Suitable Area Multi Evaluation Criteria Analysis for Afforestation in Burnaby British Columbia with Native Tree Species

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Abstract

Using native tree species of Burnaby British Columbia as the premise of a multicriteria evaluation with a weighted linear combination approach, is the basis of this analysis. Geographical Information Systems provides a platform to geospatially model a suitability map of the relevant factors and constraints of a semi-rural area to potential afforestation efforts. The results are comprised of the total available area including precise locations using the MCE module within TERRSET geospatial modelling software. The analysis specifically considers factors and constraints in relation to: biogeoclimatic zone, prominent native species, and municipal regulations (zoning laws).

Introduction

Surveying suitable areas for afforestation based on various factors and constraints in relation to digital terrain analysis creates an opportunity for geographical information systems (GIS) raster analysis applications. This project aims to identify suitable areas within the municipality of Burnaby for afforestation under the context of relevant factors and constraints that can prevent afforestation from taking place. The significance of afforestation is mainly from contributions to biodiversity, improving wildlife, reducing air pollutants among various other functions that can benefit local and global ecosystems (Oldfield et al., 2013).

Previous methods of identifying suitable afforestation areas were from Boolean based analysis and surveys of degraded or abandoned agricultural lands (Mahdavi et al., 2017). The approach provided here displays multi-criteria evaluation of Burnaby British Columbia with consideration of the biogeoclimatic zone (BEC), prominent native species, and municipal regulations (zoning laws). Note that regional experiments and further modelling must be conducted such that the full climate effect can be assessed for a net climate and ecosystem benefit (Anderson et al., 2011), before usage of identified suitable areas.

The main analysis method used, is a non-Boolean approach that requires, standardization of factors and constraints, weight assessment of weighted linear combination for the multicriteria evaluation of land suitability for afforestation (Perez-Aguilar et al., 2021). The approach used in this analysis, adds value to the issue of identifying suitable areas through usage of a non-Boolean method through weighted linear combination to define land suitability of afforestation in a semi-rural environment.

Data and Methods

The data layers obtained for parks, streets, digital elevation model (DEM), SkyTrain routes, land use and conservation areas were sourced from the open data catalogue for Metro Vancouver and Burnaby. Biogeoclimatic zones layer was sourced from the forest service research branch of British Columbia. The data layer for powerlines in Burnaby was provided by the GeoBC branch within British Columbia's data catalogue and Fortis BC. All native tree species layers for Burnaby were sourced from the forest genetics council of British Columbia. The characteristics of these native tree species are listed in a table suggesting the relevance and characteristics of the species that are suitable for consideration in the analysis (figure.5).

