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Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Ecological, Shade, and Soil Connectivity on the University of British Columbia Vancouver Campus

How can connectivity be identified to better allocate natural assets?

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Prepared for: UBC Campus + Community Planning

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Abstract

In response to growing concerns about the impacts of climate change, recent studies have been conducted investigating ecological connectivity and resiliency. Improving connectivity can increase landscape resiliency in the face of a changing climate. The University of British Columbia (UBC) Vancouver campus is interested in improving its ecological, soil, and shade connectivity, as these factors influence student and environmental health. Satellite imagery, and data from UBC Campus and Community Planning was used to analyze ecological (specifically important endemic tree species), shade and soil connectivity on the Vancouver campus. Ecological connectivity was lower in the north eastern portion of campus, specifically there were fewer trees and they were more spread out. Shade connectivity was higher in the north part of campus where there were buildings and trees. Shade connectivity was the lowest in the southern part of campus where there were more open fields. Soil connectivity was the highest in the southern part of campus, as there were more fields. Soil connectivity was the worst in the north section of campus as there was more linear infrastructure and buildings. Planting tree species that are more suitable for future climates and maintaining high levels of connectivity will improve landscape resiliency. To maintain the history of a landscape, a portion of land can be reserved for endemic species where their connectivity is maintained to a high level. Increased maintenance could help endemic species survive, and limiting the species to a section of land would keep maintenance costs as low as possible. Improving soil connectivity would improve soil health, allowing for more and healthier trees, which in turn would improve shade connectivity, helping to maintain thermal comfort.

Key Words: Soil, Shade, Ecological, Connectivity, Tree, Vancouver

Introduction

Streets and other types of linear infrastructure are important components of designing and planning for human connectivity in urban environments (Ozbil et al., 2011). Linear infrastructure is “characterized by its straight form, such as roads, railways, powerlines, and canals” while nonlinear infrastructure does not have a straight form, like airports or hospitals (U.N., 2020). Human infrastructure, primarily linear transportation networks, disrupt ecological connectivity endangering species prosperity (Mimet et al., 2016). In “Connectivity and ecological networks,” Jongman observes that while landscapes are becoming more connected for human use, they are becoming more fragmented and disintegrated in an ecological sense (2019). The goal of this project is to identify areas of poor ecological connectivity on the University of British Columbia’s (UBC) Vancouver campus and recommend site specific strategies to improve ecological connectivity and natural asset allocation on campus. UBC’s Vancouver campus is located on the Point Grey Peninsula, Vancouver, B.C. Canada which is traditional, ancestral, and unceded territory of the Musqueam people (First Nations House of Learning, 2020).

Habitat fragmentation, degradation, and loss negatively impacts biodiversity by reducing species and genetic diversity (Appalachian Corridor, n.d.). Increasing landscape/ecological connectivity has become a dominant strategy for addressing widespread anthropogenic landscape changes and their associated negative impacts on biodiversity (LaPoint et al., 2015). Just as people “rely on transportation corridors [to get around], wildlife also needs to travel across the landscape” (Biodiversity Adaptation Working Group, 2018). Ecological connectivity is “the degree of connection between the various natural environments present within a landscape, in terms of their components, spatial distribution and ecological functions” (Appalachian Corridor, n.d.). Different types of connectivity should be kept in mind when planning and designing landscapes.

Ecological connectivity is of particular interest when thinking about climate change. Preserving and restoring connectivity is a great strategy for dealing with and preparing for climate change (Appalachian Corridor, n.d.). The main argument for improving and increasing ecological connectivity “is that if the effects of land-cover fragmentation can be mitigated, this should enhance the ability of species to move into new regions as [the] climate changes … thereby decreasing the probability of [species] extirpation or extinction” (Krosby et al., 2010).

With more than 50 percent of the total human population now living in urban environments, cities are increasingly being recognized for their ability to “support biodiversity and to connect their citizens to nature,” meaning that improving ecological connectivity in cities is imperative (LaPoint et al., 2015). The University of British Columbia Vancouver Campus is currently planning and adapting for the changing climate by improving landscape resilience (UBC Green Building Action Plan, 2018). Ecological resiliency is how much disturbance an ecosystem/landscape can handle before it’s processes and structures change (Moritz et al., 2010).

UBC is also interested in furthering research and understanding on how biodiversity impacts climate resilience on the Vancouver Campus (Climate Action Plan, 2021). To this end, UBC’s Vancouver Campus is interested in improving its ecological connectivity on campus, which corresponds to the 2050 Campus Vision, which shapes how the Vancouver Campus will change and grow, up to 2050 (UBC Campus & Community Planning, 2022). This project builds on the 2021 SEEDS Ecological Connectivity Analysis, which identified two corridors on the Vancouver Campus. While all of the Vancouver Campus will be analyzed in this study, the primary focus will be the two identified corridors.

Improving connectivity on campus can improve the landscapes resiliency in the face of a changing climate. In order to achieve this, it is important of further analyze connectivity the Vancouver campus. To this end, it is important to address how areas with low, medium, and high ecological connectivity can best be identified on the UBC Vancouver campus using geospatial data to improve the allocation of natural assets. Using geographic information systems can help identify a range for connectivity on campus from poor too excellent. This will help narrow down where natural asset allocation and connectivity need improvement.

Data and Study Site Summary

Study Area Description

My study area is focusing on the University of British Columbia's Vancouver Campus. The UBC Vancouver Campus is located on the Point Grey Peninsula, Vancouver British Colombia Canada. This is a university campus, so a lot of people frequent this landscape. There are approximately 80,000 people on UBC's Vancouver campus every day, which is more than some municipality populations in B.C. (UBC Rapid Transit, n.d.). Since the landscape is a university campus, human connectivity is very important as students need to be able to get around campus easily. However, ecological connectivity is also important. This study looks at connectivity on the Vancouver campus, and focusses on soil, shade, and vegetation connectivity. A species of interest list will be used to complete more species-specific connectivity analyses.

The landscape that UBC is situated on has changed dramatically over time. In 1865, companies were granted 21-year timber leases on the Point Grey Peninsula (UBC Library, 2022). Endemic species populations and distributions were drastically altered after this point in time, as the landscape experienced continued land use change, as old growth forests were logged and much of the landscape was deforested (Norman, 2022). In 1910, Point Grey Peninsula was chosen as the site for UBC's Vancouver campus, and 175 acres of Crown land was reserved for UBC (UBC Library, 2022). UBC currently has several nice gardens on its Vancouver campus, such as the Nitobe Japanese Garden and the Rose Garden. The campus is also situated next to Pacific Spirit Regional Park, which has several nice paths. The main section of campus is centered around Main Mall which is a long grassy corridor broken up by walking paths with trees one each side.

