FLOOD VULNERABILITY ANALYSIS IN THE YAMHILL WATERSHED USING MULTI-CRITERIA EVALUATION

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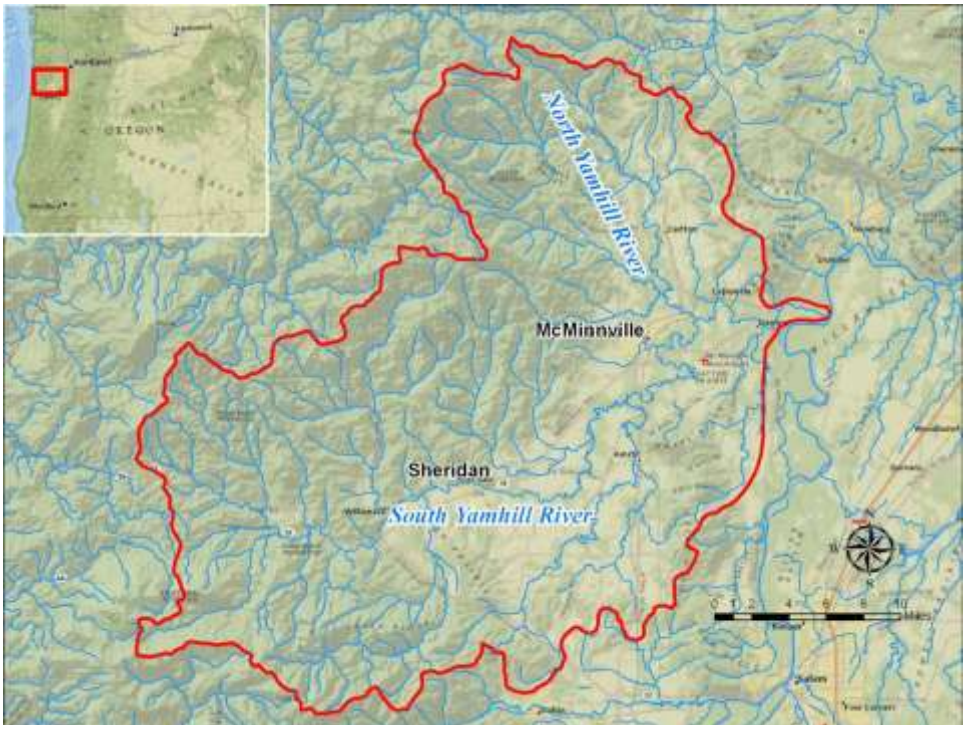
Purpose and Need

- Global population growing fastest in developing countries.
- Assessing relative flood risk in data poor areas can improve the quality of life.
- Evaluate a multi-criteria approach in a "data rich" area to support flood mitigation decision making.

