

The Best of Yosemite National Park

A quantitative look at trail intensity and viewsheds in a GIS

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Park Facts

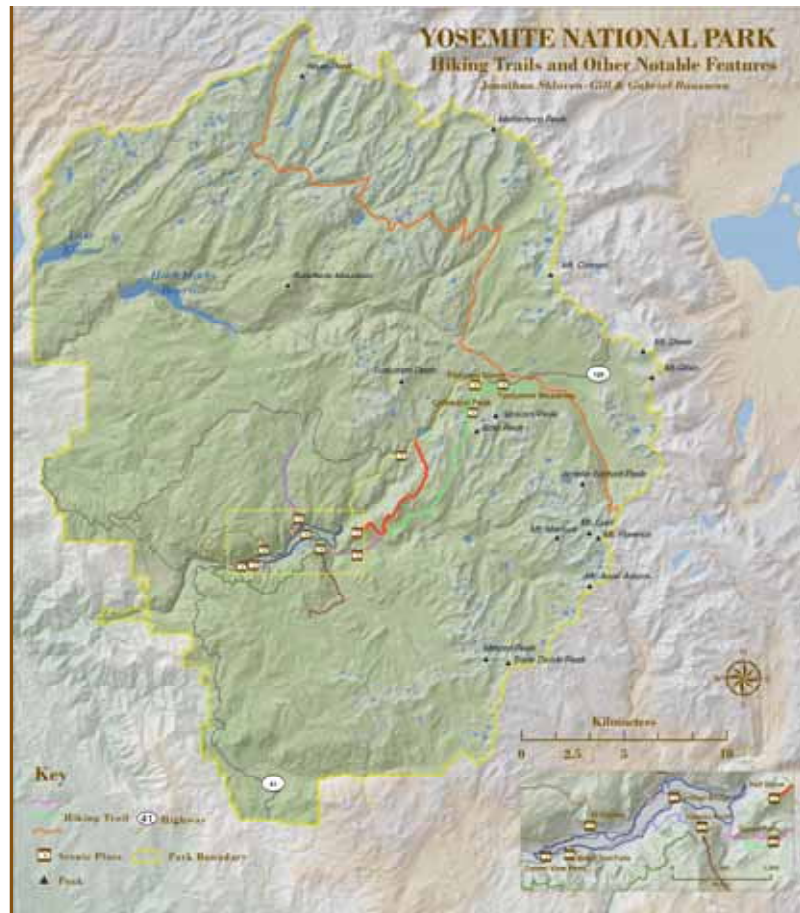
- Designated as 2nd National Park in 1890 by US Congress
- 3028 km²
- 94% of which is designated wilderness
- 1287 km hiking trails
- 451 km of roads
- Yosemite Falls is tallest waterfall in United States
- El Capitan tallest single face in North America
- Camp 4 regarded as birthplace of modern rock climbing

El Capitan



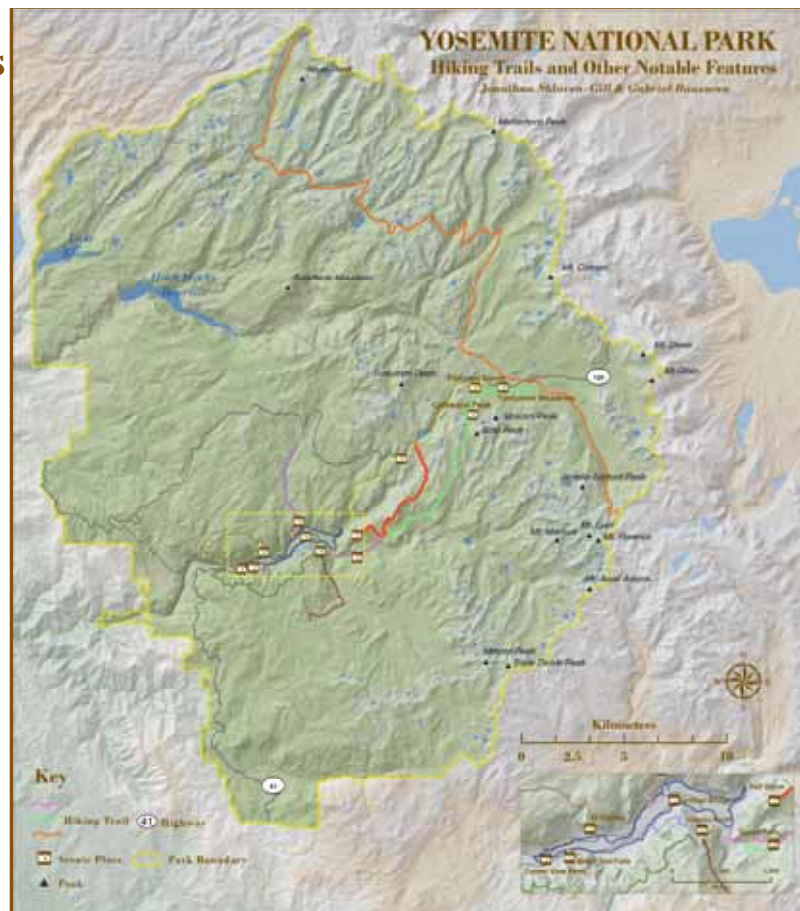
Economic Facts

- Park supports at least 3,000 jobs and has \$29 million annual operating budget
- Visited by 4 million people from each year
- Accessible from four highways
- Eastern access through historic Tioga Road
 - Highest Trans-Sierra crossing at 3031 meters
- Trail access by Pacific Crest Trail (PCT)



Study Area Parameters

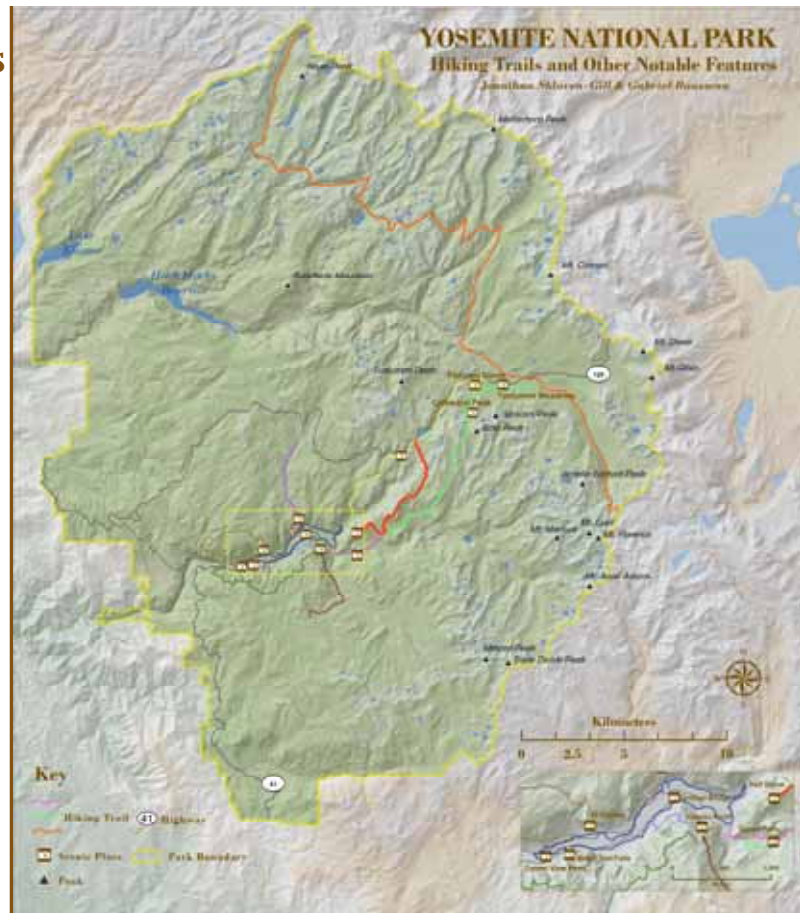
- Individuals have different needs and expectations
- **INPUT**
 - Park goer restricted roadways and Merced River Valley
 - Scenic Place
 - Park goer that wishes to spend time hiking or in solitude
 - Peak
- **OUTPUT**
 - Categorical Joining of two distinct variable types with hiking trails