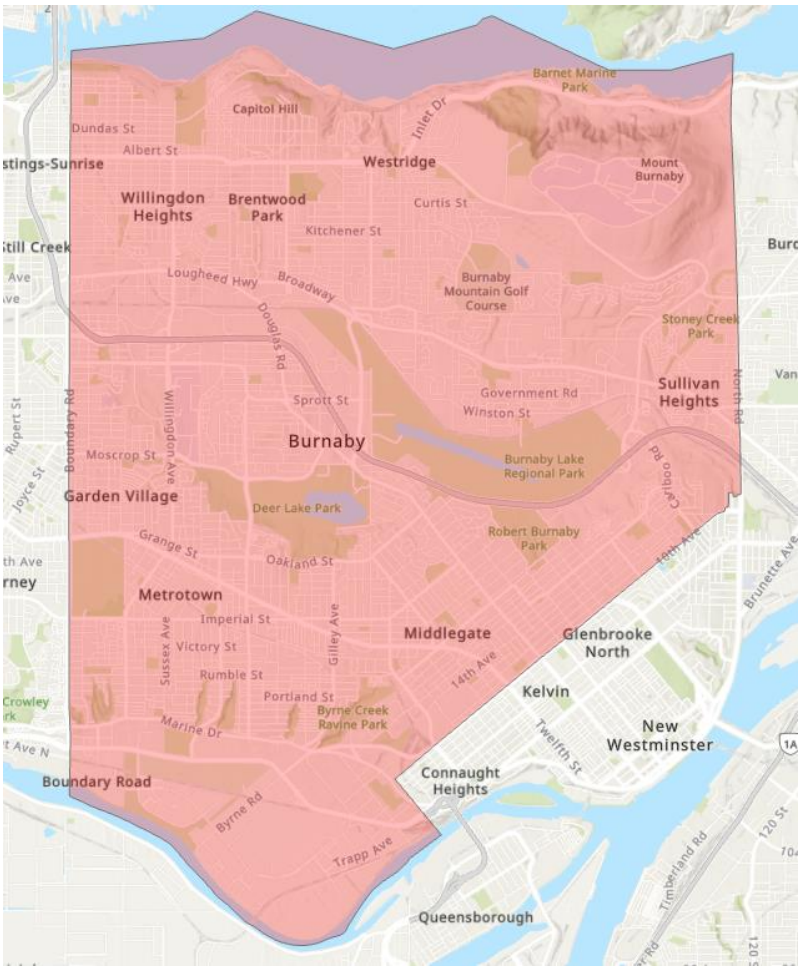

Figure 1. Location of the study area (shaded) in the lower mainland in British Columbia

The data used a spatial resolution of 1m or was converted otherwise, a coordinate reference system (NAD 1983 UTM Zone 10N) and the Transverse Mercator projection, were the basis to display the layer datasets. The study area of Burnaby covers 9,860ha within the lower mainland of British Columbia. The analysis process used to provide the outputs of non-suitable and suitable areas for afforestation, is outlined with five processes from the original data obtained (Figure.2). Data is preprocessed in ArcMap, then imported into TERRSET for reclass of data as random values were present in fields of the files from ArcMap. Once reclassed, the standardization process required usage of edit/assign module.

