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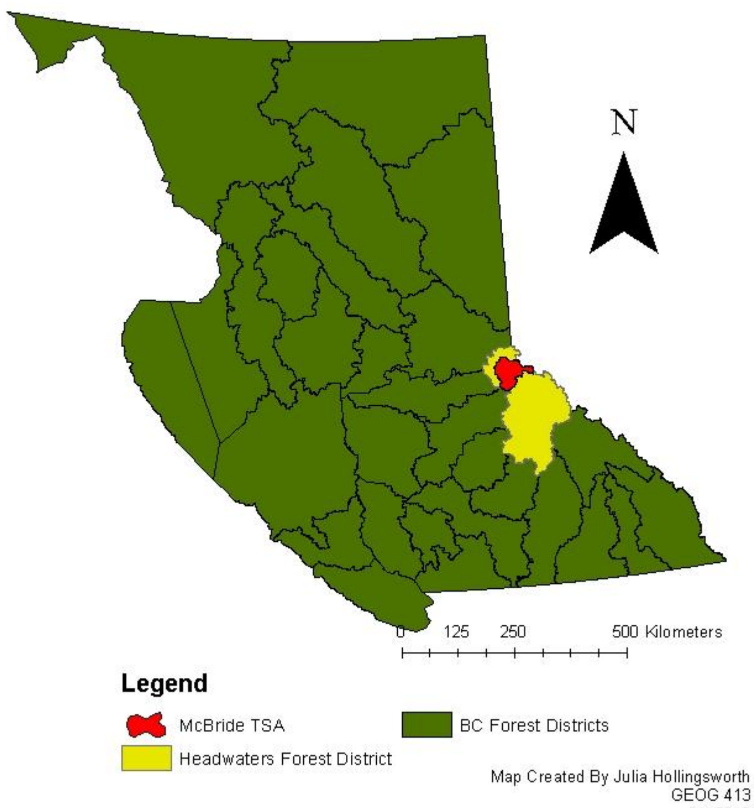
Introduction

Site index is a forestry measurement of the time it takes for trees to grow in a given area, expressed in meters of height gained in 50 years of growth (Klinka and Carter, 1990). In other words, site index is a measure of the quality of a woodland (Chen et al, 1998). In a forestry-dependent economy, site index is useful because it allows an estimate of how quickly a forest can regenerate after logging and reforestation. Given that trees are restricted geographically during their growing period, it follows that spatial characteristics may play an important role in determining site index for a given species.

Spatial characteristics associated with high site index are elevation, aspect, latitude, and slope (Stage, 1976; Hineman et al, 2010; McNab, 1993; Wang et al, 2004). Wang and Klinka have additionally shown that soil characteristics, such as moisture regime, aeration, and nutrients, may be predictors of site index (1996). In addition to the characteristics outlined in Stage (1976), McNab (1993) and Wang et al (2004), I will be looking at soil class and site hydrology to attempt to devise a predictive model for site index in the Timber Supply Area surrounding McBride, BC (Figure 1). I will evaluate the findings of McNab (1993) and Wang and Klinka (1996) to determine which of their models best predict high site index in this region.



<u>Figure 1</u> *– Illustration of the forest districts of BC. Headwaters Forest District appears in yellow, and the study area appears in red.*

Data

I obtained data from two sources. From the UNBC Data Download service, I obtained BC Forest Districts maps (***fadm_dist*** and ***fadm_tsa***), BC Base data (***rivers, lakes, roads***)Vegetation Resource Index data (***vri_83e, vri_93a, vri_93h***), and Digital Elevation Model rasters (***83e-dem25m-alb-asc***, ***93a-dem25m-alb-asc***, ***93h-dem25m-alb-asc***) (UNBC). I obtained the Soils BC Geodatabase (***soilsbcisdata.gdb***) from the Soils BC website (Ministry of Environment). Data was projected using the geographic coordinate system North American Datum 1983. This project was completed using ArcGIS 10.1.

Hypothesis

I hypothesize that variation in the ground-truthed Site Indices in the study area can be explained by one of two models: a moisture and nutrient regime model, as proposed by Wang and Klinka (1996); or a model based on slope and aspect, as proposed by Stage (1976). If this hypothesis is correct, I will be able to create a raster dataset from data collected in this fashion

