Abstract

Kimberly Gaines and Shandi Hunt

Digital Terrain Analysis of Wine Tour Routes in the Chehalem Region

The topography of the Willamette Valley plays a critical role in the ability to grow and produce wine. The Valley lies east of the Coast Range and west of the Cascades in the Willamette River drainage basin, satisfying the regional topographical prerequisites to grow grapes. The number of Vineyards and Winerys has grown from 619 in the early 2000's to 1,918 in 2017 with the highest increase over the past four years. In 2017, Oregon's wine grapes were valued at $171 million USD. This has led to an increase in the popularity of wine tourism in Oregon, specifically in the Willamette Valley. This study focuses on finding the least cost path between selected wineries and vineyards along a wine tour route within the Chehalem region with consideration to the road network and topography.

To conduct a cost route analysis of the wine tour area, slope, distance, total weight of a 10,000 pound tour bus were all considered as attributes for total cost. For this project, we found two methods that had been used previously to calculate total work as a cost along their study areas. Using the given information found in both powerpoints, we made efforts to replicate the processes. Elevation data from a 10 meter DEM was added to a road dataset using both the Add Surface Information tool and the Interpolate Shape tool. This output was run in ET Geo Wizards software to obtain the Z characteristics of the polyline. This new output was used in ArcGIS where additional fields were added to the attribute table for 3D miles, force, and total work. Using the Network Analyst tool, a least cost path analysis was conducted to identify the shortest distance and least work routes between wineries .

Using the processes provided by the aforementioned projects, we were able to create a 3D distance least cost routes and alternative routes with the least total work cost. These results could be used for analysis to determine the total work cost of existing and potential routes.

Key Words : DEM, Digital Elevation Model, Network Analysis, GIS, Topography, Geo Wizards, Spatial interpolation

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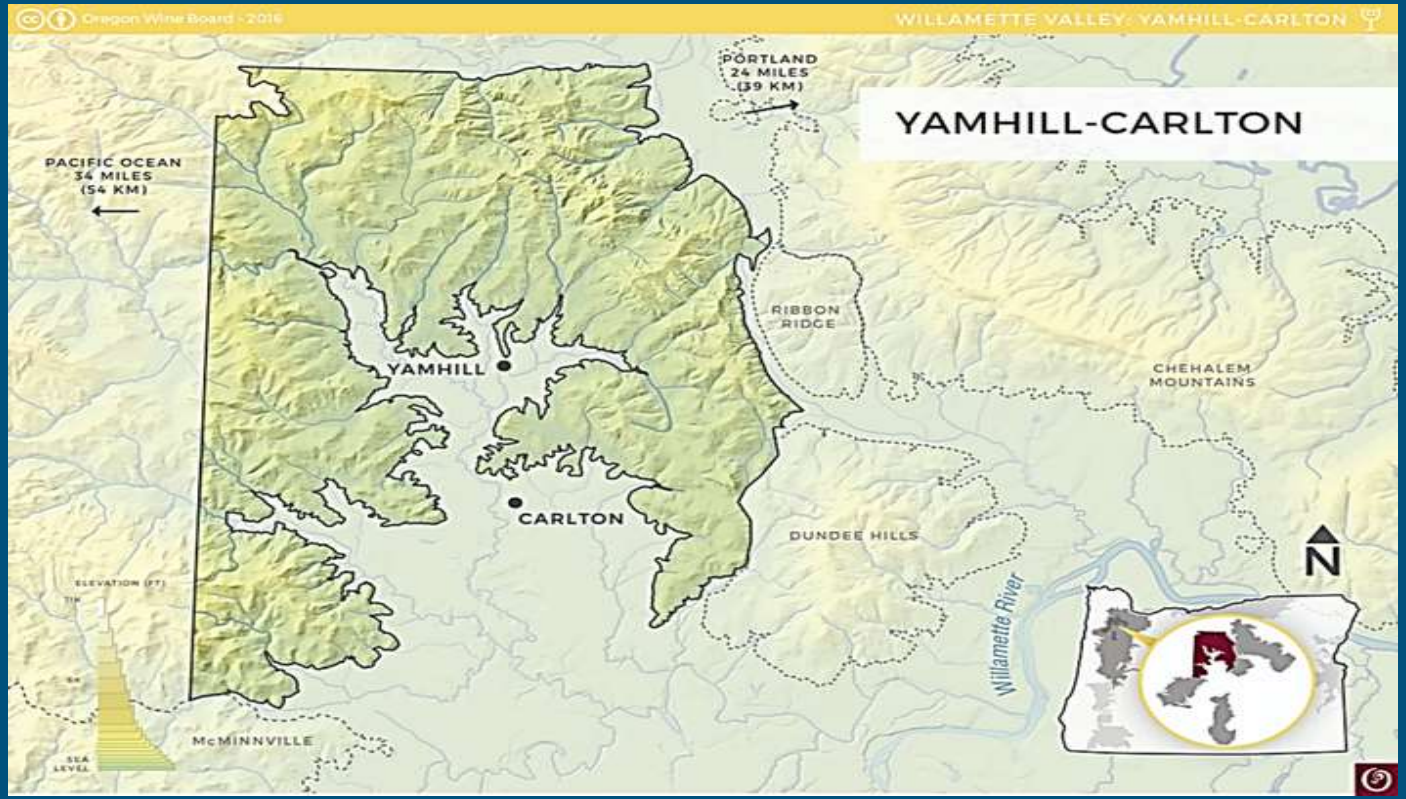
Question