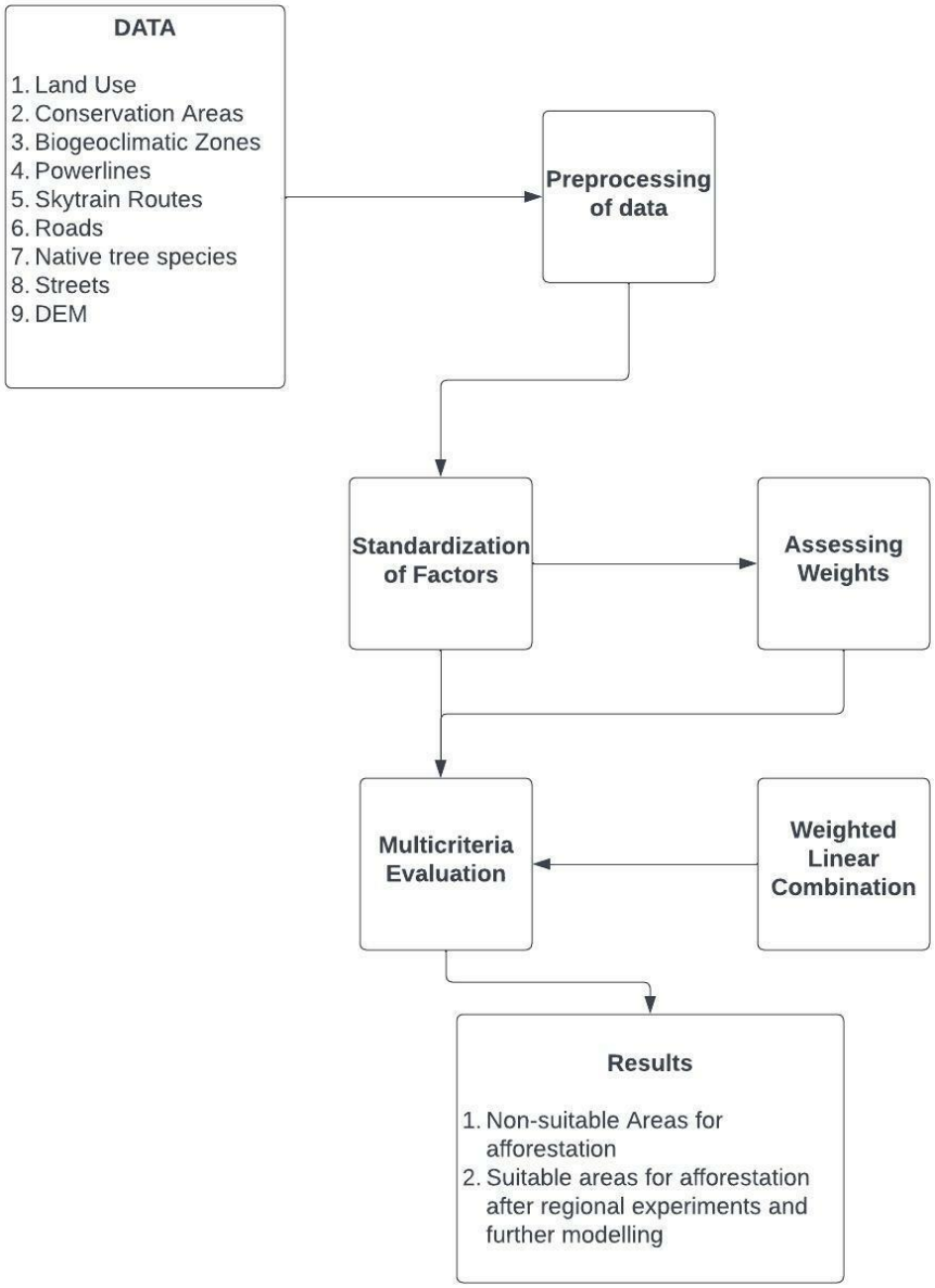

Figure 2. Selection and processing methodological framework in obtaining suitable afforestation area

The land use dataset was adjusted as the scale was set to continuous (1.0=Suitable, 0.0=not suitable). Recreation, open space areas and protected areas were given a scale of 1.0, undeveloped and unclassified areas were given a scale of 0.75, agriculture 0.25 and all other areas 0.0. Standardizing powerlines and streets required the fuzzy and distance module, to determine distance from all powerline features and assign a membership type to produce a suitability value.

A total of four constraints considering areas within parks, conservation areas, land use (specifically recreation, open spaces, and protected areas; undeveloped and unclassified areas; agricultural Areas), and the biogeoclimatic zone of Metro Vancouver known as the Coastal Western Hemlock Zone

(figure.5). With five factors: Powerlines, SkyTrain's, streets, DEM and other land use categories were used in the MCE module (figure.3). These datasets were reclassified using the Boolean approach. Errors in the process were mainly from the data conversion of spatial resolution of datasets (error in measurements) and determining the proper parameters for fuzzy and distance modules (uncertainty in measurements).