Historically the Point Grey Peninsula and the Greater Vancouver area receives a lot of rain. However, climate change is affecting environments across the globe and Vancouver is no different.

Study Area Map

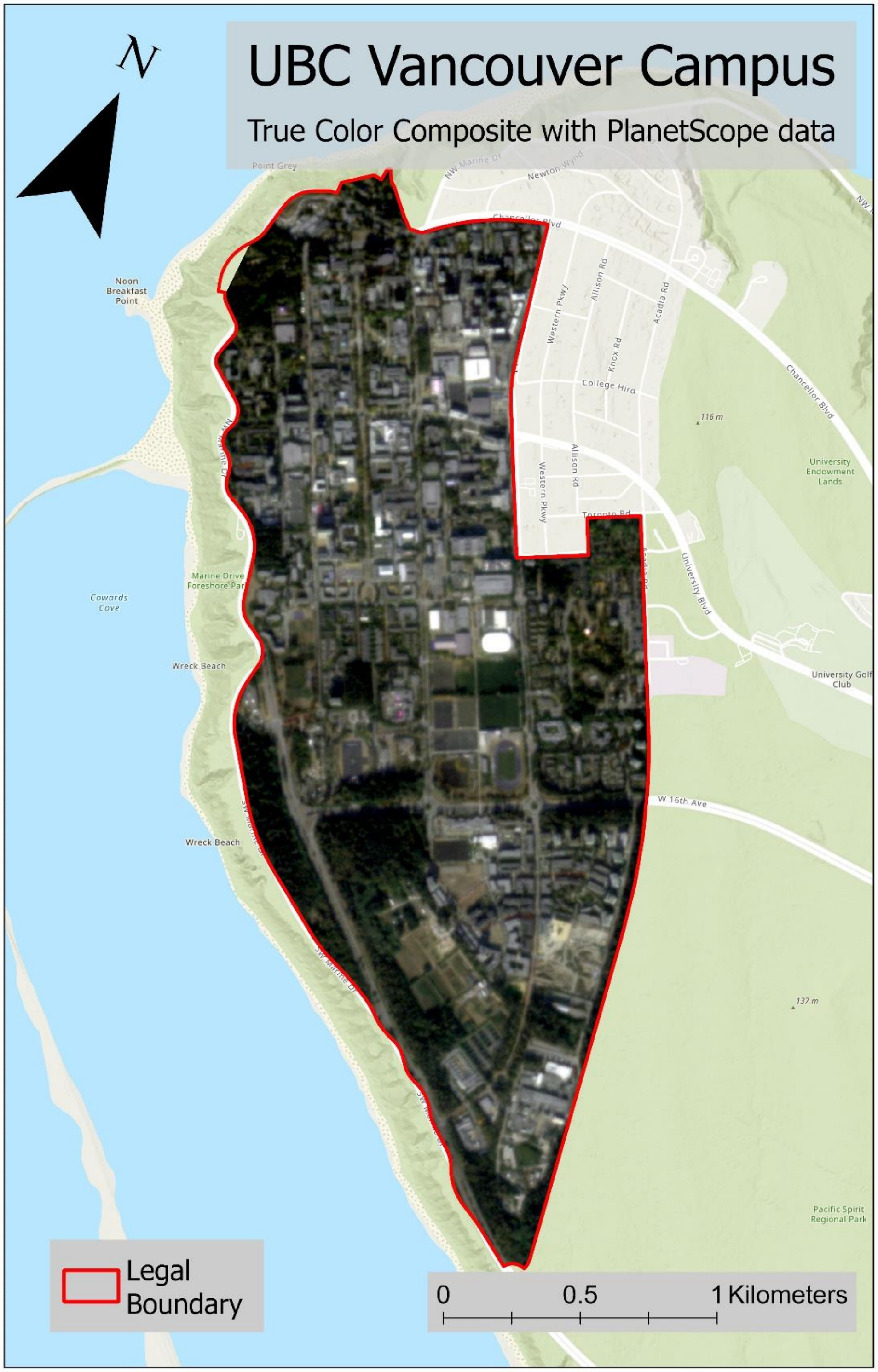


Figure 1: University of British Columbias Vancouver Campus, B.C., Canada. This map is a true color composite made from PlanetScope data collected on October 15 2022 with a 3-meter spatial resolution.

Data Summary

Landsat

Landsat is a program consisting of a series of Earth observation satellites managed by the USGS and NASA (USGS, 2022). The program has been running since 1972, and Landsat 8 and 9 are currently active and orbiting the earth collecting data (USGS, 2022). Landsat has used different multispectral scanners over the years which provides spectral information in bands, or ranges of wavelengths from the electromagnetic spectrum (USGS, n.d.). Landsat 1-3 used the multispectral scanner and collected data in four bands/ranges (USGS, n.d.). Landsat 4 and 5 used the thematic mapper sensor, which collected information from 7 bands in 30-meter pixel resolution (USGS, n.d.). Landsat 7 used the enhanced thematic mapper plus sensor, and collected most of its 8 bands with 30-meter resolution (USGS, n.d.). Landsat 8 and 9 use the operational land imager and thermal infrared sensor to collected information in 11 bands, with most bands having a spatial resolution of 30 meters (USGS, n.d.).

Landsat 8 data was downloaded for the United States Geological Survey (USGS) website. The acquisition date was August 24th, 2021, 7:08 pm (Greenwich Mean Time), which corresponds to 12:08 pm Vancouver time.

Landsat 8 image, LC08_L1TP_048026_20210824_20210831_01_T1, courtesy of the U.S. Geological Survey

Planet Scope

PlanetScope data was downloaded from the Planet Scope website. PlanetScope contains 8 bands comprised of different ranges of the electromagnetic spectrum with a spatial resolution of 3 meters (Planet, 2022). PlanetScope has datasets from 2009 to the present (Planet, 2022).

Planet Labs PBC (2022). Planet Application Program Interface: In Space for Life on Earth. https://api.planet.com

UBC Campus and Community Planning

The UBC legal boundary, tree locations, roads, and buildings datasets come from UBC Campus and Community Planning, and were downloaded from GitHub. This data will be used to visualize my study area. It will also be used to look at connectivity. Tree data can be used to look at ecological and shade connectivity. A buffer will be applied to represent the shade a tree can provide. Building data can also be used for shade connectivity as the data includes building height. Road data will be used to look at vegetation and soil connectivity. Roads can be seen as friction values in least cost path analyses used to look at connectivity. The border will be used for symbology and to clip larger data sets, such as raster layers, to the study area.