Methods

1. First, the TSA around McBride, BC was extracted from the ***fadm_tsa***, creating ***McBrideTSA***. Additionally, the Headwaters Forest District was selected from ***fadm_dist,*** creating the layer ***headwaters***. These were used to create Figure 1. ***McBrideTSA*** was set as the processing extent for the environment. ***McBrideTSA*** was set as the processing extent for the analysis.
2. VRI maps (***vri_83e, vri_93a, vri_93h***) were clipped with ***McBrideTSA***. They were then merged using Analysis -> Overlay -> Union to create one VRI (***veg_merg***) for the McBride TSA area.
3. Areas of high site index (>20) were selected out of the VRI map using Analysis -> Overlay -> Select and the SQL query "SITE_INDEX" > 20. Additionally, the VRI was converted to raster format with "SITE_INDEX" as the value field (Figure 2).
4. Digital elevation models (***83e-dem25m-alb-asc***, ***93a-dem25m-alb-asc***, ***93h-dem25m-alb-asc***) were loaded into the environment. A new raster dataset was created (***mosaic_dem***) using Data Management -> Raster -> Raster Dataset -> Create Raster Dataset, and the three DEMs were added as a mosaic to the new dataset using Data Management -> Raster -> Raster Dataset -> Mosaic . ***Mosaic_dem*** was then reclassified into 6 classes using Natural Jenks (***mos_dem_re***). Slope rasters were created (***83e_slope, 93a_slope, 93h_slope***) and were similiarly combined to make ***mosaic_slo***. Aspect raster ***mosaic_as*** were also created; the aspect mosaic was kept as an azimuth from north.
5. Raster Interpolation was used to create a soil type raster from ***soilsbcdata.gdb***:
    a. The point data SOIL was added to the working environment and reprojected from UTM10 to BC Albers. clipped to the layer ***headwaters***. This point data was joined with the table WHSE_SOILS_SOILs_site based on the field "SIT_FORM_N". Only matching records were kept.

b. The point data was converted to a raster based on the field "WHSE_SOILS_SOILS_SITE.NUTRIENT_REGIME" using Conversion -> to Raster -> Point to Raster. The value field is a 5-point rating from A – "oligotrophic" to F – "highly eutrophic". The raster conversion resulted in this scale being represented numerically, from 1 to 5. The raster data was then converted back to point data using Conversion -> From Raster -> Raster to Point (***good_point***)

c. Spatial Analyst -> Interpolation -> Kriging was used to create a raster from that symbolized the variation in soils through the processing extent based on the variation in SOILS (***nut_reg***).

d. ***Nut_reg*** was then reclassified so that the present nutrient regime designations more closely matched those in Wang and Klinka (1996). The old and new classes were:

   - 0 – 2.5 = > -0.81
   - 2.50001 – 3.0 => 1.32
   - 3.00001 – 3.59 => 2.58

   The new raster was named ***nut_reg_re***

e. The procedure from b-c was performed a second time using "WHSE_SOILS_SOILS_SITE.ECO_MOIST_REGM", producing a kriged raster named ***moi_reg***. ***Moi_reg*** was then reclassified into two classes, symbolizing the two moisture regimes present in the kriged model, based on Wang and Klinka (1996).

6. Map Algebra was used to create two models: one based on Stage (1976), and another based on Wang and Klinka (1996). (Figure 3)

   a. The Map Algebra expression used to evaluate Wang and Klinka (1996) was: Site Index = [6 – (***nut_reg_re***) + (***moi_reg_re***)]/10 (***model1***). (Figure 4).