Can cost attributes be derived from Digital Elevation Model (DEM) and a road dataset using ArcGIS Network Analyst tool?

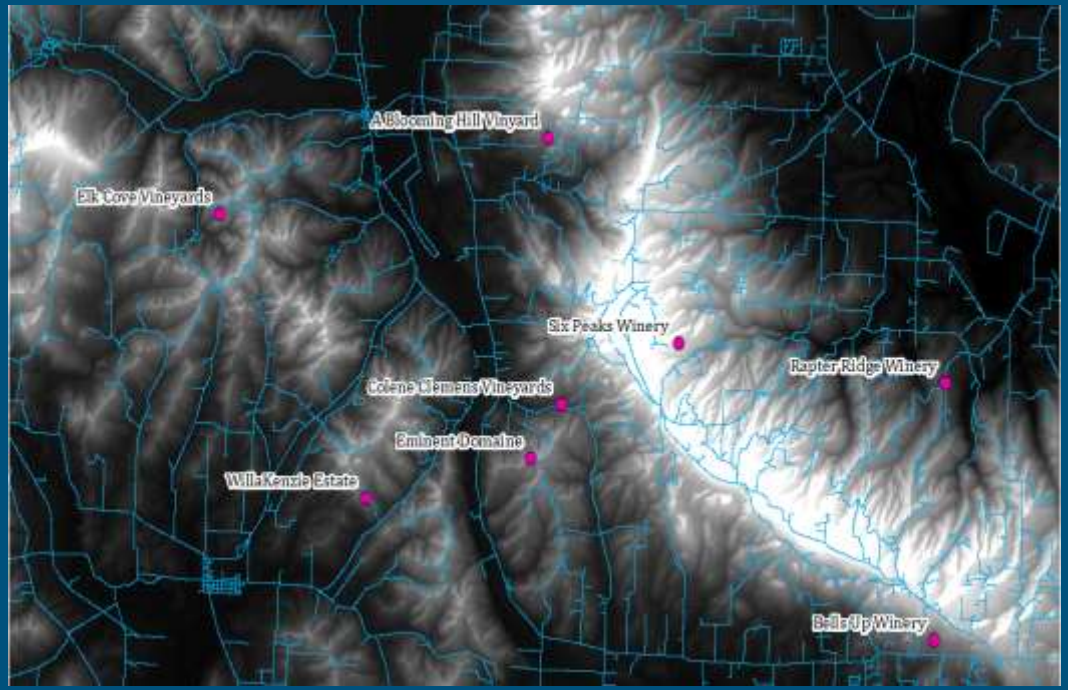
Study Area



https://www.forbes.com/sites/joemicallef/2018/04/15/how-well-can-you-taste-terroir-north-valley-vineyards-origin-series/#a6e9e1971bad

Datasets Used

- 10M Digital Elevation Model (DEM) of Oregon
- Roads - Oregon Transportation Network
- Winery and Vineyard Location Shapefile



Process

Select Wineries and Vineyards within the Chehalem Region to create point shapefile.

Clip roads and raster to target area.