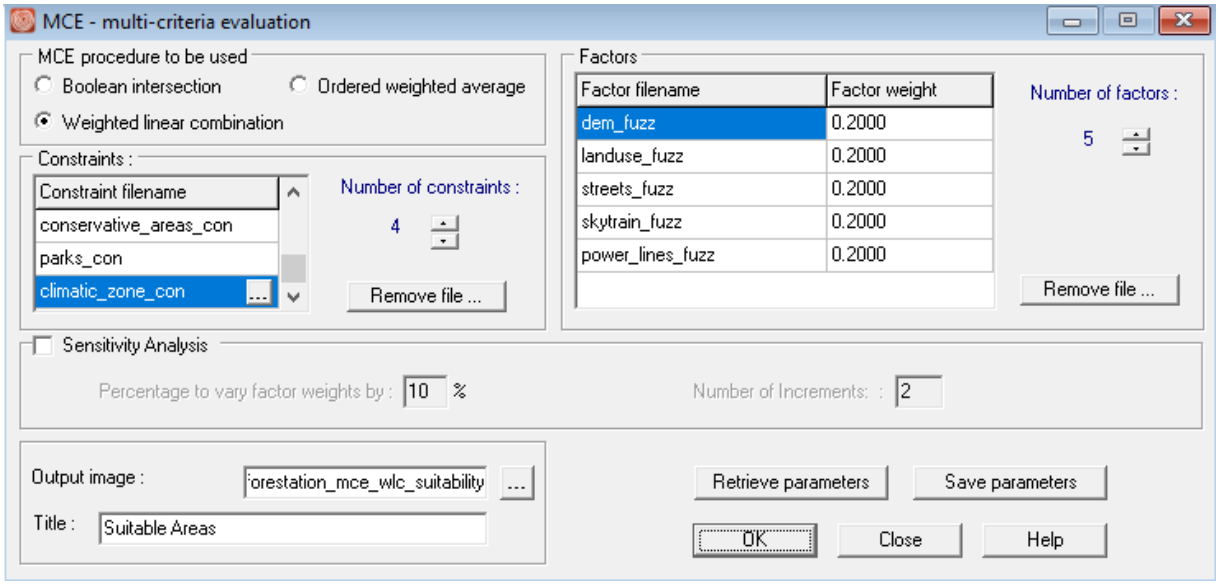

Figure 3. TERRSET MCE module parameters for afforestation of native species suitability map of study area