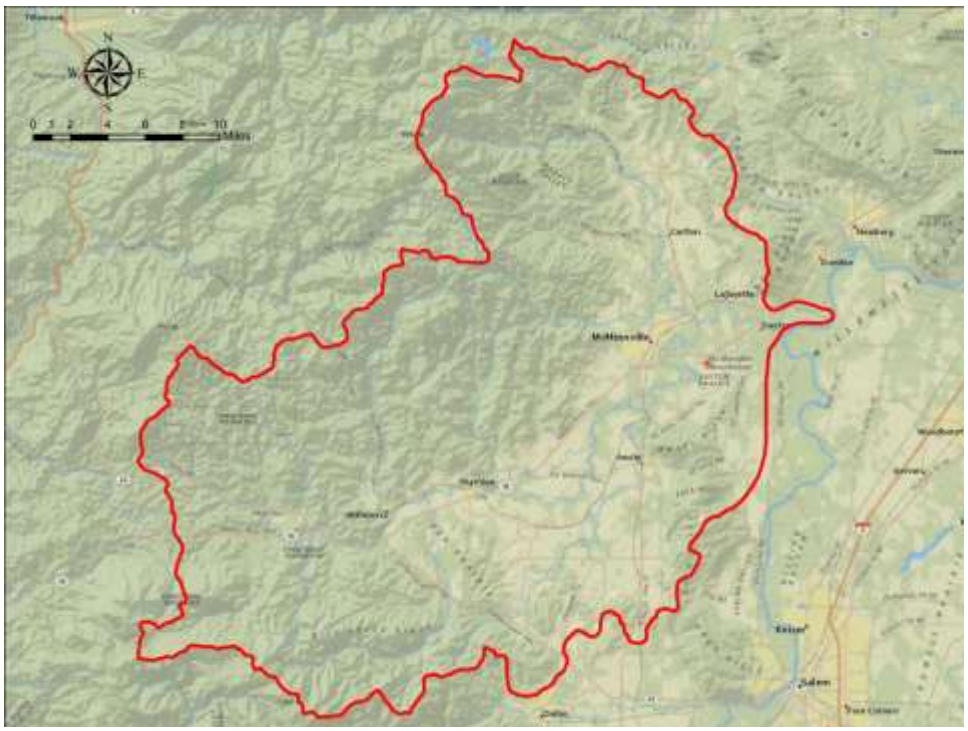


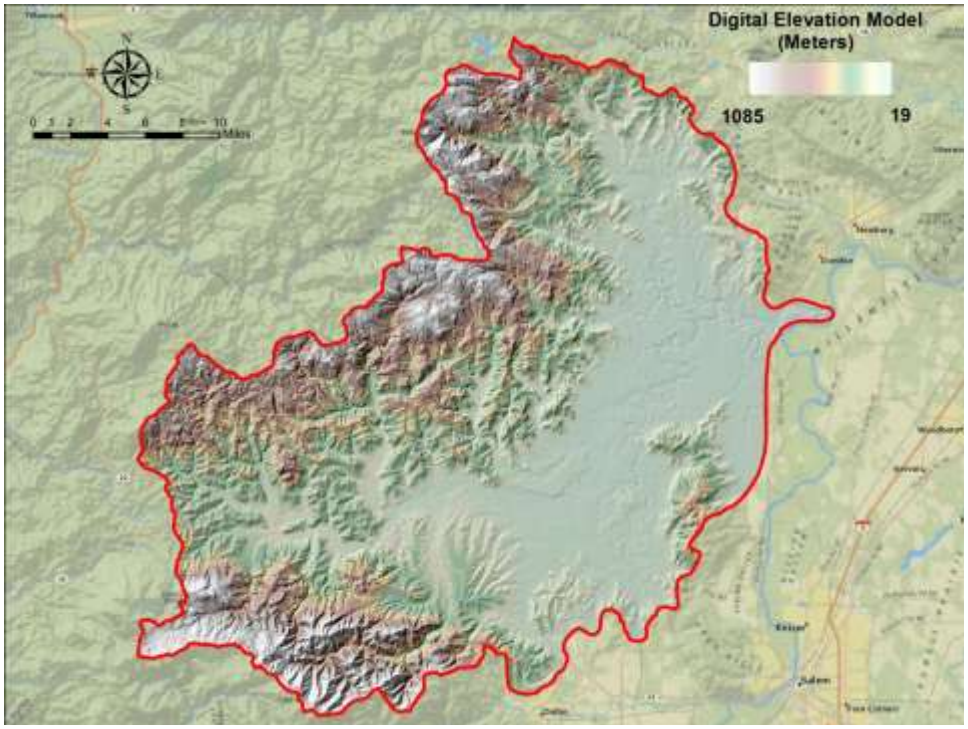
Previous Flooding

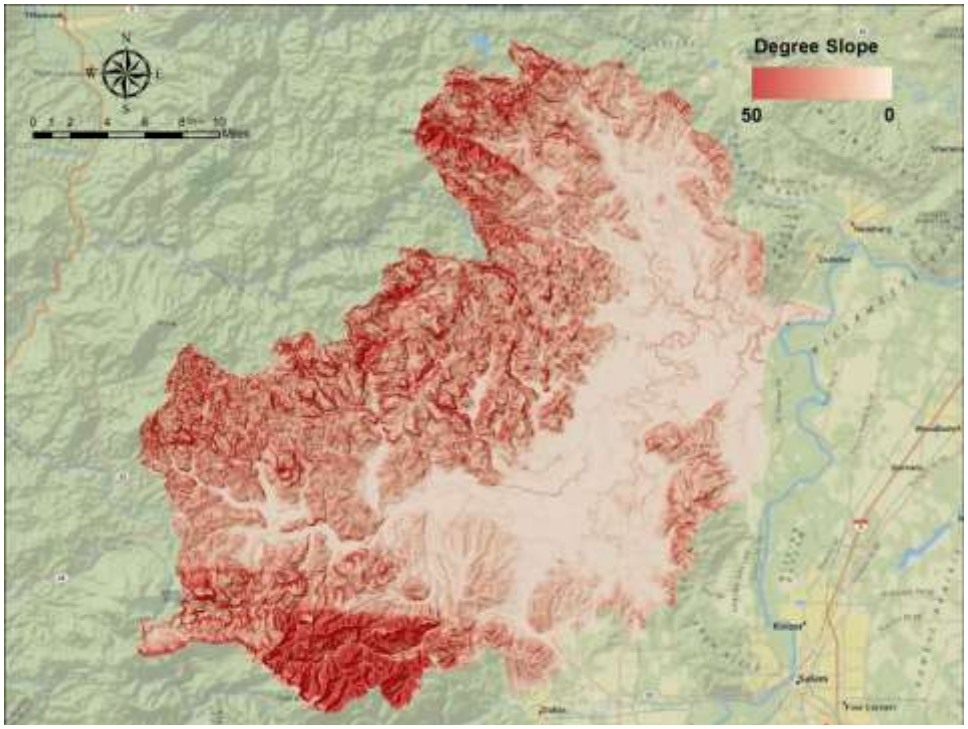
- 2007 Flood Event – Poverty Bend Rd., McMinnville