Add Surface Information to roads

Run Interpolate Shape Tool on target road layer

Use ET Geo Wizards software to calculate characteristics of the new Polyline Z output

Process Continued

Use the field calculator to calculate force and work

Run Network Analyst with distance to find the shortest route

Run Network Analyst with kilojoules to find the least work route

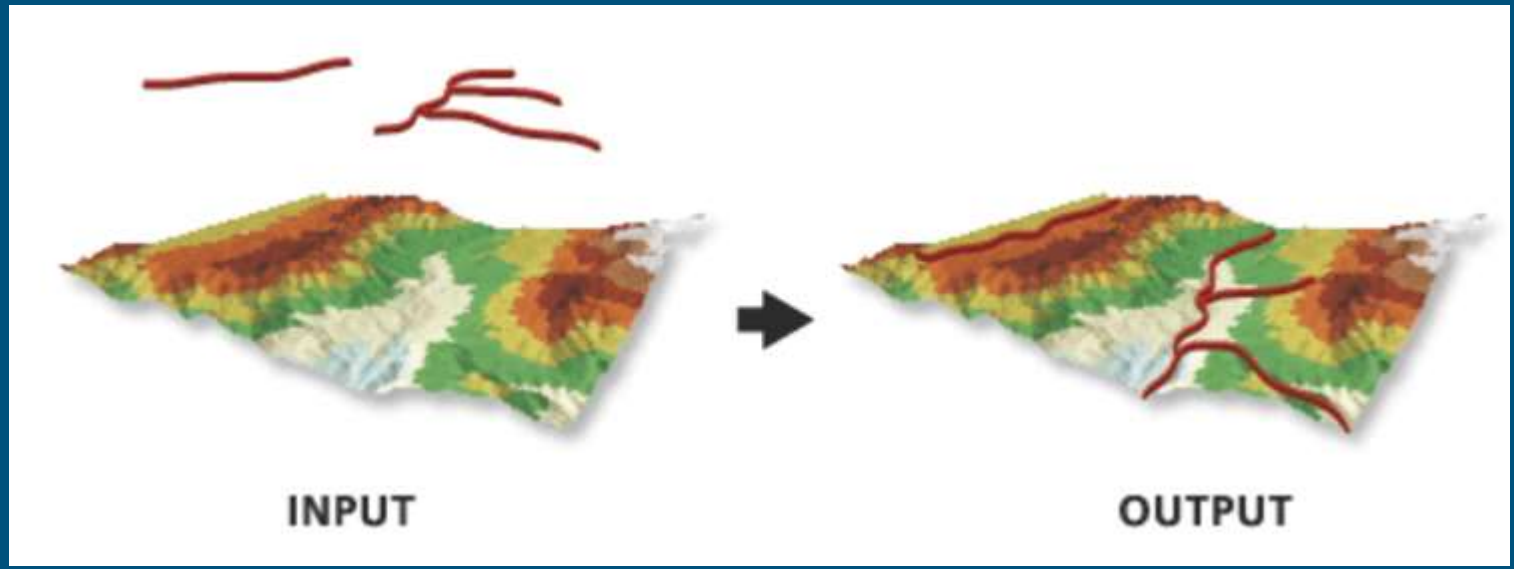
Add Surface Information

The add surface information tool adds z properties from the DEM by interpolating surface measurements along the length. This tool also provides minimum, maximum and mean elevation and slope for each segment of the line.

Z_Min	Z_Max	Z_Mean	SLength	Min_Slope	Max_Slope	Avg_Slope
363.428591	402.842141	375.702433	2545.570205	0.13112	22.15604	5.019233
296.825804	306.493897	304.526651	395.189383	0.068041	8.643906	2.710412
264.878847	305.475067	283.208606	837.858114	0	10.736172	4.895782
262	273.793058	268.273088	830.252522	0	10.851858	4.404446
304.944021	318.68824	313.11744	604.956815	0.141737	8.324575	3.722806
552.790919	595.652131	573.154918	304.309575	9.655359	20.015655	14.246006
526.649396	552.790919	539.364068	739.431331	0.02598	14.514033	6.064533
595.652131	638.38468	616.409056	477.308425	5.321629	15.038403	8.999066
595.652131	639.269493	619.265893	722.855394	1.034227	12.978296	6.270192
277.737239	297.783591	289.400974	2633.170001	0	11.675386	2.630749
296.825804	345	317.290572	385.495669	7.090235	22.653244	12.649366
320.378503	337.355831	328.585989	372.161442	0.351275	10.161102	4.600003
174	177	176.015769	592.155899	0	7.05859	0.507592
177	208.854285	183.384734	1614.570149	0	11.278103	1.979752
302.557335	313.214854	308.087899	173.6429	5.011319	8.307176	6.15054