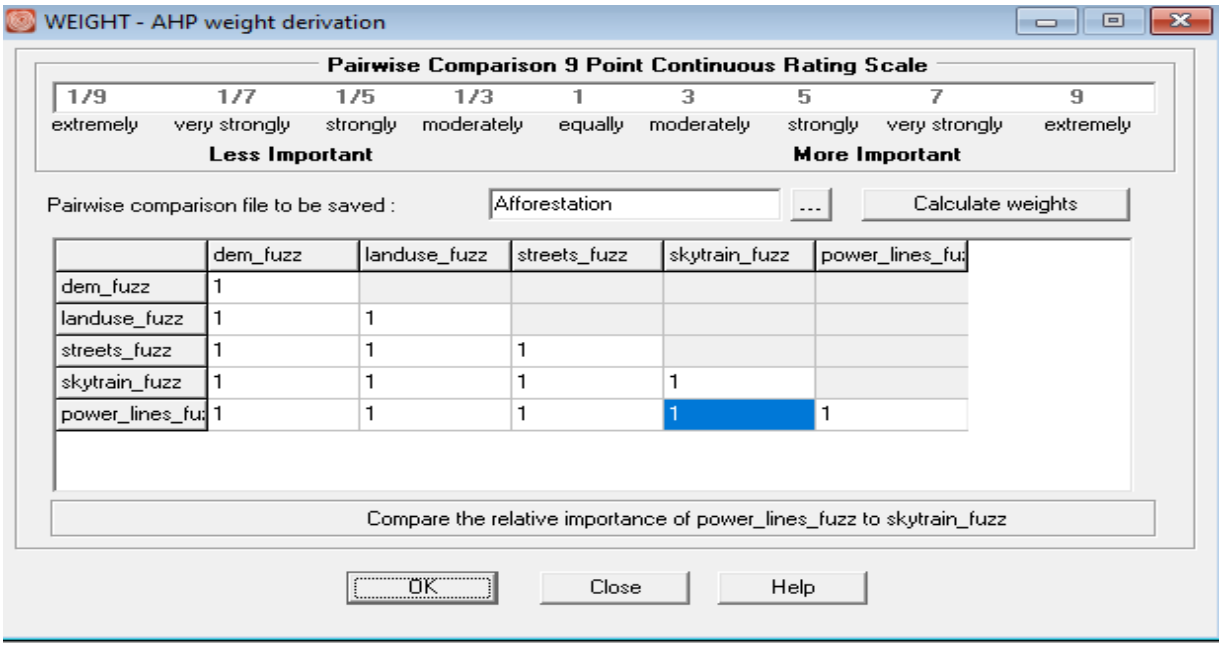

Figure.4 TERRSET WEIGHT module assigning equal weight parameters to factors

Tree Species	**Predominant Location and BEC Zones**	**Coverage in B.C. (ha)**	**Expected percent areal cover in natural forest**
Abies amabilis (Dougl. ex Loud.) Dougl. ex Forbes - Amabilis fir	East Coast B.C. Coastal Western Hemlock (CWH) Mountain Hemlock (MH)	8,462,032 (CWH) 3,175,763 (MH)	5-10% (CWH) <5% (MH)
Abies grandis (Dougl. ex D. Don) Lindl. - Grand fir	South coast and Interior B.C. Coastal Western Hemlock (CWH) Interior Cedar Hemlock (ICH)	1,541,798 (CWH) 318,695 (ICH)	>5% (CWH) <5% (ICH)
Alnus rubra Bong. - Red alder	Southeast Coast B.C. Coastal Western Hemlock Coastal Douglas Fir	8,310,289 (CWH) 250,162 (CDF)	>2% (CWH) <2% (CDF)
Pseudotsuga menziesii (Mirbel) Franco - Douglas-fir	South coast and Interior B.C. Coastal Western Hemlock Engelmann Spruce Subalpine Fir Interior Cedar Hemlock Subboreal Spruce Interior Douglas Fir	6,163,889 (CWH) 5,172,749 (ESSF) 4,121,647 (ICH) 6,208,948 (SBS) 4,365,028 (ICF)	>10% (CWH,ESSF) 5-10% (SBS) <5% (IDF,ICH)
Prunus emarginata (Dougl.) Walp. - Bitter cherry	South coast and interior B.C. Coastal Western Hemlock Interior Cedar Hemlock Interior Douglas Fir	4,364,861 (CWH) 2,898,269 (ICH) 1,335,935 (IDF)	>1%(CWH) <1% (ICH,IDF)
Pinus monticola Dougl. ex D. Don - Western white pine	South coast and East interior B.C. Coastal Western Hemlock Interior Cedar Hemlock Engelmann Spruce Subalpine Fir	5,292,006 (CWH) 3,161,412 (ICH) 1,603,134 (ESSF)	>1% (CWH) <1% (IDF, ICH)
Picea sitchensis (Bong.)Carr. - Sitka spruce	East Coast B.C. Coastal Western Hemlock Mountain Hemlock	10,323,150 (CWH) 3,228,261 (MH)	>10% (CWH) <5% (MH)

Figure.5 Selected native tree species in Burnaby with location, BEC zones and coverage characteristics

Results and Discussion

The initial issue was determination of suitable areas for afforestation from the selected native species in the study area of Burnaby. The resulting suitability map acts as a potential solution even with the multicriteria evaluation which is explained further in limitations section. Though the multicriteria evaluation incorporated weighted linear combinations to produce a land suitability layer displaying acceptable areas of afforestation of native tree species in Burnaby. Suitability is represented on a continuous scale from 0.0 to 1.0 with increasing suitability. Two area types were derived from the multicriteria evaluation process, to distinguish where suitable areas are located for the selected native tree species (figure.5) and not others. Area types are the following: suitable areas considered for afforestation (Recreation, Open Space and Protected Areas, Undeveloped and Unclassified Areas and Agricultural areas) covering approximately 37% of the study area (3624.5 ha) and suitable areas for afforestation, covering 40.7% (1475.2 ha) of the total available area.