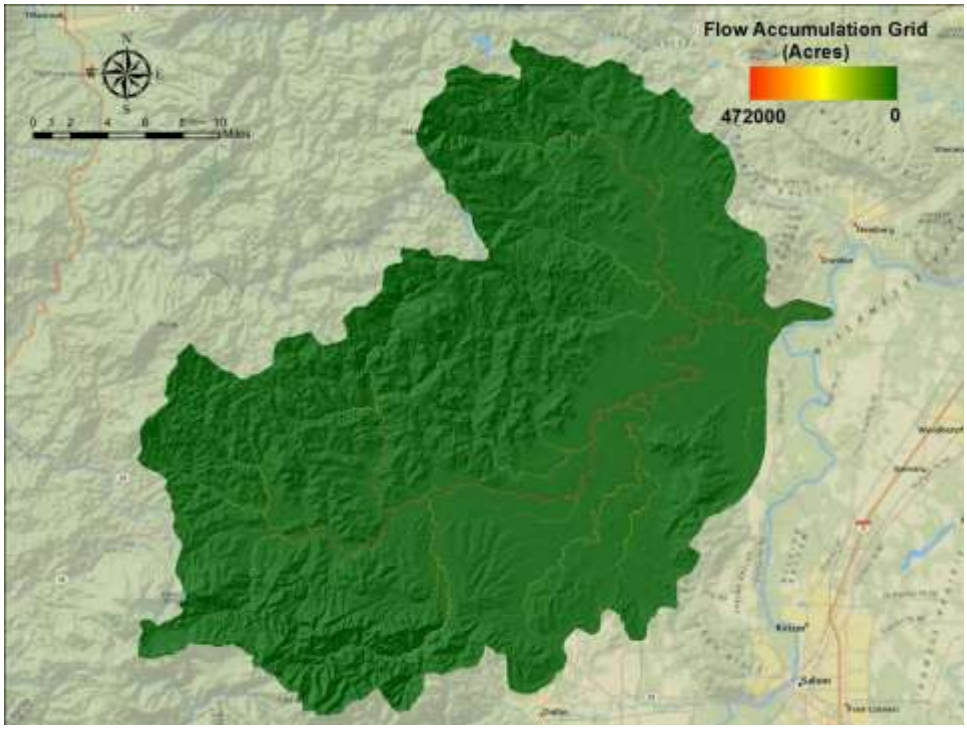
Previous Flooding

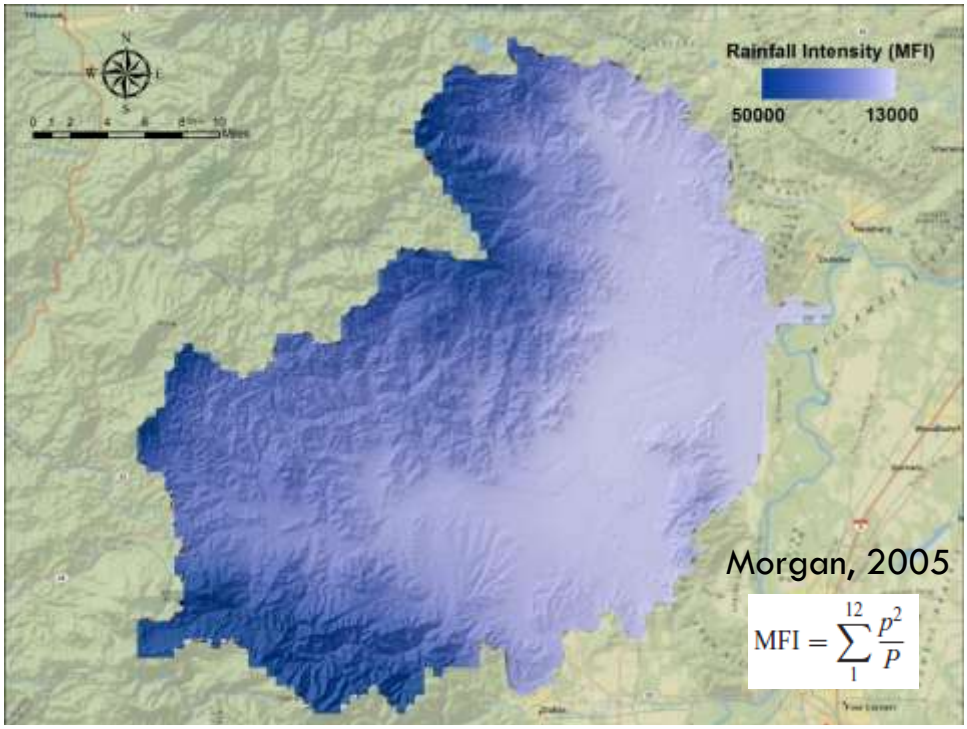
- 2007 Flood Event – Jernstedt Rd., Carlton