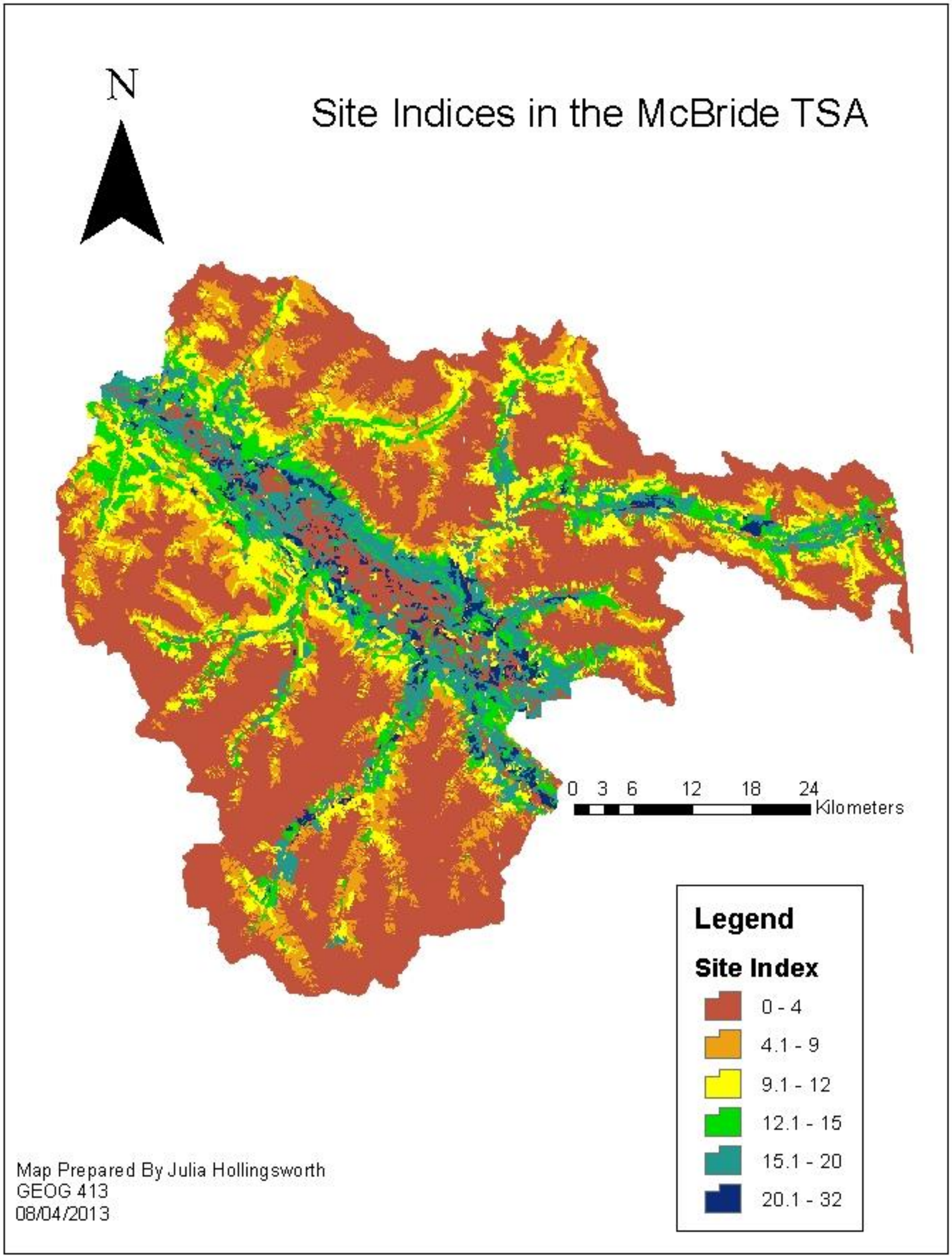
   b. The Map Algebra expression used to evaluate Stage (1976) was: Site Index = e^[0.08070(tan[***mos_slope***])(cos[***mos_asp]***) + 0.08423(tan[***mos_slope***])(sin[***mos_asp***]) – 0.12634(tan[***mos_slope***])] (***model2***)

The two models were then reclassified to have the same value classes as ***site_index***.

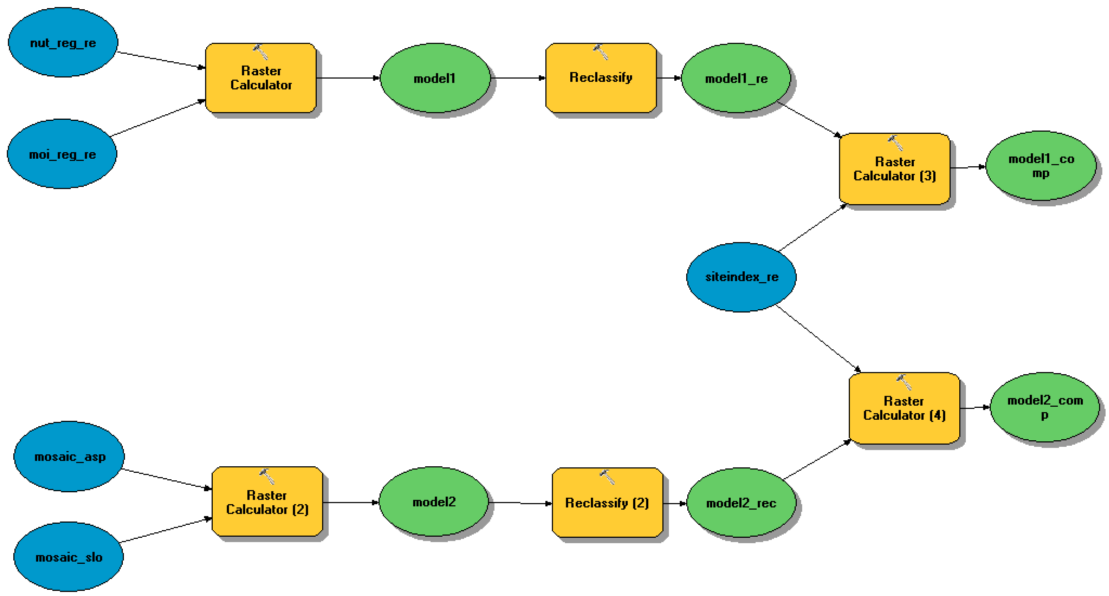
7. The two models were then compared to the site index raster ***site_index*** (Figure 3). Each model was added to ***site_index*** using Raster Calculator, creating ***model1_comp*** and ***model2_comp***. The more accurate the model, the larger the number of high-value cells (>7) the comparison raster will have (Figure 5). Because Model 1 did not produce any values greater than 4, it was discarded.