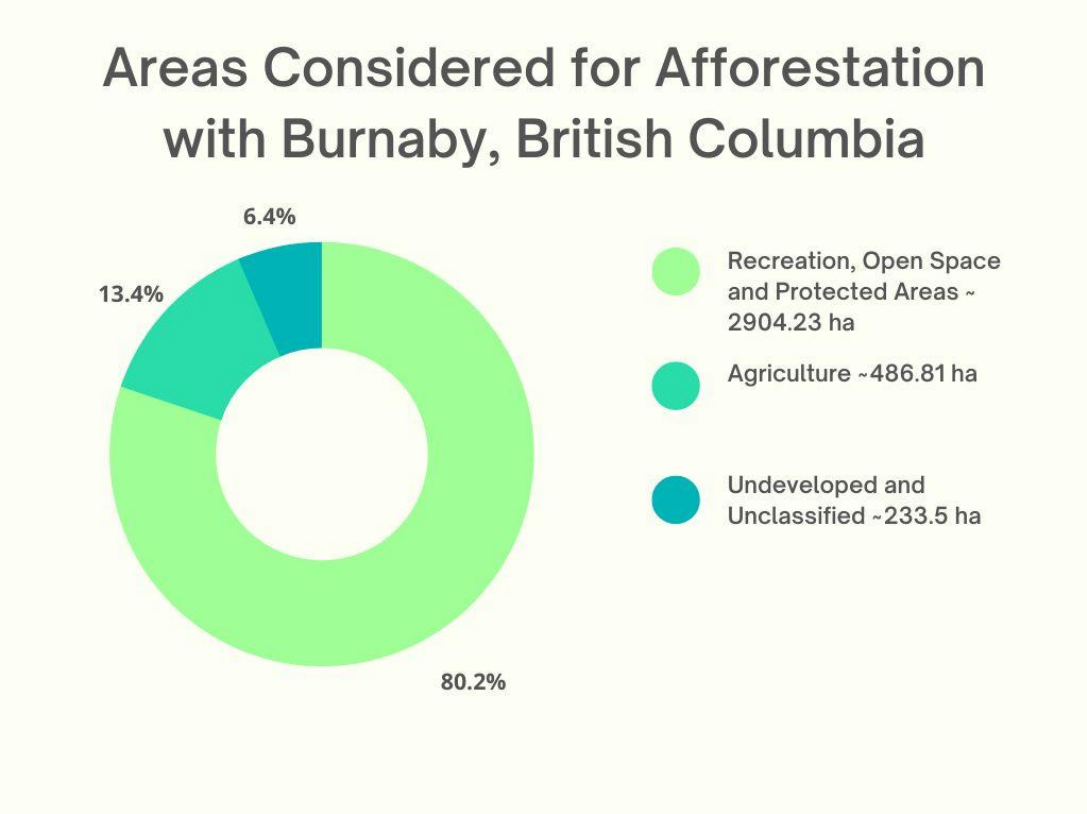

Figure 6. Calculated areas for consideration prior to multicriteria evaluation of suitable areas in study area