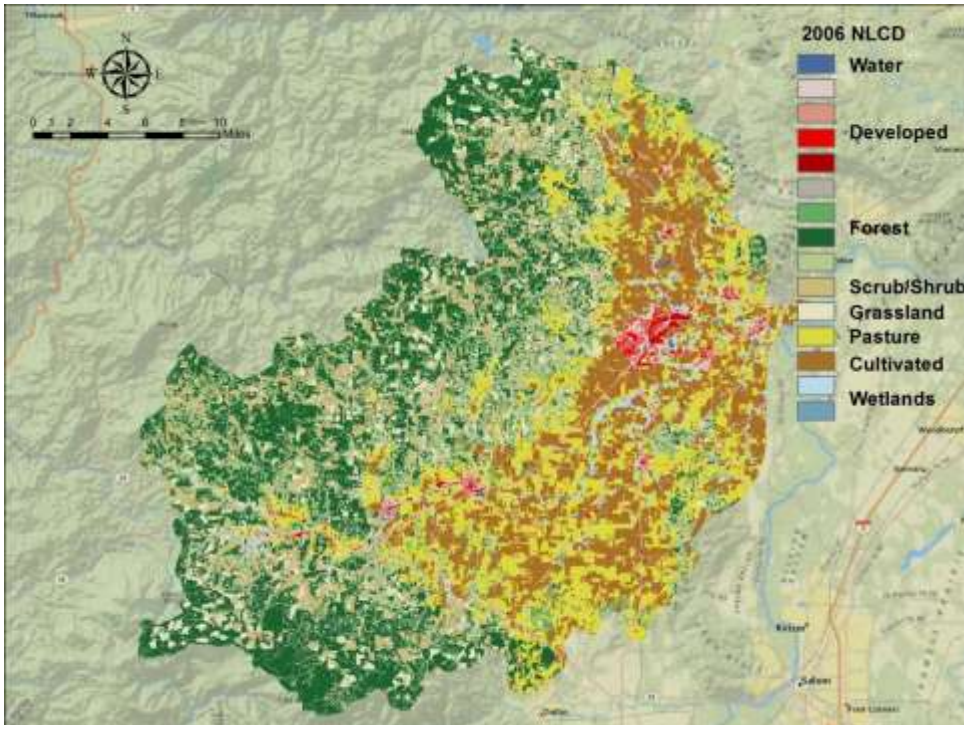


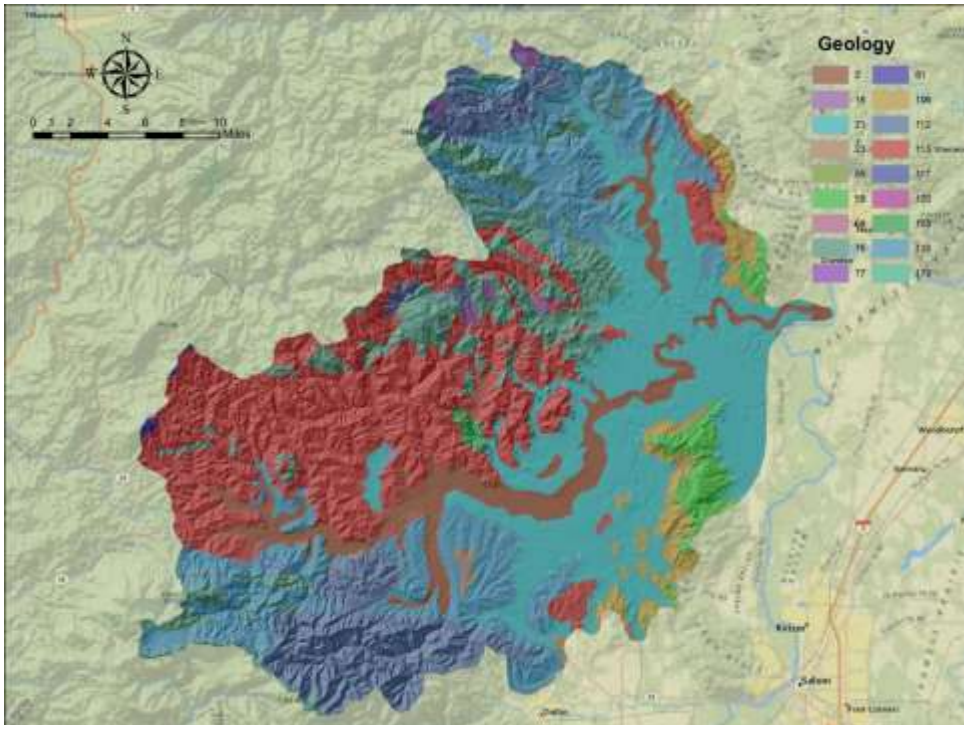

Digital Elevation Model
(Meters)
1085
19
N
W
E
S
0 1 2 4 6 8 10
Miles


Degree Slope
50
0
N
W
E
S
0 1 2 4 6 8 10
Miles


Flow Accumulation Grid
(Acres)
472000
0


Rainfall Intensity (MFI)
50000
13000
Morgan, 2005
$\mathrm{MFI} = \sum_{1}^{12} \frac{p^2}{P}$


2006 NLCD
Water
Developed
Forest
Scrub/Shrub
Grassland
Pasture
Cultivated
Wetlands


Geology

Reclassify

DEM (meters)

18 - 131	Very High	100
132 - 268	High	80
269 - 435	Moderate	50
436 - 635	Low	20
635 - 1085	Very Low	10

Flow accumulation (acres)

250000 - 472000	Very High	100
112000 - 250000	High	80
43000 - 112000	Moderate	50
11000 - 43000	Low	20
0 - 11000	Very Low	10

Rainfall intensity (MFI)

33000 - 52500	Very High	100
25000 - 33000	High	80
20000 - 25000	Moderate	50
16000 - 20000	Low	20
12700 - 16000	Very Low	10

Slope (degrees)