UBC Campus and Community Planning (2022) UBCGeodata ubc-geospatial-opendata/ubcv at master · UBCGeodata/ubc-geospatial-opendata (github.com)

Data Summary Figures and Tables

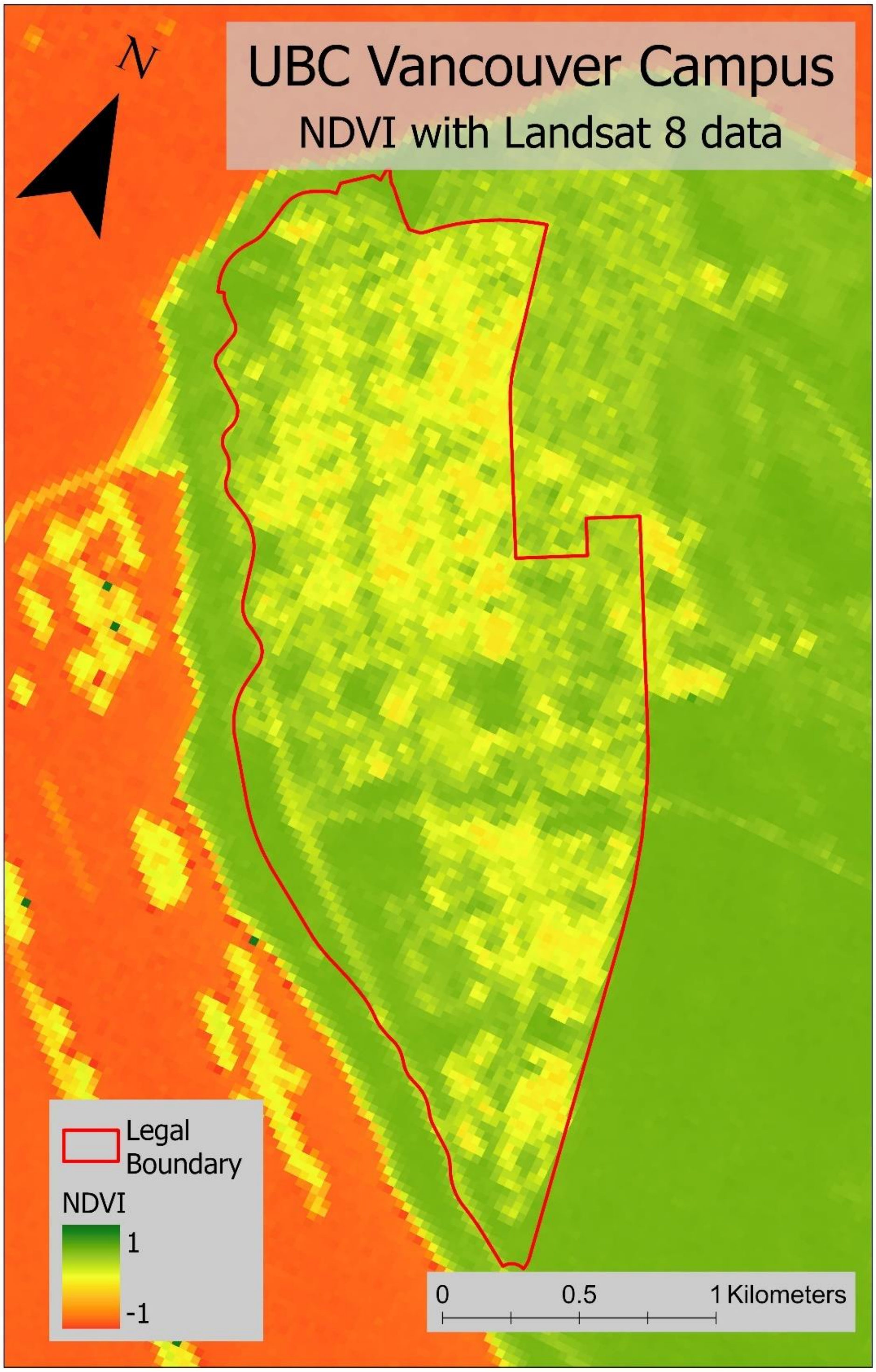


Figure 2: Overall Greenness of the UBC Vancouver Campus, determined by NDVI, which was calculated using Landsat 8, 30-meter resolution data. Values of 1 shown in green depict areas with more vegetation, and values bellow 0 depict areas with less vegetation.