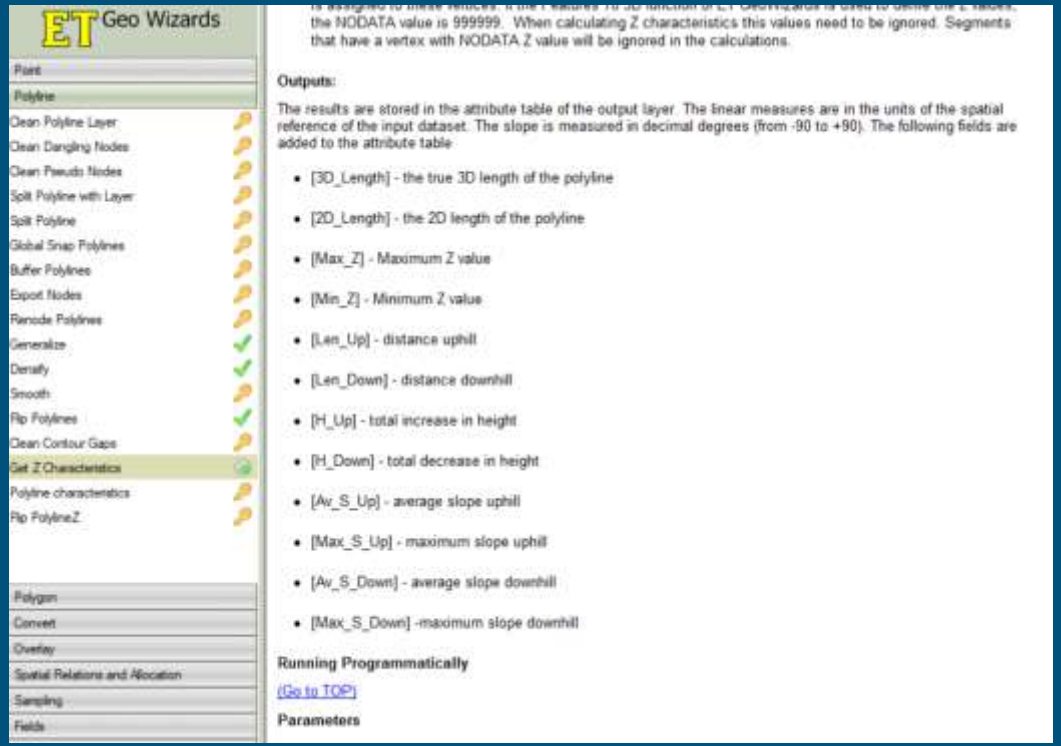
Interpolate Shape

The interpolate shape tool was used to transform the 2D road polyline to a 3D polyline. The z-value was interpolated from the 10 meter DEM surface.



ET Geowizard Get Z Characteristic Tool

ET Geowizard provides tools that expand the usability beyond what is available in Arcmap. The Get Z Characteristic tool calculates various z characteristics along a 3D polyline. The ArcGIS surface information tool provides many of the same outputs as ET Geowizard Get Z Characteristic tool. However, the ET Geowizard tool provides additional attributes distance uphill, distance downhill, height up, and height down.