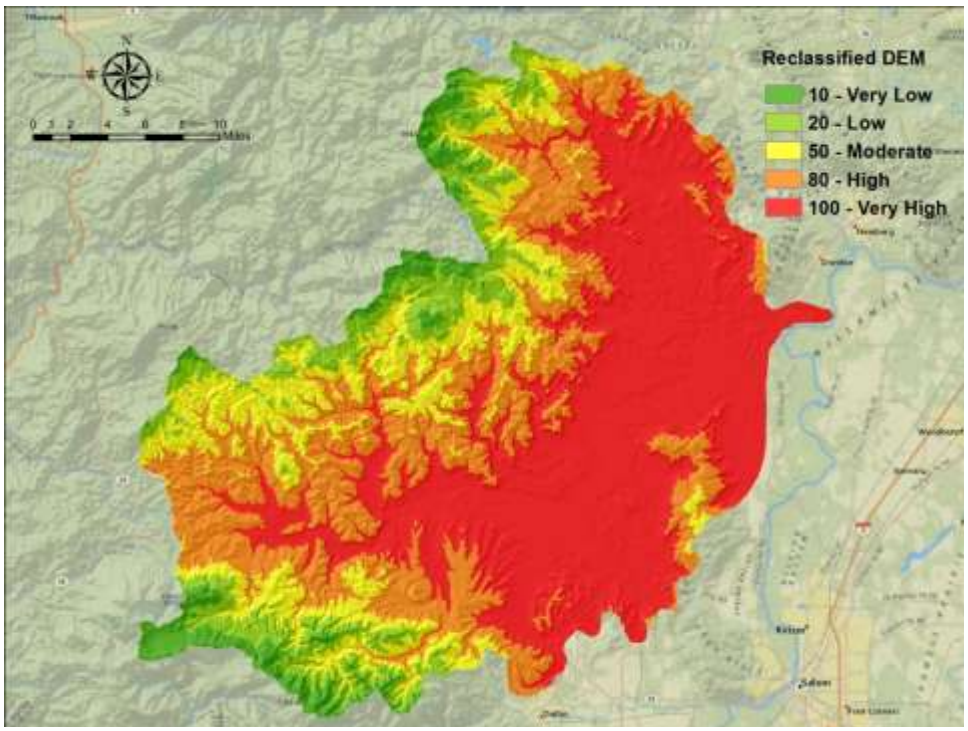
0 - 4	Very High	100
4 - 10	High	80
10 – 16	Moderate	50
16 - 25	Low	20
25 - 50	Very Low	10

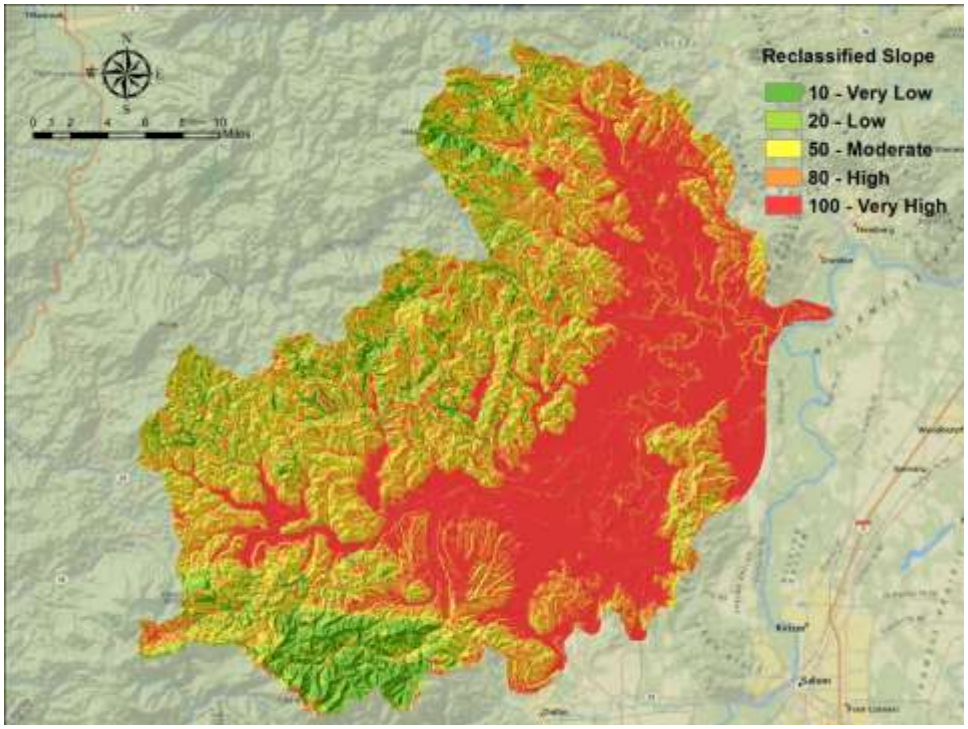
Geology

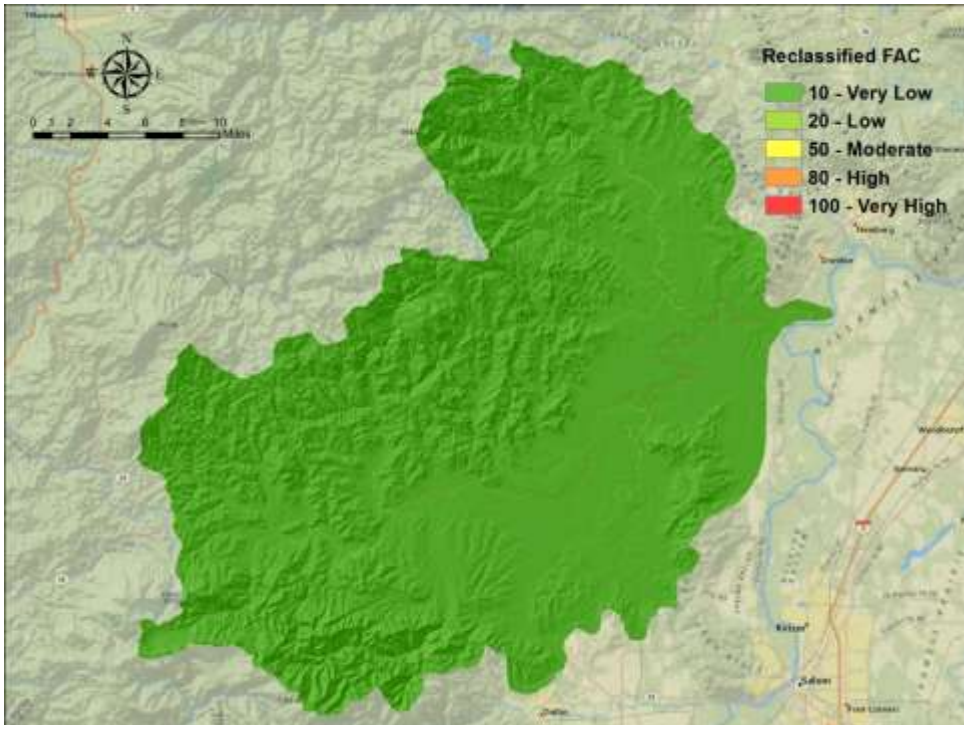
Alluvial	Very High	100
Fluvial Sediment	Very High	100
Water Bodies	Very High	100
Debris Flow	High	80
Basalt	Moderate	50
Volcanics	Moderate	50
Mafic Intrusion	Moderate	50
Mafic Intrusive	Moderate	50
Alkalic Intrusive	Moderate	50
Siletz Volcanic	Low	20
Tyee Formation	Low	20
Yamhill Formation	Very Low	10
Sandstone	Very Low	10
Pediment	Very Low	10
Sedimentary Rock	Very Low	10