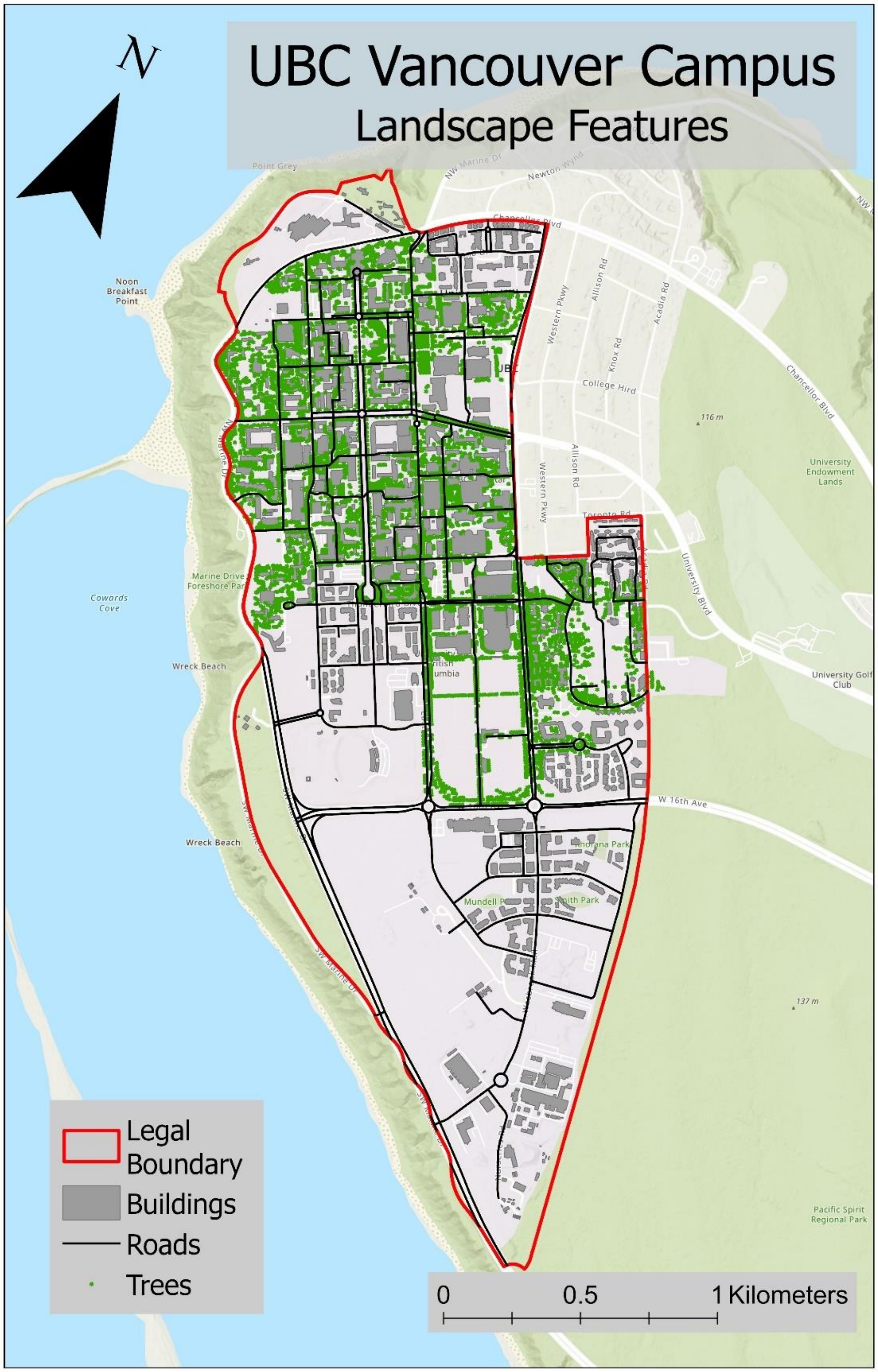


Figure 3: This map depicts landscape features (trees, roads, and buildings) on the UBC Vancouver Campus, courtesy of UBC Campus and Community Planning.

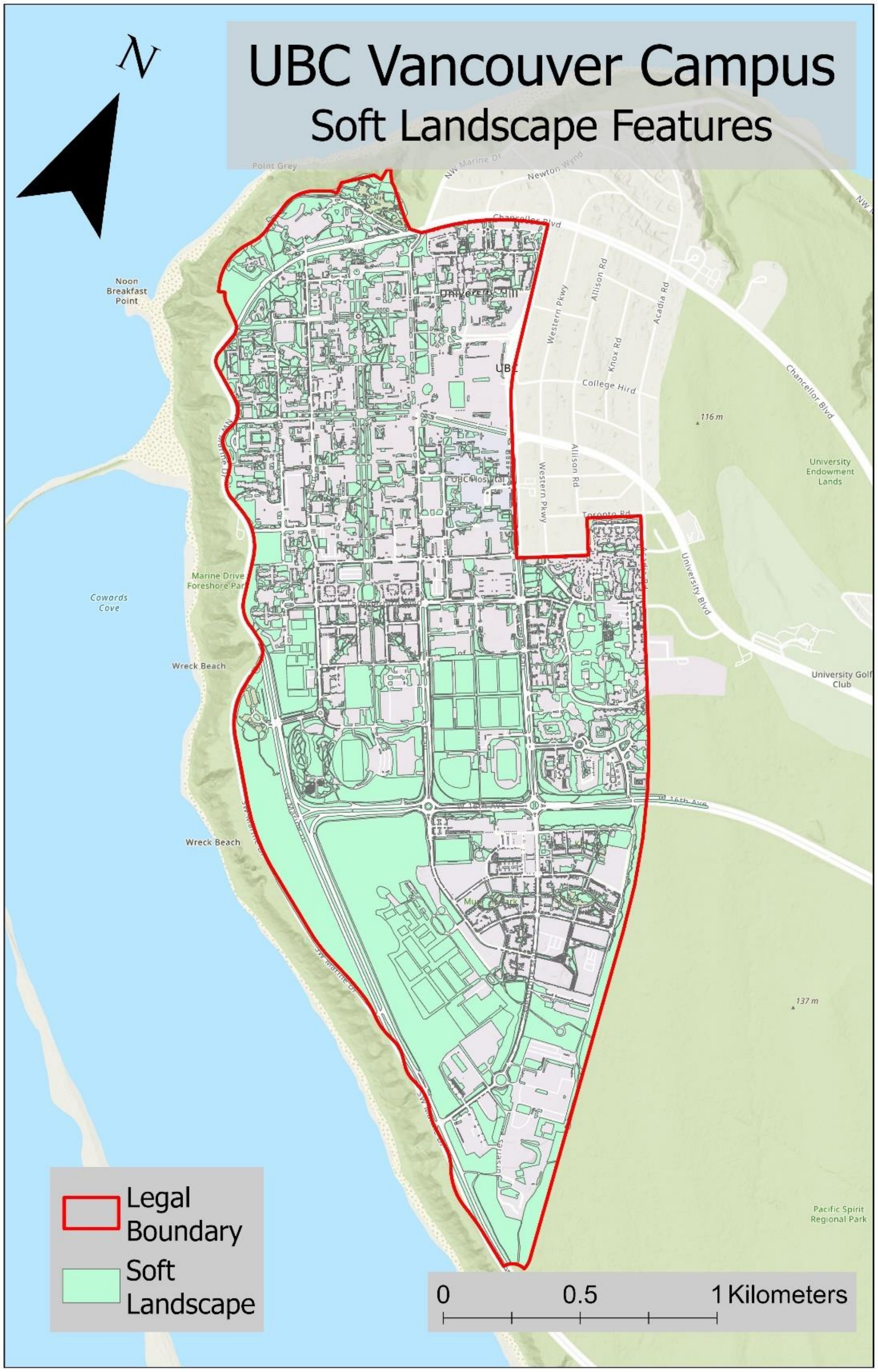


Figure 4: This map depicts soft landscape features on the UBC Vancouver campus, like gardens, wild areas, athletic fields and lawns, courtesy of UBC Campus and Community Planning.

Methods

1.1 Plant Species Connectivity

1.1.1 Buffer Analysis

To determine plant species connectivity, Landsat, PlanetScope, and UBC Campus and Community Planning data will be utilized in multiple connectivity analyses to evaluate overall vegetation connectivity, and more specific plant species connectivity. Species of interest will be grouped into individual classes from the tree data collected from UBC Campus and Community Planning. A buffer analysis will be conducted on each species in ArcGIS Pro to determine how close species are to one another. For each species, the buffers around each individual that overlap will be dissolved. In addition to species specific connectivity, an overall connectivity analysis will also be conducted using Landsat and PlanetScope data to calculate NDVI, which will be interpreted as overall vegetation connectivity.