8. The raster ***site_index*** was converted to polygon (***site_index***). A zonal statistics table (Spatial Analyst -> Zonal -> Zonal Statistics as Table) was calculated using ***model2*** as the value raster and the polygon ***site_index*** as the zonal feature class (***m2_stat***). The table was joined to polygon ***site_index***.

9. A regression was performed using Spatial Statistics -> Modelling Spatial Relationships -> Geographically Weighted Regression (Table 1). The joined field “zonal.MEAN” was used as the dependent variable, and the ground-truthed field “SITE_INDEX” was used as the independent variable.

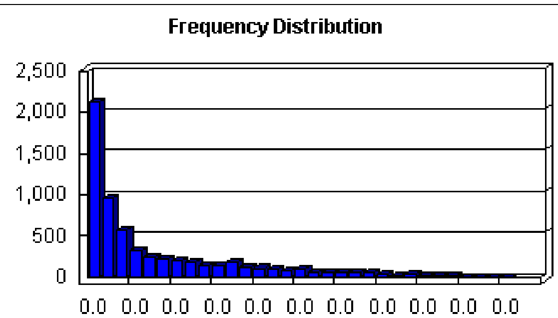


<u>Figure 2</u> *– Site indices in the McBride TSA from layer* **veg_merg***.*



Results

Model1 was not analyzed due to failure of the model; it was not possible to gather enough data from the Soils layer points to have continuous data over the entire study area. Model2 was analysed using a geographic regression (Table 1).



Count	6196 records
Min	0.0
Max	0.008617
Mean	0.00136
Standard Deviation	0.001697

Table 1 – R^2 Results of the geographical regression performed comparing model2 to the ground-truthed Site Index field in ***veg_merge***.

Conclusion

Model1 was not analysed further than Step 7 because it failed to generate any significant-appearing change in the site index map when compared to the raster ***site_index***.

The regression performed on the ***model2*** data demonstrates that there is no relationship between the ground-truthed Site_Index field in the obtained VRI data and ***model2***; the difference in ***model2_comp*** was solely due to variation in the ***site_index*** raster. The results of this analysis were not significant and this model did not describe variation in site index in this study area.

Discussion

This analysis failed to devise a spatial model to explain variation in site index in the Timber Supply Area surrounding McBride, BC. This may have been a result of inappropriate model application; the coefficients determined by Wang and Klinka (1996) and Stage (1976) were used without adjustment. Further research is needed to determine whether the lack of correlation is due to problems with the applied model, or whether the ecosystem in the study area is sufficiently different from the other forested site index models that site index is determined by other criteria altogether.

Literature Cited

Chen HYH, Klinka K, Kabzems RD. 1998. Site index, site quality, and foliar nutrients of trembling aspen: relationships and predictions. Canadian Journal of Forest Research 28(12): 1743-1755.

Hineman JL, Sachs DL, Mather WJ, Simard SW. 2010. Investigating the influence of climate, site, location, and treatment factors on damage to young lodgepole pine in southern British Columbia. Canadian Journal of Forest Research, 2010 40(6):1109-1127.

Klinka K, Carter RE. Relationships between site index and synoptic environmental factors in immature coastal douglas-fir stands. Forest Science 36(3):815-830.

McNab HW. 1993. A topographic index to quantify the effect of mesoscale landform on site productivity. Canadian Journal of Forest Research 23(6): 1100-1107.

Ministry of Environment. BC Soils Information System Data [Online Resource]. http://www.env.gov.bc.ca/soils/provsoil/ [Retrieved 07-04-2013].

Stage AR. 1976. An Expression for the effect of aspect, slope, and habitat type on tree growth. Forest Science 22:457-460.

UNBC. UNBC Data Download [Online Resource]. http://www.gis.unbc.ca/resources/data_download/login.php [Retrieved 07-04-2013]

Wang GG, Huang S, Monserud RA, Klos RJ. 2004. Lodgepole pine site index in relation to synoptic measures of climate, soil moisture, and soil nutrients. The Forestry Chronicle 80(6):678-687.

Wang GG, Klinka K. 1996. Use of synoptic variable in predicting white spruce site index. Forest Ecology and Management. 80(1-3):95-105.