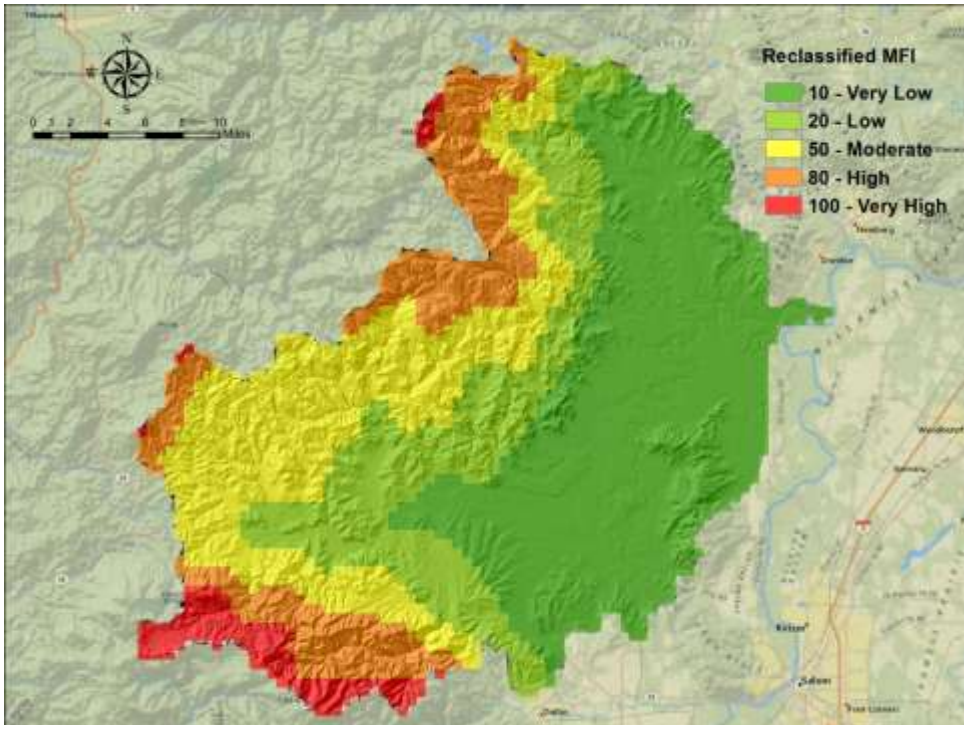
NLCD 2006

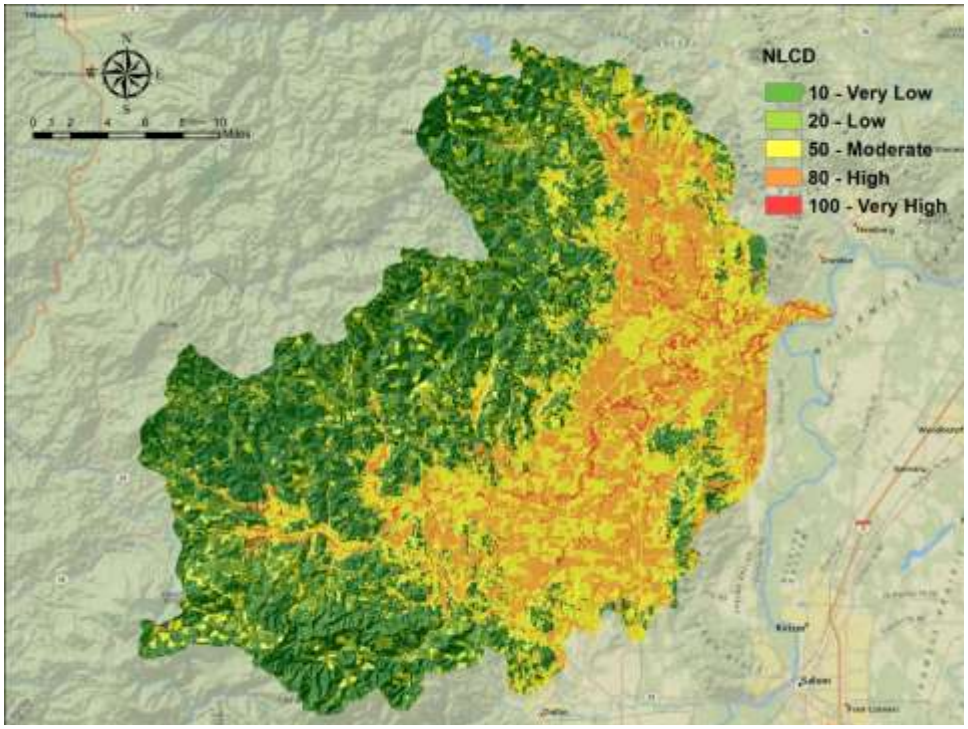
Open Water	Very High	100
Woody Wetlands	Very High	100
Wetlands	Very High	100
Cultivated Crops	High	80
Developed High Intensity	High	80
Developed Open Space	Moderate	50
Developed Low Intensity	Moderate	50
Developed Med Intensity	Moderate	50
Grassland	Moderate	50
Pasture/Hay	Moderate	50
Shrub/Scrub	Low	20
Rock/Sand/Clay	Low	20
Deciduous Forest	Very Low	10
Evergreen Forest	Very Low	10
Mixed Forest	Very Low	10

