similar to the Gorsevski et al. and Chang et al. papers. These authors use GIS and another multi-criteria decision matrix to determine ideal locations for landfills. What sets this article apart from the others, however, is the end user will be able to adjust criteria rankings and weightings, something that could be valuable to the Agency of Natural Resources. The authors did a series of geoprocessing buffers in their analysis, which we may do in our work as well.

Probable Contribution

- Create a statewide map identifying landfills and showing risk associated with each site.
  - Create an accompanying attribute table with relative information for each site.
- Create detailed maps of interpolated projections of concentrations of key pollutants for a limited number of sites. The number of sites will be determined by data availability and time constraints.
- Create and document methods used to create maps, allowing ANR to better understand as well as to repeat the process on other landfills.
- Determine which spatial variables should be used in the calculator, and deliver those spatial metrics to the calculator group.

Proposed Effort

We will address this topic through a series of geospatial analyses. A point feature GIS shapefile of each landfill site developed from XY coordinates provided by the Vermont Agency of Natural Resources will be the main focus of such analyses. In this feature class, we will create a user-friendly attribute table with vital information pertaining to each landfill, including specific contaminant levels, underlying geology, historical data regarding precipitation in each landfill’s watershed, and other useful information that we may come across in our work. Sources of these data will include the Vermont Center for Geographic Information, the US Geologic Survey’s National Hydrography Dataset, the National Land Cover Database, and others to be determined.

Once there is sufficient spatial data within the attribute table of the shapefile, we will give our findings to the Calculator subgroup and shift our focus to creating maps for the Agency of Natural Resources. The statewide maps that we create will display landfill locations with symbology that effectively represents our data, as well as and trends in the data (clusters of high or low priority in certain regions of Vermont). These maps will allow the Agency of Natural Resources to visually interpret the data within the GIS shapefile attribute table that we produce.

A third component of our effort will be running a spatial interpolation of the existing landfill data provided by ANR to predict the behavior and fate of landfill leachates. The best interpolation method and parameters will be selected based on the appropriateness of the results (likely Inverse Distance Weighted or Spline). Break lines such as rivers or other bodies of water will be applied as necessary to increase the accuracy of results. The resulting projection of pollutant concentrations will be combined with a basemap of the area of each landfill analyzed and turned into a formal map layout for presentation with the rest of the report. Throughout our work we will document our workflow and methods so our analyses can be replicated in the future.
**Effort Assignment**

As mentioned, this project has three main components: creating a shapefile with thorough and useful data included in the attribute table, creating statewide maps to effectively represent such data, and running a spatial interpolation of existing contaminant data to predict behavior of leachates. Such a vast project will require data from a variety of different sources, some easier to find than others. Tommy Hibert will be responsible for locating the files that will be used in our analyses. Once we have these files, Thomas Nieuwenhuis, Tommy Hibert, and Sam Watson will be responsible for running specific geospatial tools and processes (landfill buffer, proximity to surface water, slope, etc.). Thomas Nieuwenhuis will create the GIS shapefile of landfill locations from an existing Excel spreadsheet containing coordinate data. The data derived from the geospatial analyses will be appended to this shapefile's attribute table, which will be managed by Thomas Nieuwenhuis with the help of Tommy Hibert. Sam Watson will be creating the majority of the statewide maps, ensuring that each one adequately symbolizes the data being represented. Chris McCloud will be managing the spatial interpolation component of this project. Collectively as a group, we will document our methodology and workflow processes.