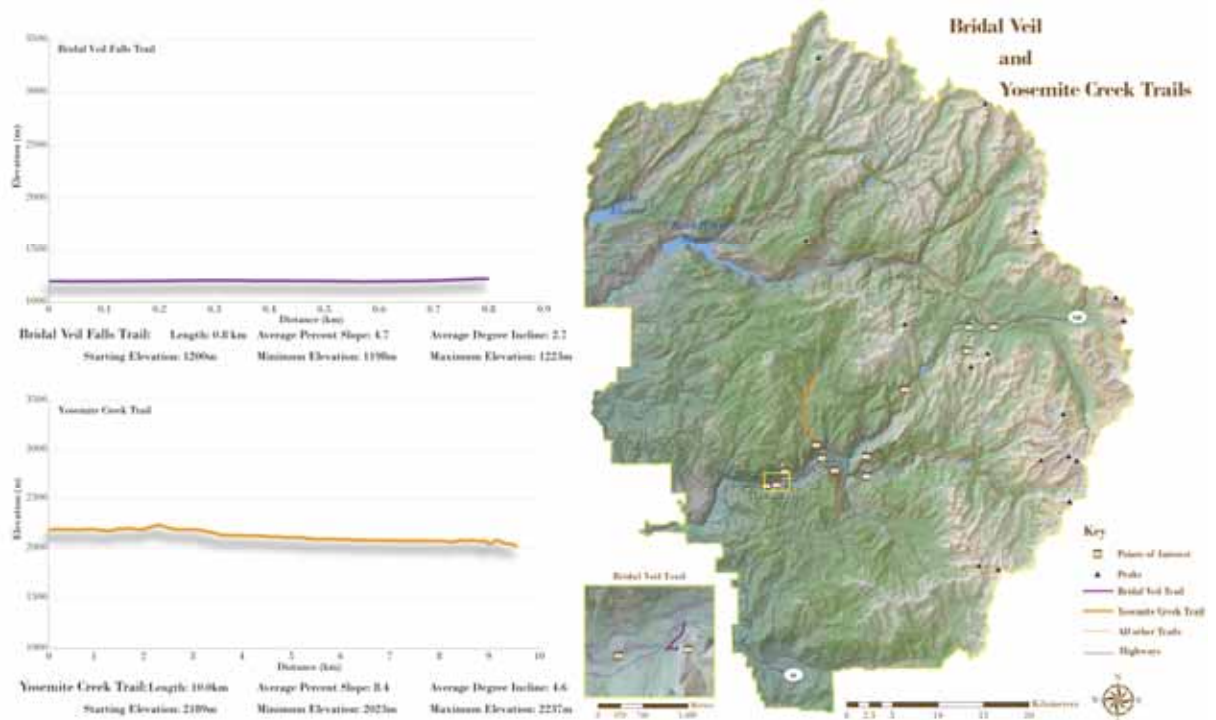
Study Area Parameters

We chose:

- 13 trails
- 6 vista areas
- 9 iconic locations
- 17 mountain peaks



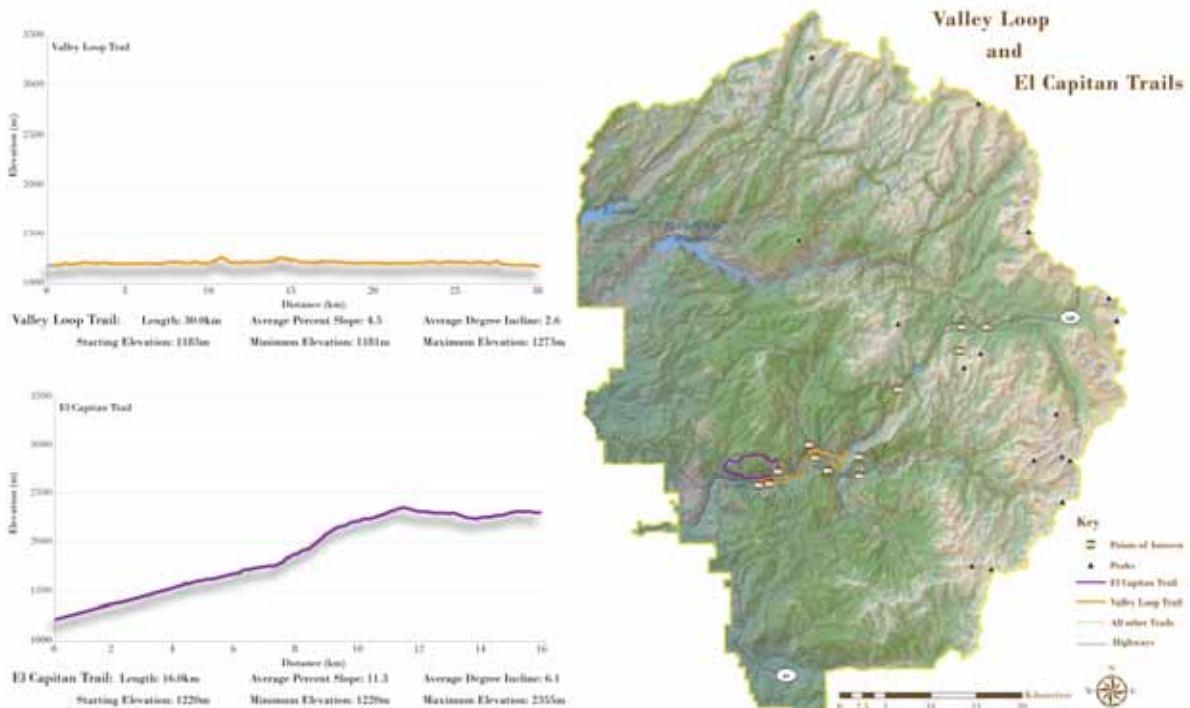
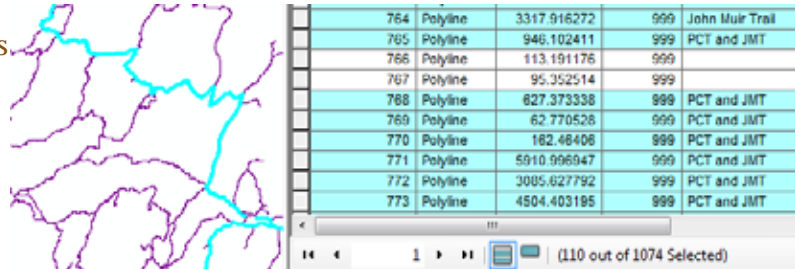
YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:



YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

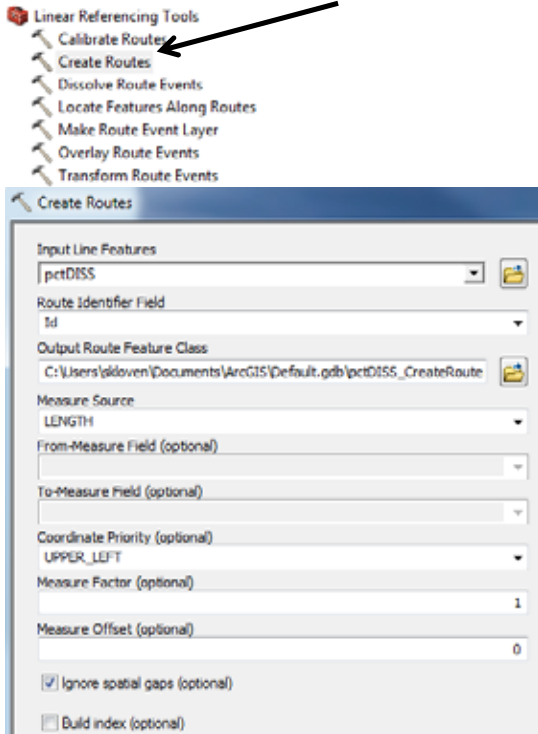
Trail Selection

- Choose Trails
 - <http://www.nps.gov/yose/planyourvisit/hiking.htm>
 - Ensure spatial variety
- Select specific trails based on "NAME" field in National Park's Trail feature class
 - EG: "NAME" LIKE 'Pacific%' OR "NAME" LIKE 'John M%' OR "NAME" = 'PCT and JMT'
- Dissolve Multi Part Lines

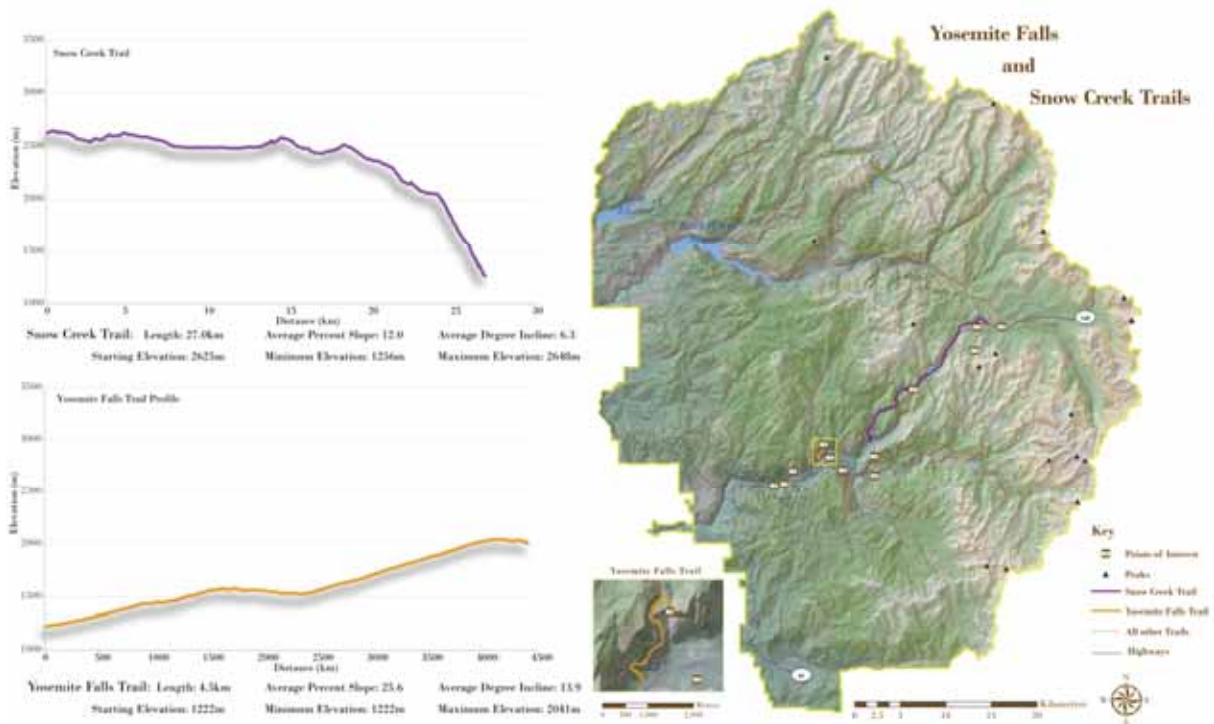


YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

Routes and Points

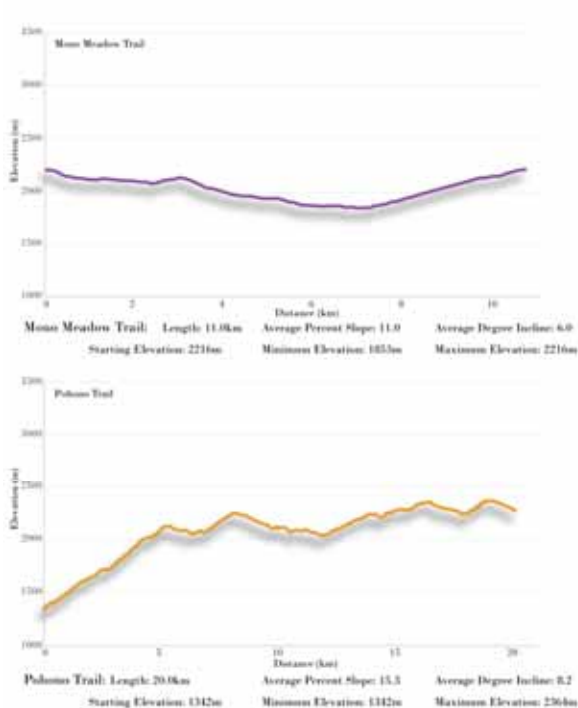
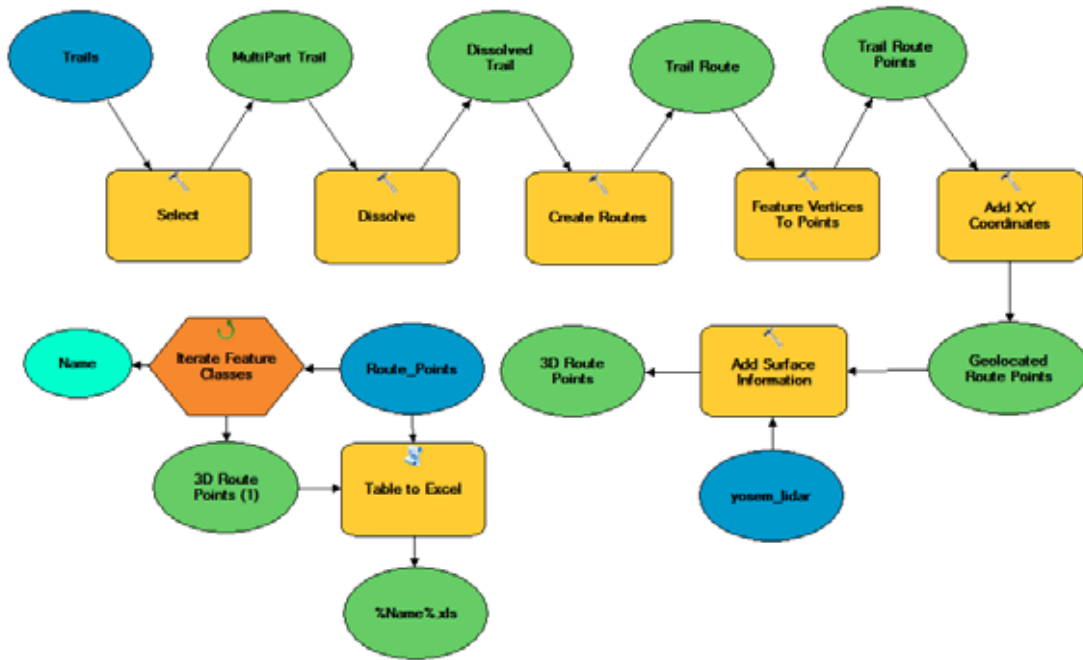