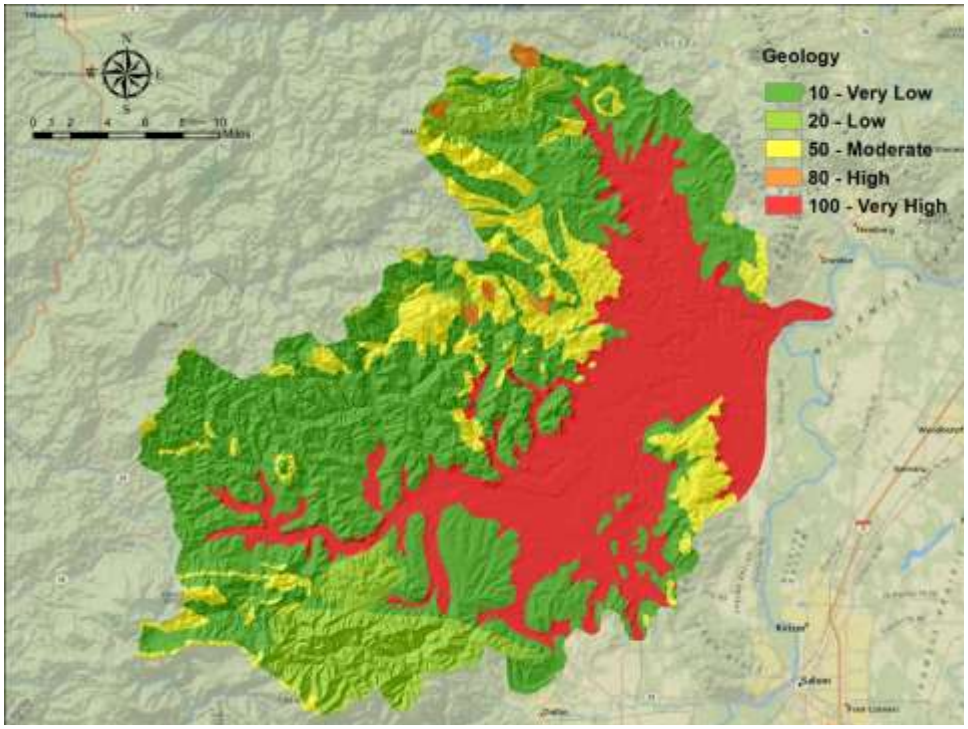



Reclassified Slope
10 - Very Low
20 - Low
50 - Moderate
80 - High
100 - Very High