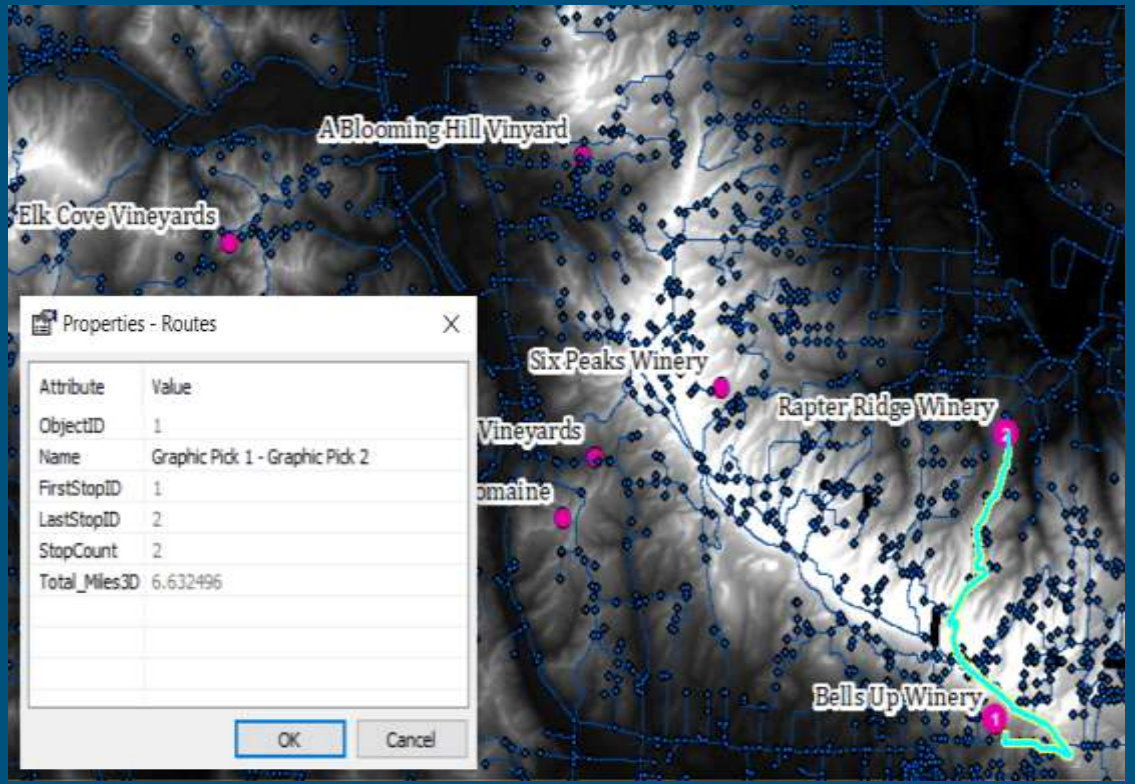


The output from the ET Geo Wizards software provides a unique identifier with the updated table.

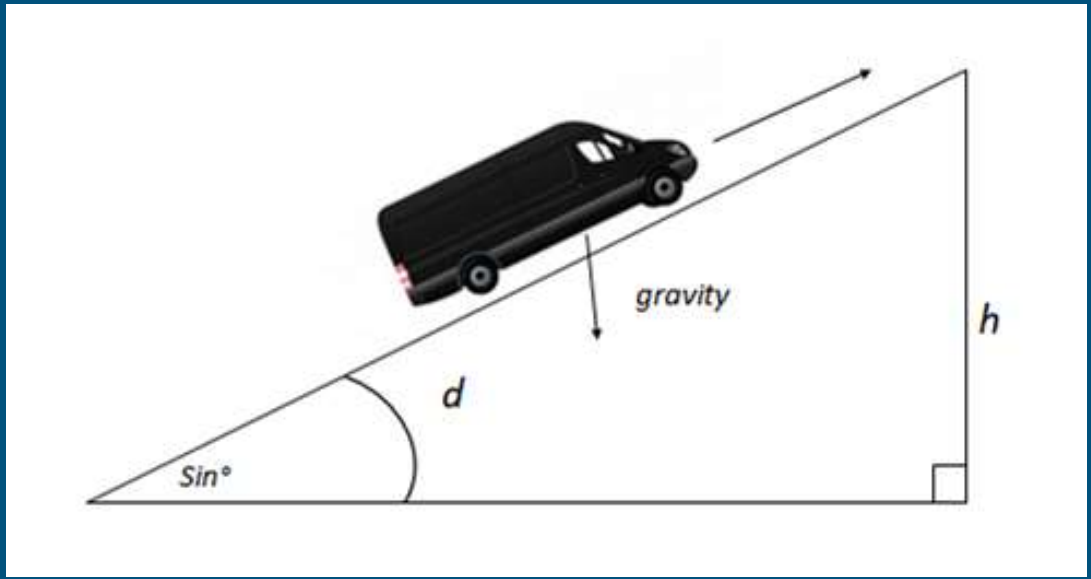
ET_ID	Length_3D	Length_2D	Max_Z	Min_Z	Len_Up	Len_Down	H_Up	H_Down	Max_S_Up	Max_S_Down	Av_S_Up	Av_S_Down
0	2545.57	2539.92	402.84	363.43	1031.67	1513.9	44.64	82.41	8.69	12.49	2.48	3.12
1	395.19	394.86	306.49	296.83	200.36	194.83	1.02	9.67	1.81	4.94	0.29	2.85
2	837.86	836.44	305.48	264.88	32.64	742.32	0.16	40.75	0.28	6.13	0.28	3.15
3	830.25	828.96	273.79	262	348.94	422.85	19.3	17.17	6.19	5.61	3.17	2.33
4	604.96	604.38	318.69	304.94	222.88	382.07	7.59	14.9	4.76	3.8	1.95	2.24
5	304.31	301.14	595.65	552.79	304.31	0	42.86	0	11.32	0	8.1	0
6	739.43	737.45	552.79	526.65	302.07	437.36	18.49	26.15	8.26	6.88	3.51	3.43
7	477.31	475.22	638.38	595.65	477.31	0	42.73	0	8.55	0	5.14	0
8	722.86	720.97	639.27	595.65	661.64	61.21	43.94	1.21	7.39	1.68	3.81	1.13
9	2633.17	2631.3	297.78	277.74	1103.87	1084.89	32.15	36.98	5.68	6.66	1.67	1.95
10	385.5	382	345	296.83	0	385.5	0	48.17	0	12.76	0	7.19
11	372.16	371.62	337.36	320.38	343.09	29.07	16.98	0.1	5.8	0.2	2.84	0.2
12	592.16	592.07	177	174	0	62.41	0	3	0	4.04	0	2.76
13	1614.57	1613.32	208.85	177	519.07	0	31.85	0	6.43	0	3.52	0
14	173.64	173.3	313.21	302.56	173.64	0	10.66	0	4.75	0	3.52	0
15	383.37	382.94	291.11	276	0	287.64	0	15.11	0	4.57	0	3.01
16	488.08	487.58	328.23	314.98	320.28	107.17	13.25	4.09	5.09	3.96	2.37	2.19
17	1107.36	1104.77	341.73	314.98	503.92	542.11	32.34	26.84	9.48	8.2	3.68	2.84
18	348.79	347.94	302.56	279	348.79	0	23.56	0	6.1	0	3.87	0