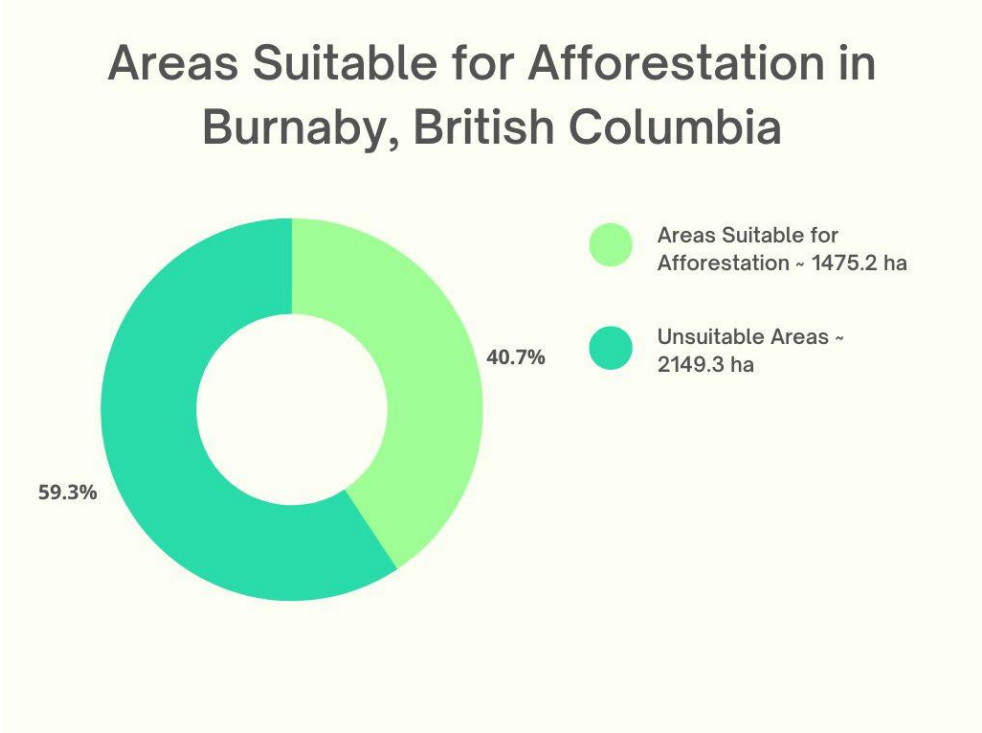

Figure 7. Calculated areas in hectares from multicriteria evaluation; produced from suitability layer of study area

The obtained area types can act as a guideline for resource and environmental management in the context of urban planning. In attempting to locate areas with the potential to add further constraints and factors through a weighted linear approach. As opposed to a Boolean approach (Mahdavi et al., 2017) the multicriteria evaluation enables a constraint and factor-oriented analysis for the determining land suitability to produce an afforestation land suitability map (Perez-Aguilar et al., 2021) and (Dubovyk et al., 2016). The approach utilized in this analysis incorporates fuzzy logic, equal weighted linear combination, municipal guidelines of afforestation practices (figure.8), and biogeoclimatic zones in respect to selected native species of the study area to produce a suitability map.

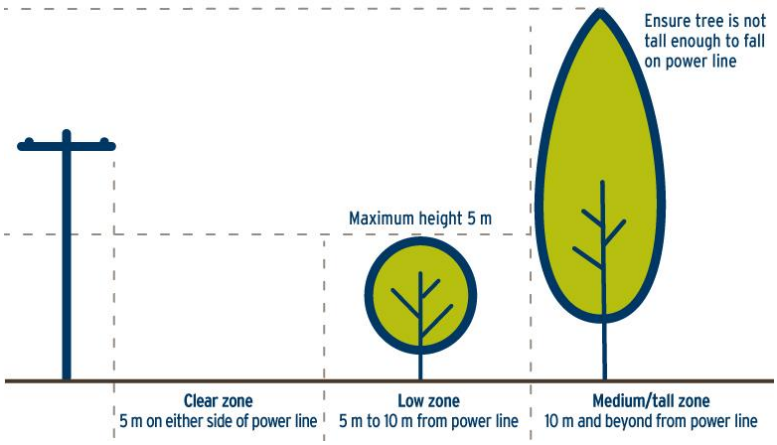

Figure 8. Fortis BC, (2022). *Safe planting near utility equipment*. [Diagram]. Safety and Outages.

Limitations

Further modelling, ground surveying and research will need to be conducted prior to utilizing these areas. Modelling and ground surveying must examine the exact requirements for suitable afforestation based on relation of the study areas ecosystem to the native tree species biophysical properties (Anderson et al., 2011). The weighted linear approach also used a equal weight distribution; attempting to infer the "optimal" weights for each factor without expert or relevant research would be unacceptable. Studies will conduct the necessary means to identify the exact conditions of suitability, "to define a range of suitability values for each criterion, a literature review was performed, with interviews were conducted with local afforestation experts" (Dubovyk et al., 2016). Thus, values of each factor within the weight module were assigned an equal weight denoted with a value of 1 within the matrix (figure.4).

Conclusion

In this analysis, exploration of the location and areas within Burnaby, British Columbia, for suitable for afforestation of Native Tree Species was conducted. Usage of a multi-criteria evaluation to produce a suitability map of areas that fit factors and constraints specified above. To drastically improve the analysis, deriving weights for the weighted linear combination from expert opinions is necessary. Instead of assigning every factor an equal weight within the weighted linear combination. This would allow factors that are more prevalent to the suitability of areas to play a greater role when determining the suitability of areas.

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