1.1.2 Overall Greenness

The normalized difference vegetation index (NDVI) is often used as a metric to evaluate overall greenness of a landscape (Muratet et al., 2013). Interpreting NDVI as overall greenness allows researchers to use satellite derived NDVI to evaluate landscape connectivity (Muratet et al., 2013). I will calculate NDVI from two true color composite images, one created from Landsat 8 data with a 30-meter spatial resolution, and one from PlanetScope data with a 3-meters spatial resolution. The 30-meters resolution image will act as a validation image for the finer spatial resolution (3-meter) image to make sure observations are similar between datasets. Multiple observations from different data sources will help support the validity of the findings of this study.

1.2 Shade Connectivity

1.2.1 Buffer Analysis

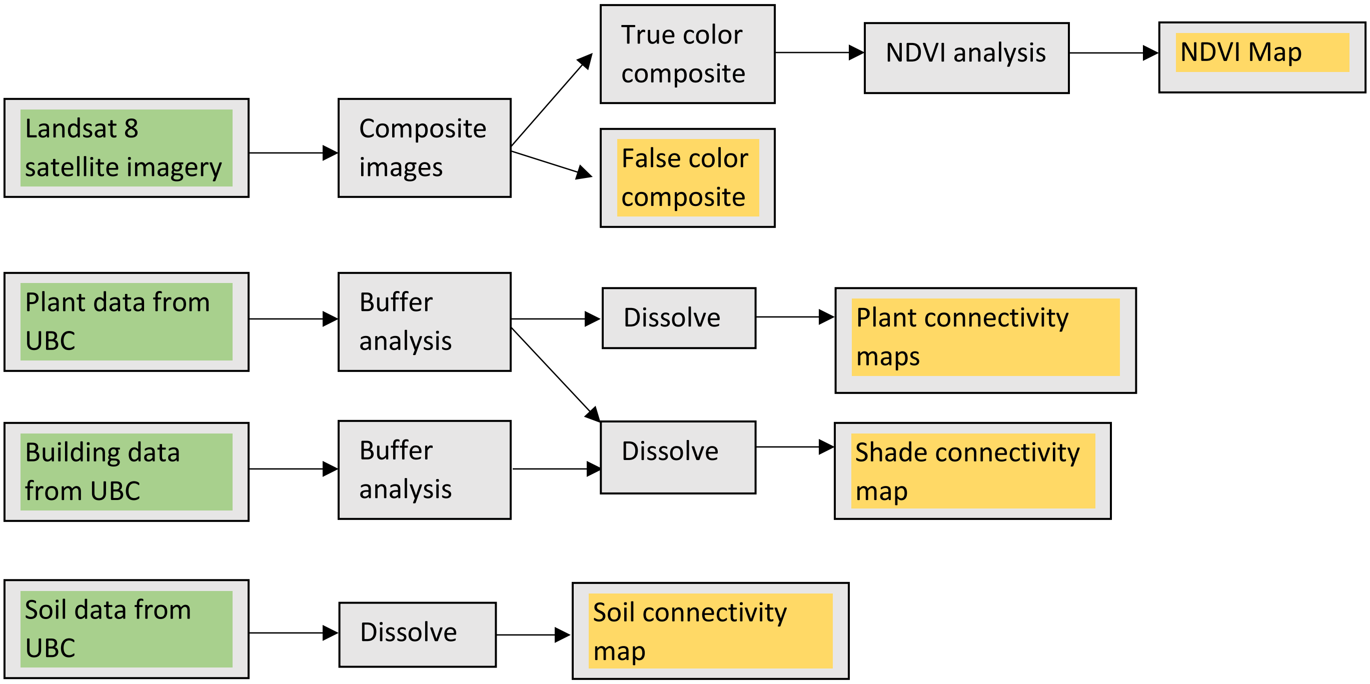
To evaluate shade connectivity, a buffer analysis will be applied to trees and buildings. A buffer is a specified distance from the edge of a feature, which makes it a good metric for shade, as shade originates from the edge of features on a landscape. Tree and buildings heights collected from UBC Campus and Community Planning will be used to approximate shade distribution around buildings and trees, represented by the buffer analysis. Overlapping buffers will be dissolved to highlight shade connectivity on campus.

1.3 Soil Connectivity

1.2.1 Dissolve Existing Features

Soil locations, such as fields and gardens, will be mapped out using data collected from UBC Campus and Community Planning. Soil features that touch will be dissolved together in ArcGIS Pro to highlight soil connectivity.

Workflow Diagram



Results

Plant Species Connectivity

Overall tree connectivity on the UBC Vancouver Campus was worse (fewer and more spaced-out trees) where there was more built infrastructure and sports fields. Individual tree species connectivity varied, with some species having much worse connectivity than others. Overall vegetation connectivity was the highest (NDVI values above 0.5) to the southern and western portions of the UBC Vancouver campus. The northeast portion of campus had the lowest ecological connectivity, with NDVI values of 0 or less.