Creating the Network

- ET Geo Wizards Road dataset output.
- Wine Locations
- DEM

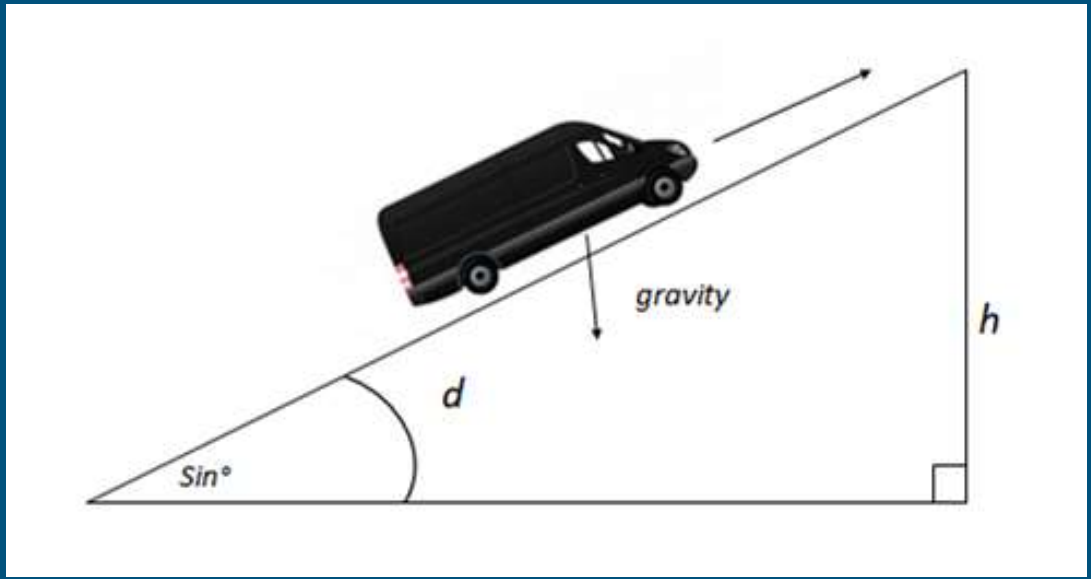


Force Assumptions



Force = mass * gravity * sine

Work Assumptions



Work = force * distance

Components of Work

- Gross weight of tour bus (vehicle and max passenger weight) 10,000 lbs or 4535.924 kgs
- Gravity 32.2 ft/s ^{2} or 9.8 m/s ^{2}
- Slope
- Distance

Components outside the scope of this project

- Wind resistance
- Friction
- Gas mileage

Results Using Distance

Bells Up Winery to Rapter Ridge Winery

Total distance = 6.6 miles

Rapter Ridge Winery to Colene Clemens Vineyard

Total distance = 9.65 miles

Colene Clemens Vineyard to Eminent Domaine

Total distance = 1.61 miles

Eminent Domaine to Willakenzie Estate

Total distance = 4.91 miles

Willakenzie Estate to Six Peaks Winery

Total Distance = 7.79 miles

Six Peaks Winery to A Blooming Hill Vineyard

Total Distance = 5.95 miles

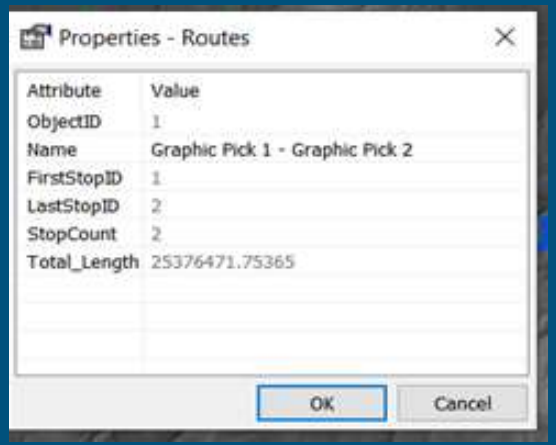
A Blooming Hill Vineyard to Elk Cove Vineyard