- Transform polyline Trails into Routes
 - Adds Directionality
 - Adds Cumulative Measures
- Convert Routes' Vertexes to Points
- Add Geographic Data
 - X and Y
 - 3D Z from LiDAR for trails within the Yosemite Valley
 - 3D Z from 10m DEM for trails outside the Yosemite Valley
- Export Attribute Table to Excel for further calculations



YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

ArcGIS Workflow Model



YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

Rout Point Spreadsheet Work

X_CORD	Y_CORD	Z	Del_H	Del_D	Length	Percent Slope	Degrees Inclination
266646	4178150	1200.222383	0	0	0	0	0
266644	4178110	1199.78201	-0.44037	40.050	40.050	1.10	0.63
266643	4178090	1200.101715	0.319705	20.025	60.075	1.60	0.91
266642	4178070	1200.338469	0.236755	20.025	80.100	1.18	0.68
266640	4178060	1200.292436	-0.04603	10.198	90.298	0.45	0.26
266639	4178040	1200.6897	0.397265	20.025	110.323	1.98	1.14
266633	4178010	1201.324764	0.635064	30.594	140.917	2.08	1.19
266625	4177980	1202.479975	1.155211	31.048	171.965	3.72	2.13
266625	4177980	1202.519902	0.039927	0.000	171.965	0.00	0.00
266601	4177940	1204.900597	2.380696	46.648	218.613	5.10	2.92
266579	4177920	1207.395193	2.494596	29.732	248.345	8.39	4.80
266518	4177880	1208.725717	1.330524	72.945	321.290	1.82	1.04
266497	4177860	1207.645352	-1.08037	29.000	350.290	3.73	2.13
266475	4177840	1205.101556	-2.5438	29.732	380.023	8.56	4.89
266465	4177820	1205.516655	0.415098	22.361	402.383	1.86	1.06
266425	4177760	1204.458656	-1.058	72.111	474.494	1.47	0.84
266388	4177730	1201.139051	-3.31961	47.634	522.128	6.97	3.99
266388	4177730	1201.139051	0	0.000	522.128	0.00	0.00
266364	4177710	1199.669139	-1.46991	31.241	553.369	4.71	2.69
266346	4177700	1198.117129	-1.55201	20.591	573.960	7.54	4.31
266388	4177730	1201.139051	3.021922	51.614	625.574	5.85	3.35
266447	4177720	1205.14724	4.00819	59.841	685.416	6.70	3.83
266521	4177710	1218.800589	13.65335	74.673	760.089	18.28	10.36
266540	4177710	1223.270824	4.470235	19.000	779.089	23.53	13.24
266547	4177730	1223.338353	0.067529	21.190	800.278	0.32	0.18
					Average	4.68	2.66
	min	1198.117129					
	max	1223.338353					

Bridal Veil Falls Trail

Data from Route Points
shapefile imported
to Excel

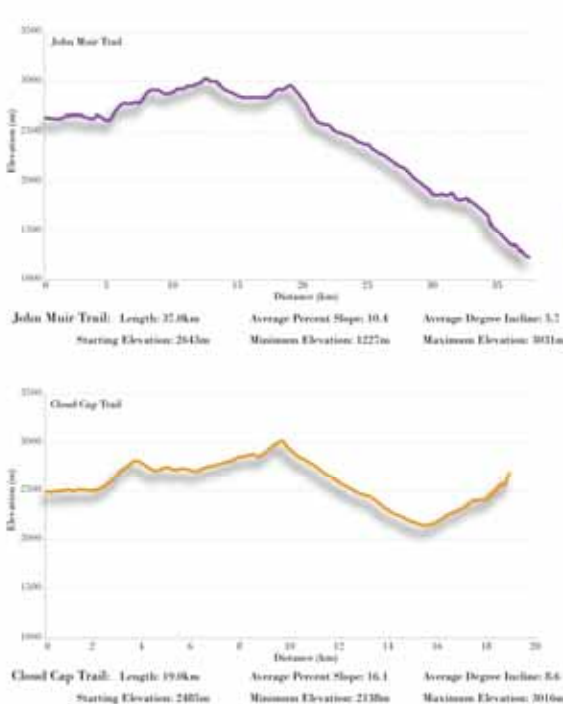
Calculations:

$$\Delta H = Z_2 - Z_1$$

$$\%Slope = \frac{\Delta H}{\Delta D}$$

$$\Delta D = \sqrt{(Xcoord_2 - Xcoord_1)^2 + (Ycoord_2 - Ycoord_1)^2}$$

$$^\circ Inclusion = \tan^{-1} \frac{\%Slope}{100} \times \frac{180}{\pi}$$



YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

Ranking Calculations

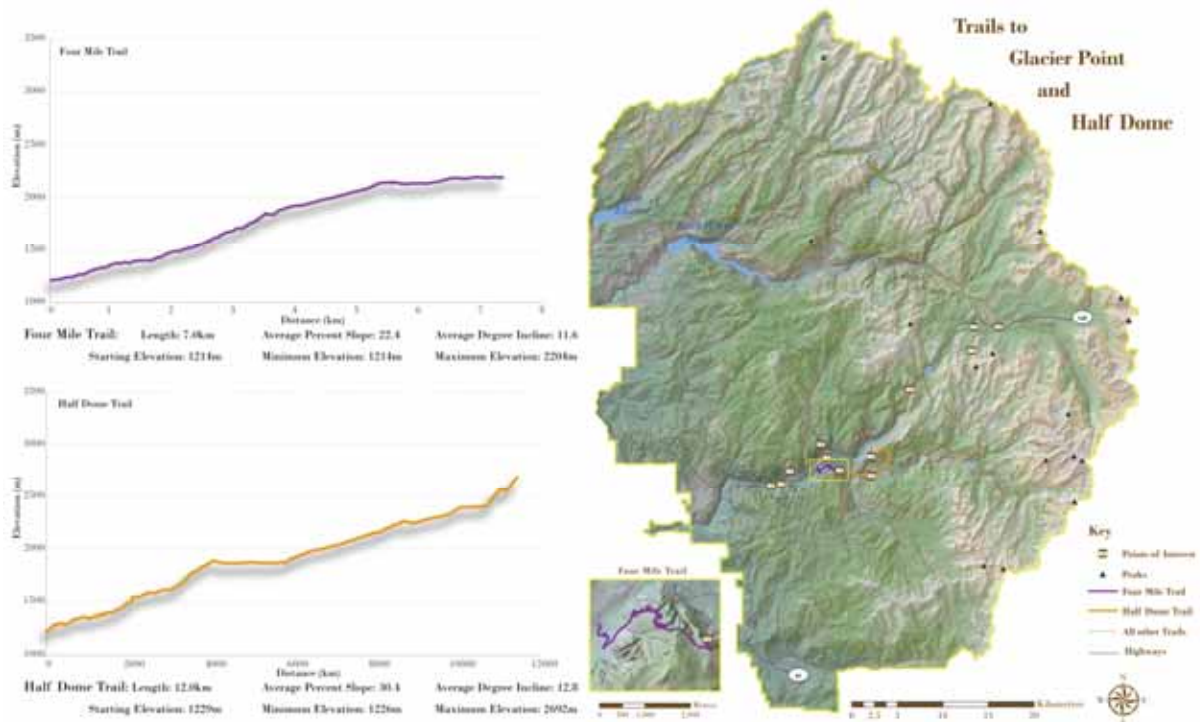
Trail Name	Length (km)	Avg Slope (%)	Avg Incline (°)	Starting Elevation (m)	Max Elevation (m)	Elevation Range (m)
Valley Loop Trail	30.0	4.5	2.6	1183	1273	92
El Capitan Trail	16.0	11.3	6.1	1220	2355	1135
John Muir Trail	37.0	10.4	5.7	2643	3031	1804
Cloud Cap Trail	19.0	16.1	8.6	2485	3016	878
Bridal Veil Falls Trail	0.8	4.7	2.7	1200	1223	25
Yosemite Creek Trail	10.0	8.4	4.6	2189	2237	214
Four Mile Trail	7.0	22.4	11.6	1214	2204	990
Half Dome Trail	12.0	3.4	12.8	1229	2692	1466
Mono Meadow Trail	11.0	11.0	6.0	2216	2216	363
Pohono Trail	20.0	15.3	8.2	1342	2364	1022
Snow Creek Trail	27.0	12.0	6.3	2625	2648	1392
Yosemite Falls Trail	4.5	25.6	13.9	1222	2041	819
Pacific Crest Trail	108.0	11.2	6.0	2900	3375	1060