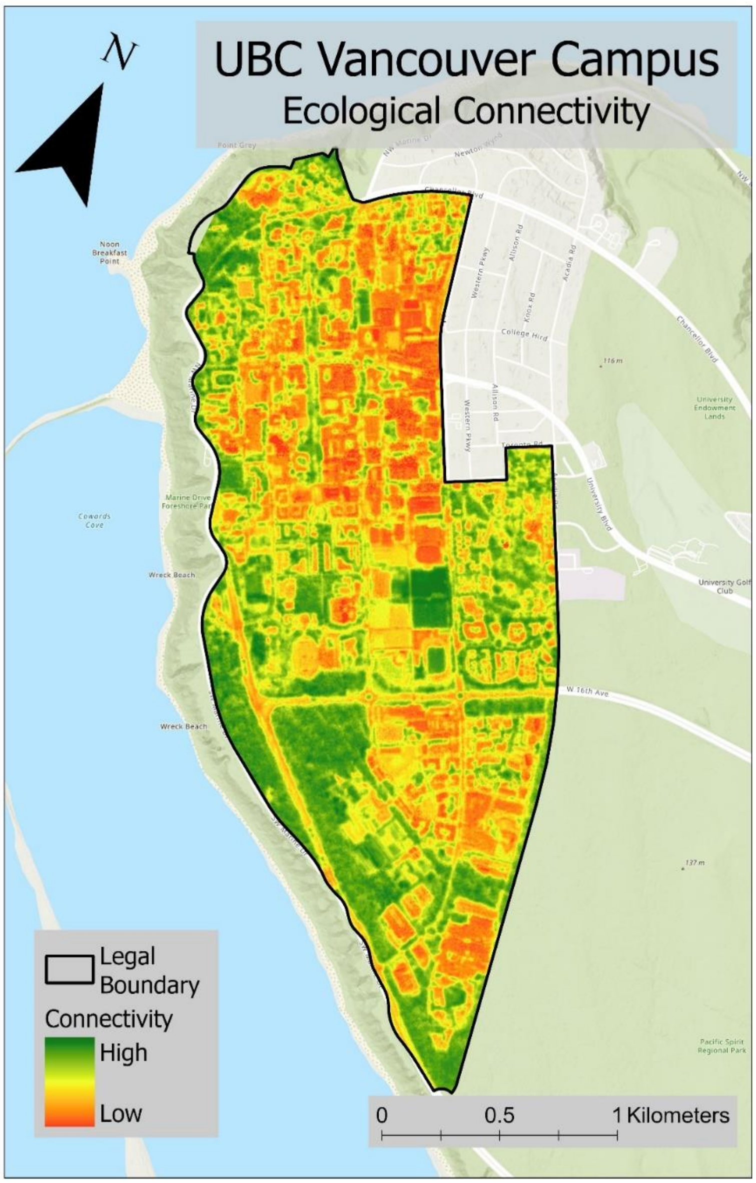


Figure 1: Plant species NDVI connectivity on UBC Vancouver campus: This map shows NDVI values which range from -1 to 1 and correlate to overall greenness and vegetation health on campus calculated from PlaentSCope data. NDVI values are stylized to show areas of higher and lower ecological connectivity.

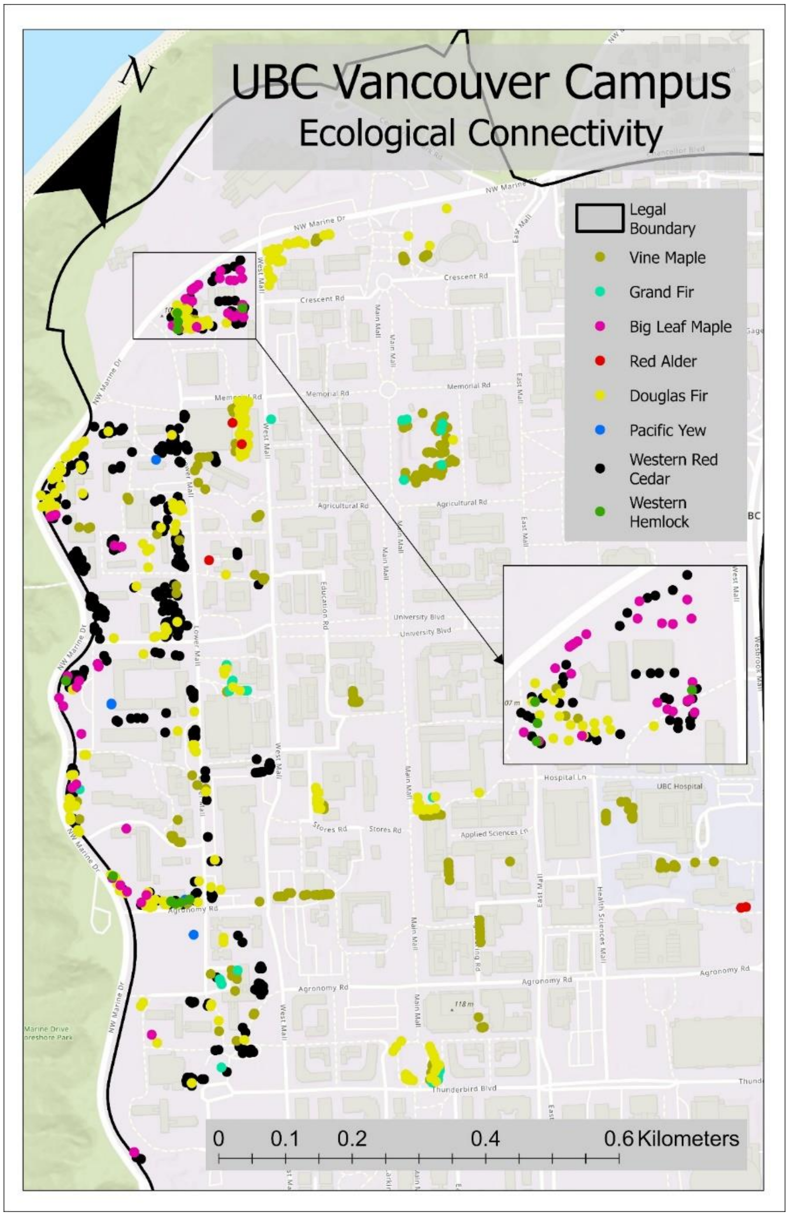


Figure 2: Tree species of interest on the UBC Vancouver Campus. Eight endemic tree species are shown, depicting individual tree connectivity.

Western Hemlock distribution was contained to the north western section of campus. The overall connectivity of this species was very low due to the great distance between tree clusters and individual trees. There were two main clusters of a few trees, with a few individual trees spread out in the northern part of campus. Western Red Cedar was primarily located in the north western section of campus. This species connectivity was better than Western Hemlock, however there were breaks in its connectivity. Western Red Cedar trees were typically near one another, with the occasional lone tree. Pacific yew had very poor connectivity, with only four individual trees identified. The four trees were not close together, with the closest two Pacific Yew trees being approximately 54 meters apart.

Douglas Fir trees were located in the northern part of campus. Overall connectivity was much better than Pacific Yew as more trees were located closer together and there was a greater distribution across campus. Douglas Fir trees had clusters of higher connectivity, and areas with lone trees.

Red Alder had very poor connectivity, being located in the northern part of campus with only 5 individual trees that were not distributed close together. There were two trees that were close together to the eastern portion of campus, but they were far away from the other three trees that were located more to the western portion of campus. Big leaf maple distribution was restricted to the northern and western parts of campus. Overall connectivity for this species was low as they were distributed over a large distance. However, there was an area near the northern tip of campus with better connectivity due to several trees being clustered together. Grand Fir trees had four clusters with individual tress spread out in the norther part of campus. Overall connectivity was low as the clusters and individual trees were quite separated. Vine Maple had a cluster of trees in the northern part of campus between Agricultural and Memorial Road with high connectivity due to the dense distribution in this area. Overall connectivity was better than some other species, as there were clusters where connectivity was good but the clusters didn't connect in any way. Vine Maples were primarily found in the northern part of campus.