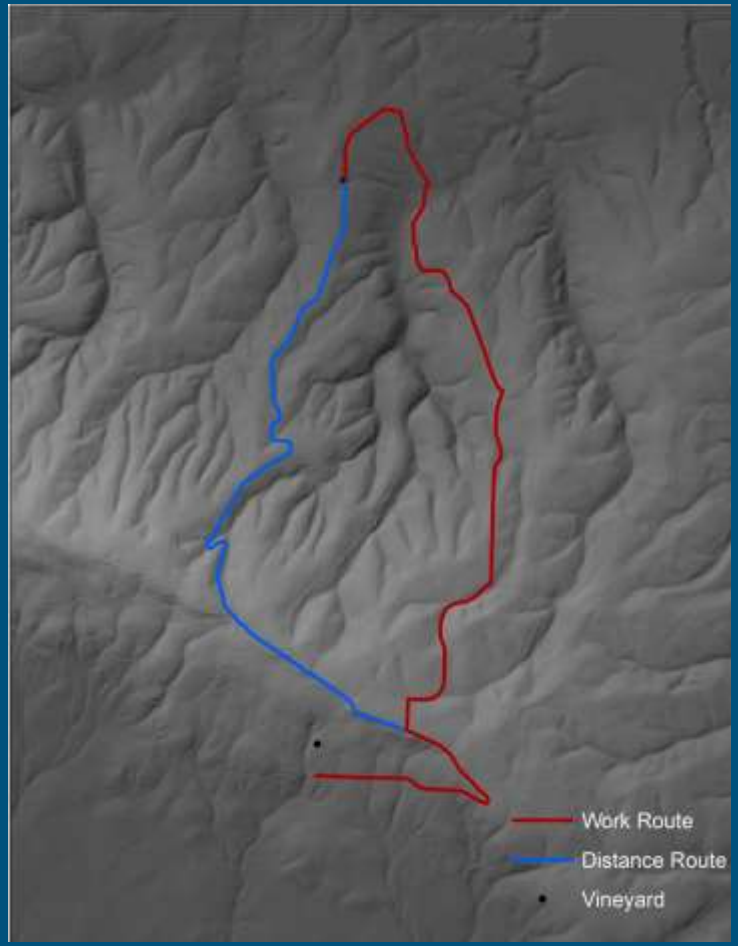
Total Distance = 8.76 miles

Results Using Work

Bells Up Winery to Rapter Ridge Winery

Total Work = 25376471.75 kj

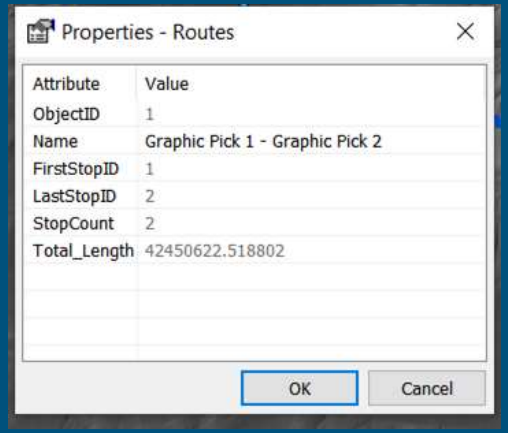


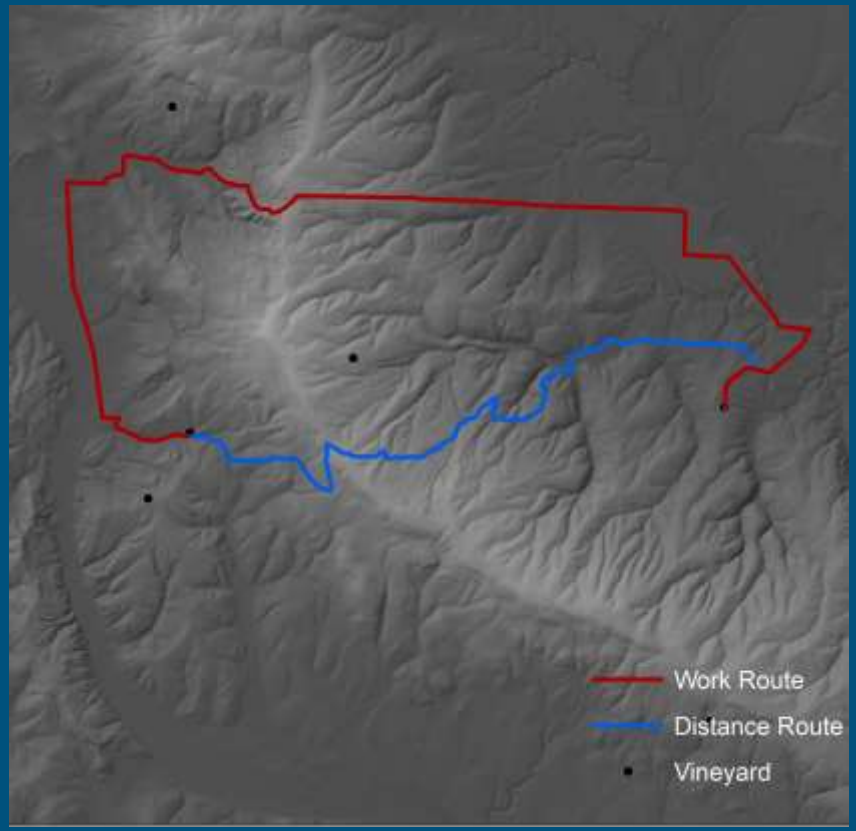


Results Using Work

Rapter Ridge Winery to Colene Clemens Vineyard

Total Work = 42,450,622.52 kj

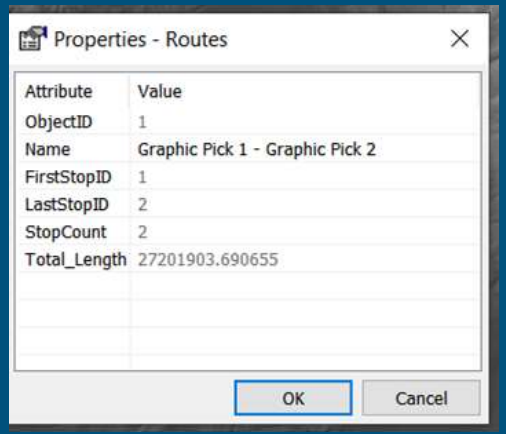




Results Using Work

A Blooming Hill Vineyard to Elk Cove Vineyard

Total Work = 27,201,903.69 kj



Other Methods Attempted

Alternative Network Impedance for Bike Route

$Force_{weight}$ = weight * sine Work = force * distance Power = work/time

- Generate from node and to node at each link
- Convert polyline to point
- Extract elevation from DEM at both end points