Trail Name	Sum Values	Z Score
Valley Loop Trail	1312.1	-1.45
El Capitan Trail	2388.4	-0.35
John Muir Trail	4500.1	1.81
Cloud Cap Trail	3406.7	0.69
Bridal Veil Falls Trail	1233.2	-1.53
Yosemite Creek Trail	2426.0	-0.31
Four Mile Trail	2245.0	-0.50
Half Dome Trail	2723.2	-0.01
Mono Meadow Trail	2607.0	-0.13
Pohono Trail	2407.5	-0.33
Snow Creek Trail	4062.3	1.36
Yosemite Falls Trail	2085.0	-0.66
Pacific Crest Trail	4085.2	1.39

Using the Excel Point Spreadsheets for each trail:

- Calculated Summary Statistics
- Summed the values
- Calculated the Z-Score of the sums $z = \frac{x - \mu}{\sigma}$
- Ranks based on Z-Scores

Average 2729.4
Standard Deviation 978.0

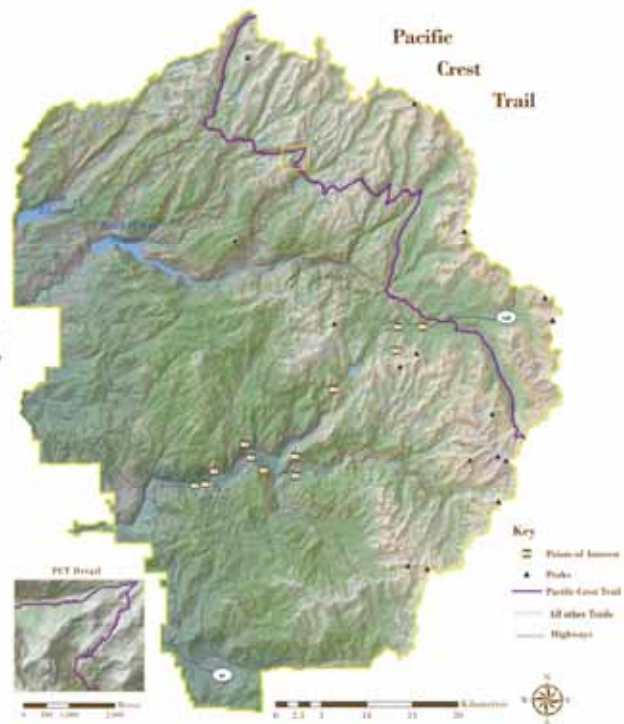
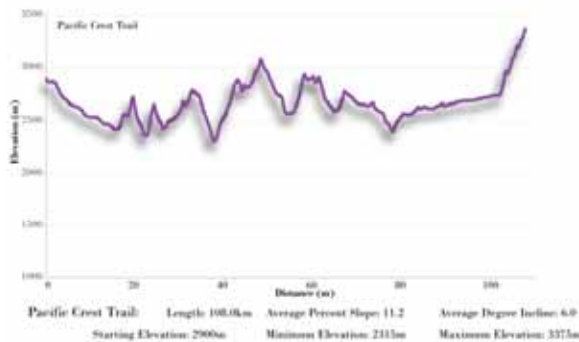


YOSEMITE NATIONAL PARK TRAIL DIFFICULTY:

Trail Difficulty Rankings

- All ranks are based on Z-Scores
 - created a normalized relationship that could then be ordered
 - Lower Z-Score meant easier trail

Trail Name	Difficulty Rank
Bridal Veil Falls Trail	1
Valley Loop Trail	2
Yosemite Falls Trail	3
Four Mile Trail	4
El Capitan Trail	5
Pohono Trail	6
Yosemite Creek Trail	7
Mono Meadow Trail	8
Half Dome Trail	9
Cloud Cap Trail	10
Snow Creek Trail	11
Pacific Crest Trail	12
John Muir Trail	13



YOSEMITE NATIONAL PARK VIEW POINTS:

Answering the Question: What are the defining features within Yosemite National Park

- Step 1: Extensive Internet Search
 - <http://www.nps.gov/yose/planyourvisit/placestogo.htm>
 - <http://www.travelchannel.com/destinations/california/photos/yosemite-attractions>
 - <http://www.yosemitedhikes.com/yosemite-tour/yosemite-tour.htm>
 - Some icons were too remote/not along hiking trails and were not included
- Step 2: Increase Quantity of View Points
 - Top rated mountain summits were used
 - Ratings according to <http://www.summitpost.org/>

Peak Names	Outline Points
Amelia Earhart	12
Echo and Unicorn	13
Keyes Peak	17
Materhorn Peak	16
Merced Peak	16
Mount Dana	16
Mount Florence	17
Mount Maclure	17
Ansel Adams	15
Mount Connuss	15
Mount Gibbs	16
Mount Lyell	17
Ranchera	16
Triple Devide	16
Tuolumne Peak	17
Cathedral Peak	16

- Step 3: Finding these View Points on the Map
 - Google Earth Search for each point then exported as .kml into ArcGIS

Iconic Feature Names	Outline Points
Half Dome Summit	14
Half Dome Face	15
El Capitan	16
Fairview Dome	12
Yosemite Falls	19
Vernal Falls	15
Bridal Veil Falls	14
Tuolumne Meadows	12
Tunnel View	16

The End Result



YOSEMITE NATIONAL PARK VIEW POINTS:

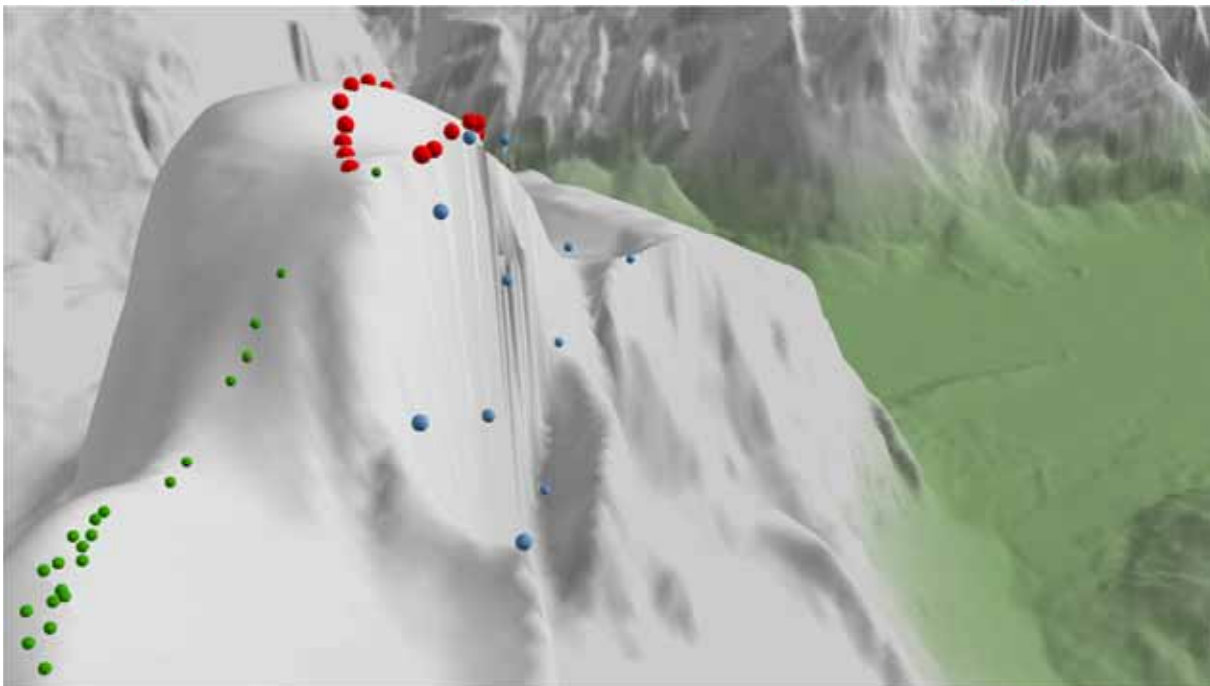
3D Point Outlines

- Create Feature Outline
 - Accurately depict target feature surface with a cluster of points
 - Visibility tool works best with ~ 16 input points
- Align Points to 3D
 - Sheer cliff faces have 'stacked points'
 - Some image locations were displaced when compared to DEM data
 - Interpolate Shape tool to make points a 3D object
- Add OFFSETA Attribute (when needed)
 - When point clusters were for people looking out of a lot/view area, add OFFSETA
 - When point clusters were for geological/geographic features, no OFFSETA but...
- Manually Offset Points from Features
 - To force a perspective and create a frame, point clusters were uniformly displaced
 - Prevents missing parts of a mountain or cliff that would otherwise be hidden, despite being obviously visible.

YOSEMITE NATIONAL PARK VIEW POINTS:

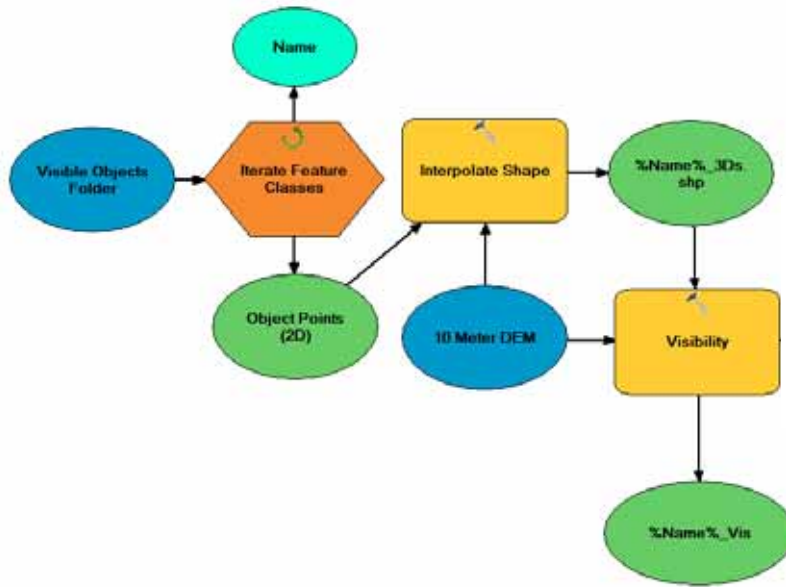
3D Point Outlines

- Half Dome Trail
- Half Dome Face Points
- Half Dome Summit Points



YOSEMITE NATIONAL PARK VIEWSHEDS:

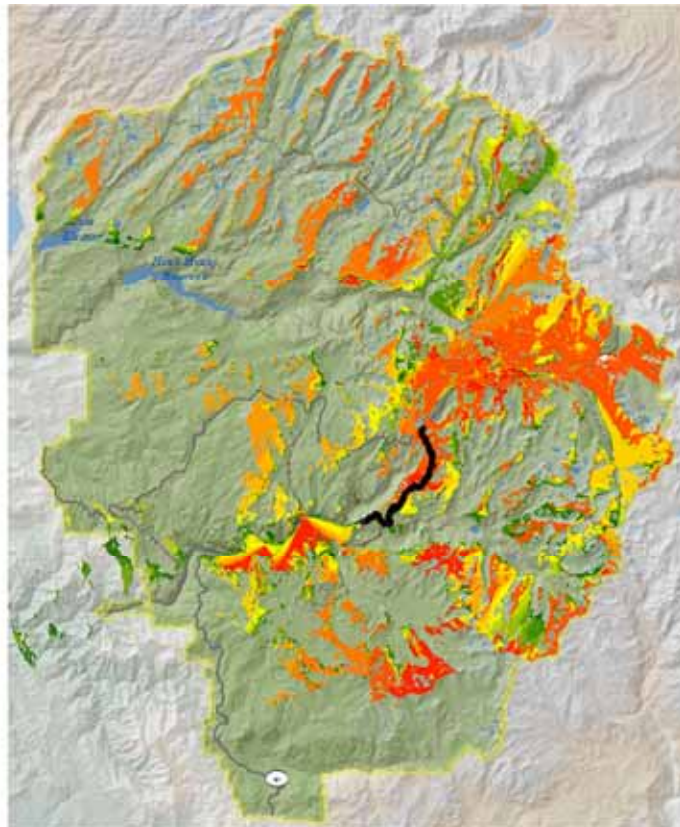
Vista Area, Peak and Icon Viewsheds Workflow



YOSEMITE NATIONAL PARK VIEWSHEDS:

Trail Visibility

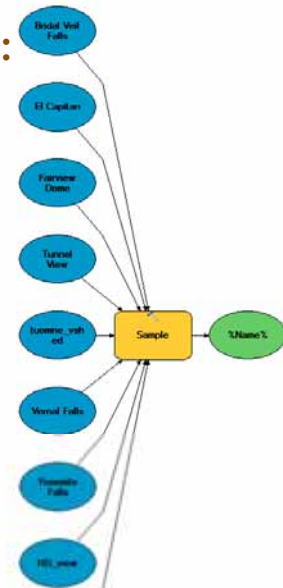
- Cloud_Cap_RoutePOINTS
 - Tuolumne Peak
 - Mount Lyell
 - Yosemite Falls
 - Fairview Dome
 - El Capitan
- Value
High : 16
Low : 1



YOSEMITE NATIONAL PARK VIEWSHEDS:

Trail Visibility Workflow

- Apparently Sample and Extract Multiple Values to Points tools are known to be broken for more than 1 or 2 rasters
- Solutions
 - A) use python to write an iterating tool
 - B) use model builder to repeat tool with a built in iterator



Expectations:



Reality:



YOSEMITE NATIONAL PARK VIEWSHEDS:

Trail Visibility

FID	Yosem Fall	Vern Falls	Tuolu Mead	Tunnel V	Half Dome	Fair Dome	El Cap	Bridal Fal
1				8				13
2				6				13
3				6				13
4				6				13
5				6				14
6				6				14
7				6				12
8				6				12
9				6				12
10				5				10
11				4				13
12				5				13
13				4				13
14				3				13
15				5				12
16				5				13
17				5				13
18				3				13
19				5				13
20				5				13
21				5				10
22				6				6
23				2				5
24				6				5
Average Vis	0	0	0	5	0	0	12	13
Max Vis	0	0	0	8	0	0	14	14
Max Possible	19	15	12	16	15	12	16	14
Count of Vis Points	0	0	0	25	0	0	25	16
Percent of Points Vis	0.0	0.0	0.0	100.0	0.0	0.0	100.0	64.0

Sum	30
Sum	36
Possible	371
Sum	66
Sum	264.0
Raw Visibility Score	132

Partial Spreadsheet for Bridal Veil Falls Trail

Raw Visibility Score: Sum of the Average, Max and Point Sums

YOSEMITE NATIONAL PARK VIEWSHEDS:

Trail Visibility Calculations

Trail Visibility Raw Scores		# of Features		Lengths	
Trail Name	Raw Score	Count	Score by Variety	Meters	Points
Cloud Cap Trail	2228	11	24508	18928.8	910
Yosemite Falls Trail	856	3	2568	4422.2	469
Bridal Veil Falls Trail	132	3	396	800	25
El Capitan Trail	909	13	11817	15854.5	706
Four Mile Trail	1319	11	14509	7338.6	356
Half Dome Trail	863	11	9493	11525.8	523
John Muir Trail	4895	17	83215	37427.1	1656
Mono Meadow Trail	941	12	11292	10731.9	349
Pacific Crest Trail	5273	15	79095	107778.8	5845
Pohono Trail	2136	15	32040	20101.7	715
Snow Creek Trail	1644	11	18084	26720.4	1205
Valley Loop Trail	2908	5	14540	29935.5	1135
Yosemite Creek Trail	0	0	0	9503.8	324

- **Score by Variety:** Raw Score x Count

YOSEMITE NATIONAL PARK VIEWSHEDS:

$$z = \frac{x - \mu}{\sigma}$$

Trail Visibility Calculations

Attempt to normalize data:

- View Score based on number of different objects seen
- View Score based on number of points sampled per trail
- View Score based on over all length of the trail

	Score Options		Z Scores			
	Score per Meter (Variety)	Score per Point	Score per Meter	per M	per Point	per M(v)
Cloud Cap Trail	1.295	26.9	0.118	0.52	0.30	0.30
Yosemite Falls Trail	0.581	5.5	0.194	-0.65	-1.15	1.72
Bridal Veil Falls Trail	0.495	15.8	0.165	-0.79	-0.45	1.18
El Capitan Trail	0.745	16.7	0.057	-0.38	-0.39	-0.83
Four Mile Trail	1.977	40.8	0.180	1.64	1.23	1.46
Half Dome Trail	0.824	18.2	0.075	-0.25	-0.30	-0.50
John Muir Trail	2.223	50.3	0.131	2.04	1.88	0.55
Mono Meadow Trail	1.052	32.4	0.088	0.13	0.67	-0.26
Pacific Crest Trail	0.734	13.5	0.049	-0.40	-0.61	-0.98
Pohono Trail	1.594	44.8	0.106	1.01	1.51	0.09
Snow Creek Trail	0.677	15.0	0.062	-0.49	-0.51	-0.75
Valley Loop Trail	0.486	12.8	0.097	-0.80	-0.66	-0.08
Yosemite Creek Trail	0.000	0.0	0.000	-1.60	-1.52	-1.90
Average	0.98	22.51	0.10			
Standard Deviation	0.61	14.78	0.05			

YOSEMITE NATIONAL PARK VIEWSHEDS:

Trail Visibility Calculation Rankings

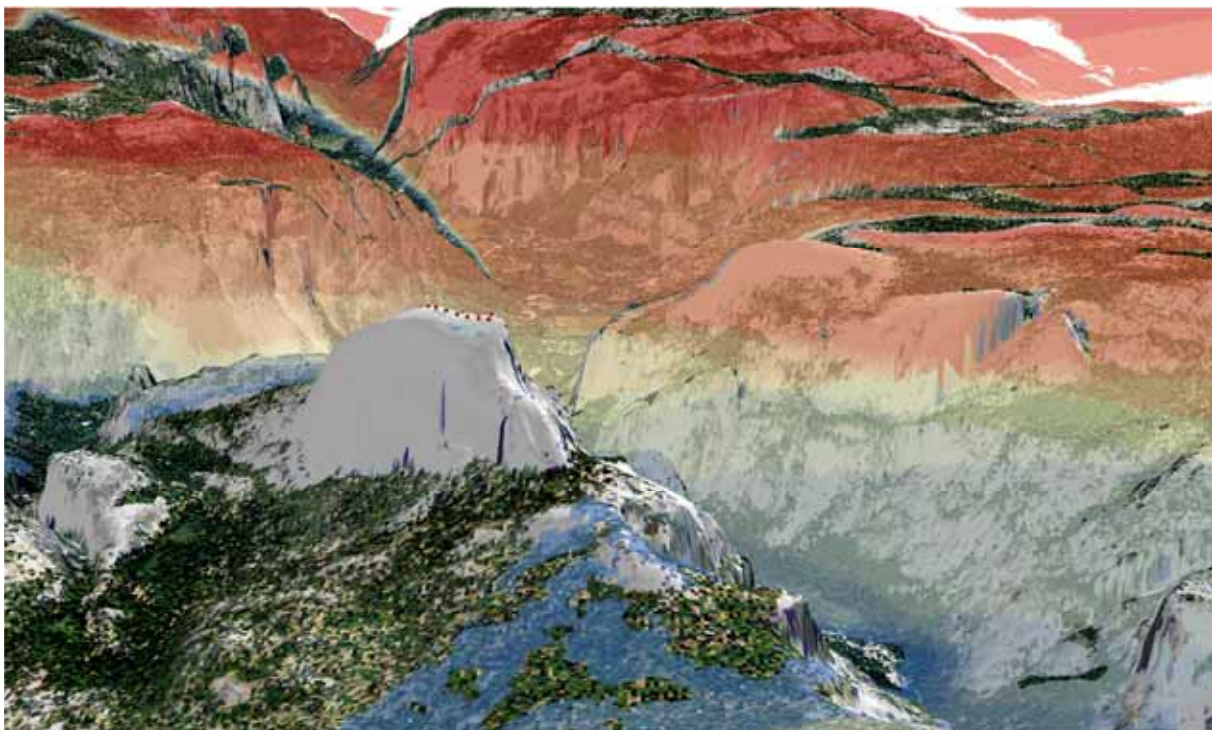
- All ranks are based on Z-Scores
 - created a normalized relationship that could then be ordered
 - Lower Z-Score meant fewer features seen

	Rankings		
	Z per Distance	Z per Points	Z per Distance (Variety)
Cloud Cap Trail	5	5	4
Yosemite Falls Trail	1	12	10
Bridal Veil Falls Trail	3	8	11
El Capitan Trail	11	7	7
Four Mile Trail	2	3	2
Half Dome Trail	9	6	6
John Muir Trail	4	1	1
Mono Meadow Trail	8	4	5
Pacific Crest Trail	12	10	8
Pohono Trail	6	2	3
Snow Creek Trail	10	9	9
Valley Loop Trail	7	11	12
Yosemite Creek Trail	13	13	13

YOSEMITE NATIONAL PARK VIEW SHEDS:

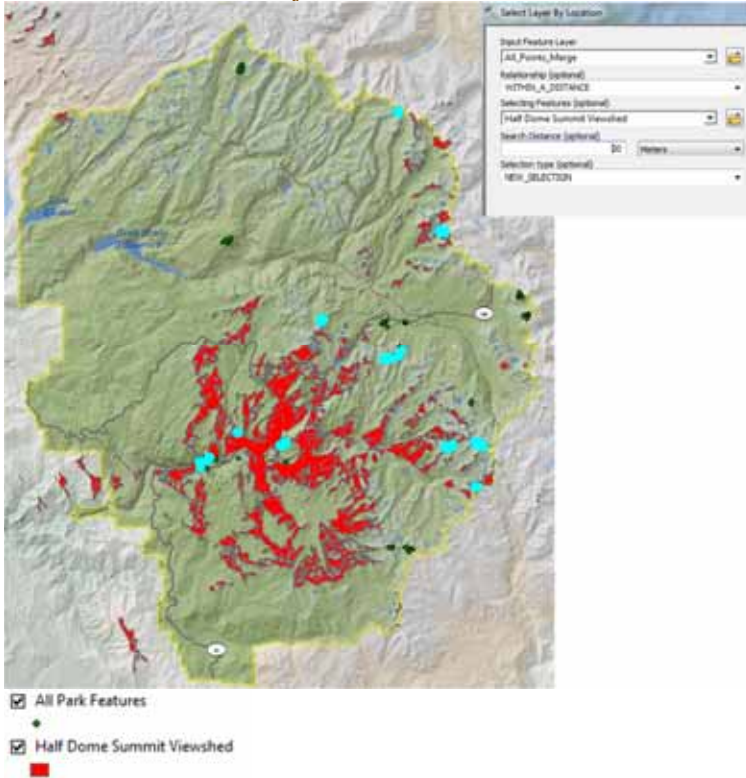
Vista Area Visibility

- Half Dome Summit Points
- Half Dome Summit Viewshed Value
- High: 14
- Low: 1



YOSEMITE NATIONAL PARK VIEW SHEDS:

Vista Area Visibility



FID	Id	name
34	0	Tuolumne Meadows
35	0	Tuolumne Meadows
36	0	Tuolumne Meadows
37	0	Tuolumne Meadows
38	0	Tuolumne Meadows
39	0	Tuolumne Meadows
40	0	Tuolumne Meadows
41	0	Tuolumne Meadows
42	0	Tuolumne Meadows
43	0	Tuolumne Meadows
44	0	Tuolumne Meadows
45	0	Tuolumne Meadows
91	0	Fairview Dome
92	0	Fairview Dome
93	0	Fairview Dome
94	0	Fairview Dome
95	0	Fairview Dome
101	0	Fairview Dome
199	0	Mount Gibbs
200	0	Mount Gibbs
201	0	Mount Gibbs
202	0	Mount Gibbs
203	0	Mount Gibbs
204	0	Mount Gibbs

YOSEMITE NATIONAL PARK VIEW SHEDS:

Vista Area Visibility Examples

Glacier Point Vista Area

	Echo Peaks	Half_Dome_Face	Half_Dome_Summit	Mount Florence	Mount Lyell	Mount Maclure	Tunnel View	Yosemite_Falls	Grand Total
Count of name	4	15	12	11	2	12	2	19	77
Max Available	13	15	14	17	17	17	16	19	128
Percent of Max									60.15625

View Area 69.22 square kilometers

Can see	8	Features
of	25	Features
at	60.16%	Quality
across	69.22	square kilometers

Glacier Point Score 13.33

Tuolumne Meadows Vista Area

	Fairview Dome	Mount Dana	Mount Gibbs	Tuolumne Meadows	Unicorn Peak	Grand Total
Count of name	6	16	16	12	3	53
Max Available	12	16	16	12	13	69
Percent of Max						76.8115942

View Area 54.95 square kilometers

Can see	5	Features
of	25	Features
at	76.81%	Quality
across	54.95	square kilometers

Tuolumne Meadows Point Score 8.44

YOSEMITE NATIONAL PARK VIEW SHEDS: $z = \frac{x - \mu}{\sigma}$

Vista Area Visibility Ranking and Bonus Power

- All ranks are based on Z-Scores
 - created a normalized relationship that could then be ordered
 - Lower Z-Score meant fewer features with that viewshed

Vista Area Scores

Lot Name	Score	Z Score	Rank	Bonus Power
Tuolumne Meadows	8.44	-0.280	3	1.290
Olmstead Point	5.42	-0.398	4	1.173
Glacier Point	13.33	-0.090	2	1.480
Tunnel View	1.74	-0.541	6	1.030
Sentinel Bridge	1.77	-0.539	5	1.031
Half Dome Summit	77.89	2.418	1	3.988
Gates of the Valley	0.98	-0.570	7	1.000

average 15.652857
standard deviation 25.73821

Vista Area Name	Accessed By
Half Dome Summit	Half Dome, Cloud Cap
Glacier Point	Pohono, 4Mile, Mono Meadow
Tuolumne Meadows	John Muir, PCT, Snow Creek
Olmstead Point	Snow Creek
Sentinel Bridge	Valley Loop
Tunnel View	Valley loop
Gates of the Valley	Valley Loop

Bonus Power: In order to apply viewing areas as “rewards” for certain trails

- Based entirely on Z-Score
- Added 1 + the lowest Z-Score to every Z-Score
- Meant to act like a Handicap Value in Golf

YOSEMITE NATIONAL PARK TRAIL RANKING:

The Final Frontier

Trail Name	Difficulty Rank	View Rank (Z/Distance)	View Rank (Z/Points)	View Variety (Z/Points)	Vista Area Bonuses
Bridal Veil Falls Trail	1	3	1	8	0.00
Cloud Cap Trail	10	5	7	5	3.99
El Capitan Trail	5	11	11	7	0.00
Four Mile Trail	4	2	2	3	1.48
Half Dome Trail	9	9	9	6	3.99
John Muir Trail	13	4	4	1	1.29
Mono Meadow Trail	8	8	5	4	1.48
Pacific Crest Trail	12	12	12	10	1.29
Pohono Trail	6	6	3	2	1.48
Snow Creek Trail	11	10	10	9	2.46
Valley Loop Trail	2	7	6	11	3.06
Yosemite Creek Trail	7	13	13	13	0.00
Yosemite Falls Trail	3	1	8	12	0.00

YOSEMITE NATIONAL PARK TRAIL RANKING:

The Final Frontier

Wait for it.....!

Trail Name	Raw Final Ranks
Bridal Veil Falls Trail	13.00
Cloud Cap Trail	23.01
El Capitan Trail	34.00
Four Mile Trail	9.52
Half Dome Trail	29.01
John Muir Trail	20.71
Mono Meadow Trail	23.52
Pacific Crest Trail	44.71
Pohono Trail	15.52
Snow Creek Trail	37.54
Valley Loop Trail	22.94
Yosemite Creek Trail	46.00
Yosemite Falls Trail	24.00

YOSEMITE NATIONAL PARK TRAIL RANKING:

The Final Frontier

Relative to the rest, here are the rankings
for best bang for your buck!

Trail Name	Ranking
Four Mile Trail	1
Bridal Veil Falls Trail	2
Pohono Trail	3
John Muir Trail	4
Valley Loop Trail	5
Cloud Cap Trail	6
Mono Meadow Trail	7
Yosemite Falls Trail	8
Half Dome Trail	9
El Capitan Trail	10
Snow Creek Trail	11
Pacific Crest Trail	12
Yosemite Creek Trail	13