Shade Connectivity

Shade connectivity was greater near large tall buildings and trees, and lower near flat low infrastructure and areas with few or very spread-out trees. Locations on campus with more buildings and trees had more shade connectivity than areas with fewer buildings and/or trees. Shade connectivity was greater in the norther part of campus, specifically north of West 16^{th} Ave.

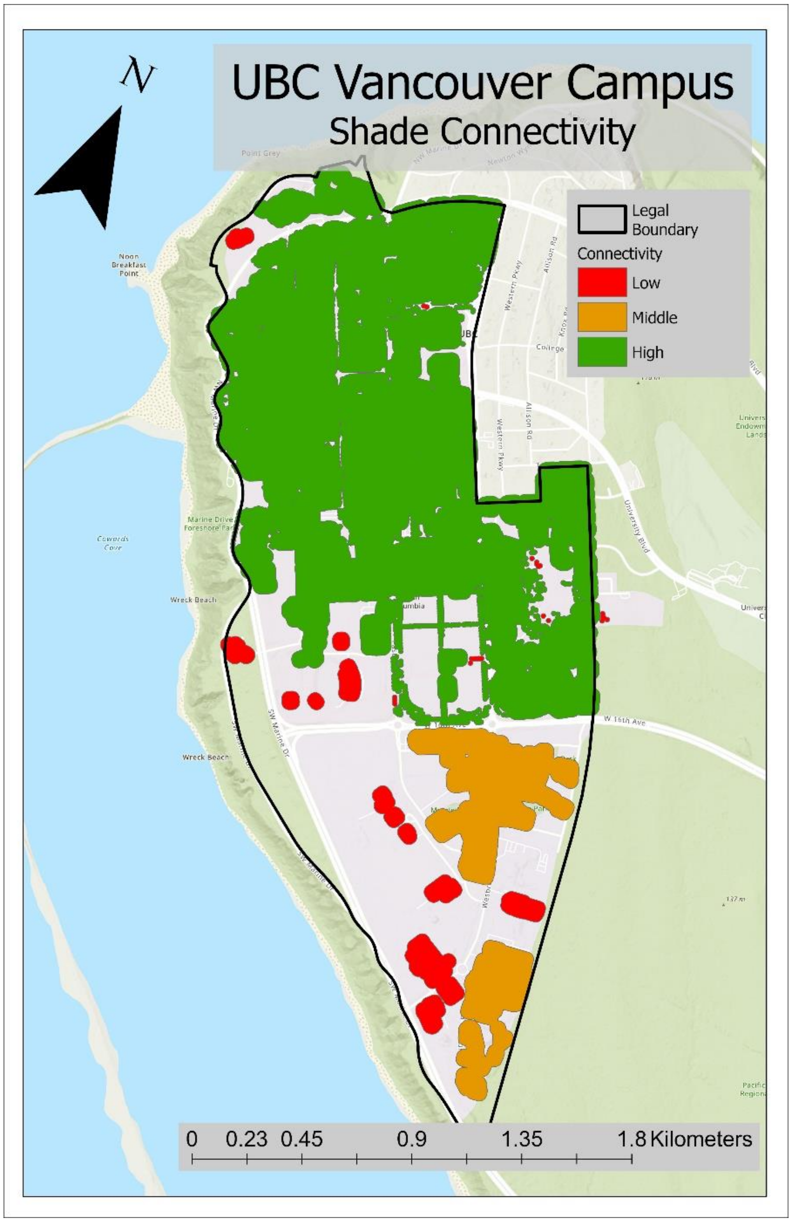


Figure 3: Shade connectivity on the UBC Vancouver Campus. This map predicts shade connectivity based on buildings and trees and gives each a buffer to predict the amount of shade. Areas with greater building and tree density have more shade connectivity than areas with fewer buildings and/or trees.

Soil Connectivity

Soil connectivity was the greatest on large tracks land that do not have built infrastructure. Areas on campus that have more built infrastructure have lower connectivity than areas with less built infrastructure. Sports fields in the southern part of campus had high soil connectivity compared to other areas of campus. Areas with more impermeable surfaces, like the northern part of campus, had lower soil connectivity.

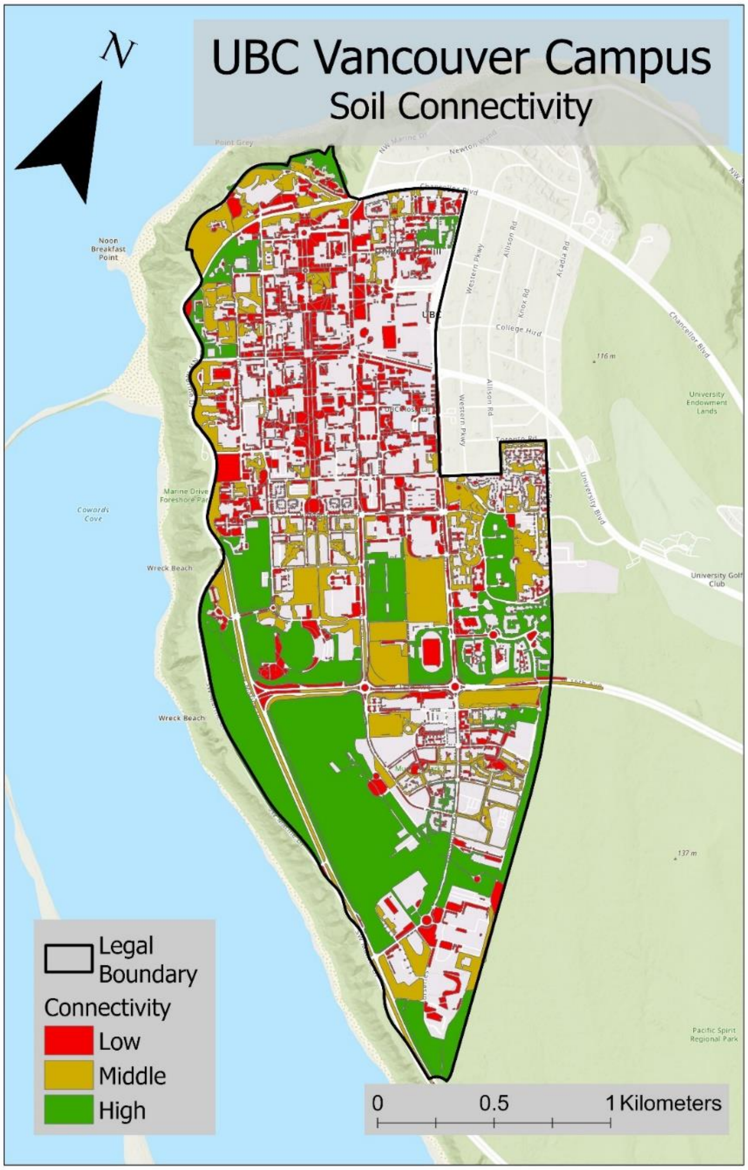


Figure 4: Soil connectivity on UBC Vancouver campus. This map depicts expected soil connectivity based on soft landscape data from UBC Campus and Community Planning. Areas with more roads, walkways, and buildings has lower connectivity than areas with less linear infrastructure.