- Add X, Y coordinates to points
- Manipulate Attribute tables to remove duplicates and add to node elevation
- Use Network Analyst for traditional impedance time and alternate work and power

Other Methods Attempted

A Cost Path Analysis of the Chehalem Mountain Wine Region (we used a variation of this method)

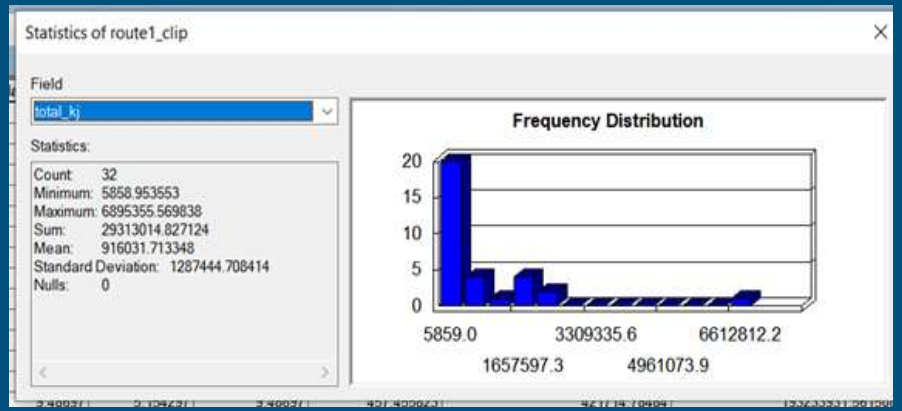
Force = mass * gravity * slope Work = force * distance

- Interpolate shape
- ET GeoWizard Get Z Characteristic
- Network Analyst used to find cost path for work and distance

Other Methods Attempted

Force = mass * gravity * slope Work = force * distance

- Calculate using the field calculator
- Use statistics tool to find the sum of the kilojoules



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