Discussion

1.1 Vegetation Connectivity: Planning for the future while preserving the past

The goal of this research was to identify areas of low connectivity on the UBC Vancouver campus to better inform resource allocation. This study built off of a 2021 SEEDS Ecological Connectivity Analysis which looked at mycorrhizal networks and identified ecological connectivity dead zones on campus with the hopes of creating a more resilient campus in the face of climate change. This research expands on the 2021 SEEDS study to look at shade, soil, and ecological (specifically tree) connectivity on the UBC Vancouver campus.

Planting tree species that will survive and be resilient in future climates is essential, however maintaining important endemic species that may be restricted in future climates is also important. Vital ecological landscape features are threatened by anthropogenic land use, resulting in the reduction of connectivity and scattered trees (Henry et al., 2017). Connectivity is a key characteristic that maintains "linkages between fragmented habitat patches within landscapes" (Henry et al., 2017). Tree connectivity is important as it helps reduce fragmentation and habitat loss (Henry et al., 2017). The UBC Vancouver Campus is affected by anthropogenic use so mitigating environmental damage by this use is an important consideration of the University if it wants to combat fragmentation and habitat loss.

Many important endemic species on the UBC Vancouver campus are not suitable for future climates. Important endemic species like western hemlock are "anticipated to be restricted to moist sites under [the] future climate" (metrovancouver, n.d.). Endemic species are important to preserve as they are part of the natural environment of the landscape and contribute to biodiversity. However, maintaining species that might not do well in future climates can be difficult, as it involves active intervention to maintain conditions favorable to that species. Species like rocky mountain white pine which are very suitable for future climates (metrovancouver, n.d.) might be a better species to plant and improve their connectivity as they will require less maintenance to survive in the future. Garry oak is an important endemic species that could do well in future climates (metrovancouver, n.d.), so it is a species that should be focused on, and its connectivity could be improved by planting more garry oak trees. Pacific yew is an important endemic species that may be somewhat suitable in future climates (metrovancouver, n.d.), however it already has very poor connectivity on campus. Improving this species connectivity could be done since it is suitable for future climates, but there are other species that are more suitable, so considering it already has low connectivity, it may be more economic to focus on another tree species. UBC needs to decide which endemic species should be preserved on the Vancouver campus, and how much money they are willing to allocate to maintenance and tree planting.

1.2 Importance of healthy soils

Maintaining and improving soil connectivity is of extreme importance, as healthy and productive soils facilitate a healthier landscape and environment. Healthy soils are vital for plant growth and animal life (Jansson et al., 2020). Disconnected soils create "resource islands" (Jansson et al., 2020), which are regions of healthy, fertile soil that are not connected. Improving soil connectivity on the UBC Vancouver campus could benefit plants and animals that reside on campus. There are many trees located in the northern part of campus where soil connectivity is very poor. Increasing soil connectivity in this section of campus could improve tree species health and biodiversity. Improving soil connectivity could results in more and healthier trees, which would then improve shade connectivity as healthier trees could grow larger. Soil connectivity is of vital importance then as it could influence the ecological and shade connectivity on campus. For this reason, it is important that UBC takes care of its soils and improves soil connectivity, especially in the northern part of campus. This is especially important as many species might struggle to survive in future climates, so improving soil connectivity and health could help many species survive and reduce the amount of maintenance some plant species may need to survive.

1.3 Shade connectivity in a changing environment

Shade connectivity is of importance to many species that thrive in shade, but also to human wellbeing in a changing environment. People living in urban environments "suffer from health problems and discomfort that are caused by overheating of urban areas, and there is compelling evidence that these problems will be exacerbated by global climate change" (Brown et al., 2015). Shade is an important contributor to thermal comfort (Brown et al., 2015). Vancouver is predicted to double "in the number of summer days above 25°C" by 2050 (metrovancouver et al., n.d.). As the climate changes, and environments get sunnier and warmer, shade becomes more important to provide not only comfort, but health benefits as well. For such reasons, it is important that UBC not only maintain in shade connectivity, but improve it. Improving shade connectivity on campus means students can more safely traverse campus on hot sunny days. The southern part of campus has the worst shade connectivity, but there are the most open sports fields in this part of campus so improving shade connectivity there may be difficult.

1.4 Limitations

There were limitations when working with the data, as some of it was old and confirming the accuracy was difficult. Looking at satellite imagery it was evident that there were more trees on campus then what was identified in the tree point data. This impacted the tree and shade connectivity analysis as tree information was missing. Shade connectivity included tree shade, so there could have been higher shade connectivity in some areas of campus if more point data for trees on campus was available. Soil connectivity could only be assed at the surface level, as depth of soils was not known. Tree connectivity was only assessed based on point data available, so it is possible there are some errors with tree connectivity, especially considering not all of the trees on campus had point data.

1.5 Future Research

Future research could look at soil health, not just soil connectivity. Soil health could be mapped out alongside soil connectivity to get a better understanding of how soil connectivity influences soil health on the UBC Vancouver campus. Tree health and age could also be analyzed to better inform UBC of how to better move forward regarding what trees to plant in the future and where, given the changing climate. The cost of maintaining trees that are less likely to survive in the future climate could also be compared to the cost of maintaining trees that will be more suitable given the future climate of campus. If maintaining certain endemic species is of major importance, then maybe just a certain section of campus be designated to have higher maintenance standards to help ensure endemic species that are less suitable for a new climate can still persist. This could also be a good educational tool, as visitors to campus in the future could then see what endemic species used to be located on campus, in comparison with other trees that are more suited for the new climate but are not necessarily endemic to the area. These suggestions could all be future research projects with the goal of creating a healthier and more sustainable landscape, while still preserving some of its history.

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