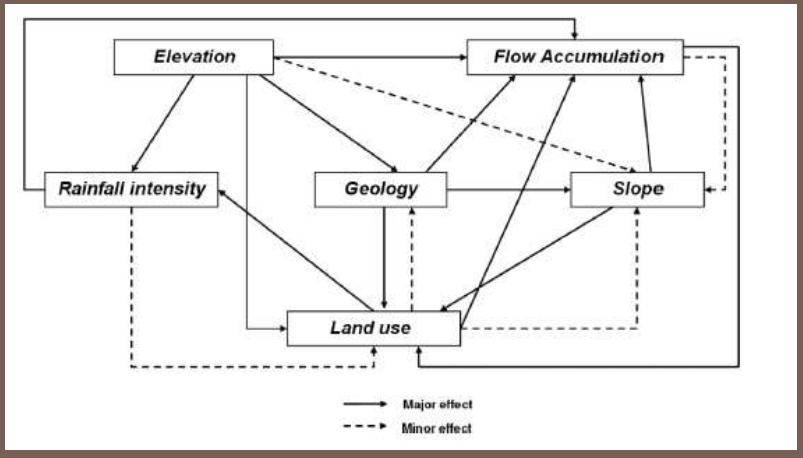

Reclassified FAC
10 - Very Low
20 - Low
50 - Moderate
80 - High
100 - Very High


Reclassified MFI
10 - Very Low
20 - Low
50 - Moderate
80 - High
100 - Very High


NLCD
10 - Very Low
20 - Low
50 - Moderate
80 - High
100 - Very High



Pairwise Comparison



Shaban, 2006

Factor Weights

Slope: 1.5

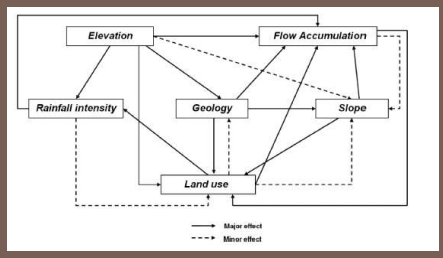
Land use/cover: 3.0

Rainfall Intensity: 1.5

Geology: 3.0

Elevation: 4.5

Flow accumulation: 1.5



Weighting Scheme

Factor	Classification	Vulnerability	Weight	Rate	Weighted Rate	Total Weight	Percent
DEM	18 - 131	Very High	100	4.5	450		
(meters)	132 - 268	High	80	4.5	360		
	269 - 435	Moderate	50	4.5	225	1170	29.03%
	436 - 635	Low	20	4.5	90		
	635 - 1085	Very Low	10	4.5	45		
Flow Accumulation	250000 - 472000	Very High	100	1.5	150		
(Acres)	112000 - 250000	High	80	1.5	120		
	43000 - 112000	Moderate	50	1.5	75	390	9.68%
	11000 - 43000	Low	20	1.5	30		
	0 - 11000	Very Low	10	1.5	15		
Rainfall Intensity	33000 - 52500	Very High	100	1.5	150		
(MFI)	25000 - 33000	High	80	1.5	120		
	20000 - 25000	Moderate	50	1.5	75	390	9.68%
	16000 - 20000	Low	20	1.5	30		
	12700 - 16000	Very Low	10	1.5	15		
Slope	0 - 4	Very High	100	2	200		
(Degrees)	4-10	High	80	2	160		
	10-16	Moderate	50	2	100	520	12.90%
	16 - 25	Low	20	2	40		
	25 - 50	Very Low	10	2	20		

Factor	Classification	Vulnerability	Weight	Rate	Weighted Rate	Total Weight	Percent
Geology	Alluvial	Very High	100	3	300		
	Fluvial Sediment	Very High	100	3			
	Water Bodies	Very High	100	3			
	Debris Flow	High	80	3	240		
	Basalt	Moderate	50	3	150	780	19.35%
	Volcanics	Moderate	50	3			
	Mafic Intrusion	Moderate	50	3			
	Mafic Intrusive	Moderate	50	3			
	Alkalic Intrusive	Moderate	50	3			
	Siletz Volcanic	Low	20	3	60		
	Tyee Formation	Low	20	3			
	Yamhill Formation	Very Low	10	3	30		
	Sandstone	Very Low	10	3			
	Pediment	Very Low	10	3			
	Sedimentary Rock	Very Low	10	3			
Land use/cover	Open Water	Very High	100	3	300		
	Woody Wetlands	Very High	100	3			
	Wetlands	Very High	100	3			
	Cultivated Crops	High	80	3	240		
	Developed High Intensity	High	80	3			
	Developed Open Space	Moderate	50	3	150	780	19.35%
	Developed Low Intensity	Moderate	50	3			
	Developed Med Intensity	Moderate	50	3			
	Grassland	Moderate	50	3			
	Pasture/Hay	Moderate	50	3			
	Shrub/Scrub	Low	20	3	60		
	Rock/Sand/Clay	Low	20	3			
	Deciduous Forest	Very Low	10	3	30		
	Evergreen Forest	Very Low	10	3			
	Mixed Forest	Very Low	10	3			

Weighting Scheme Summary

DEM = 0.290

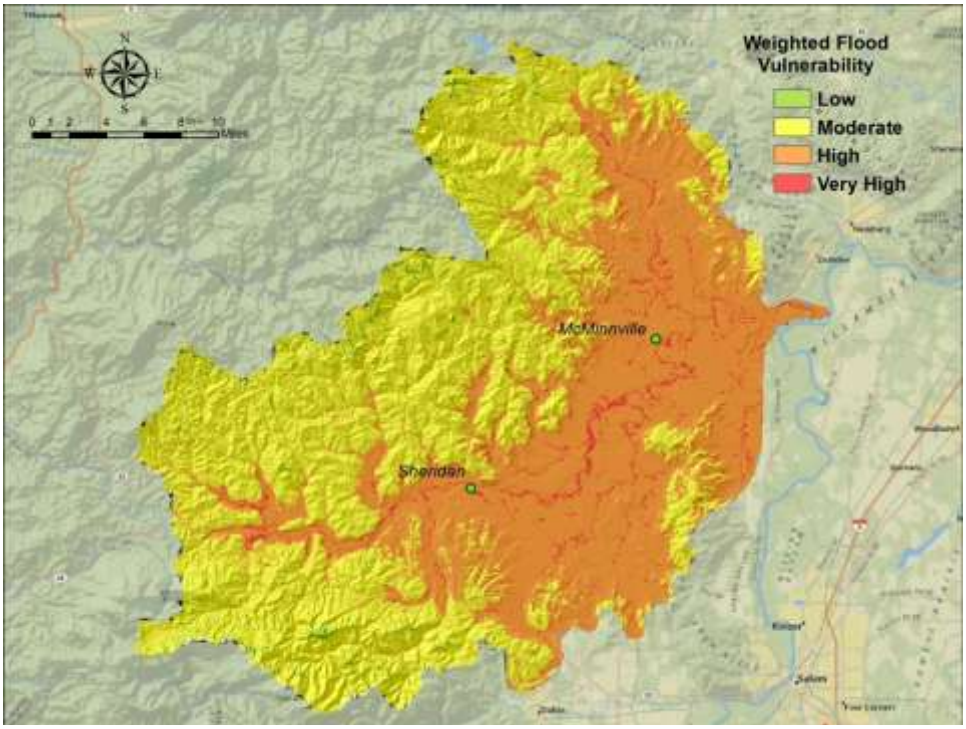
Slope = 0.129

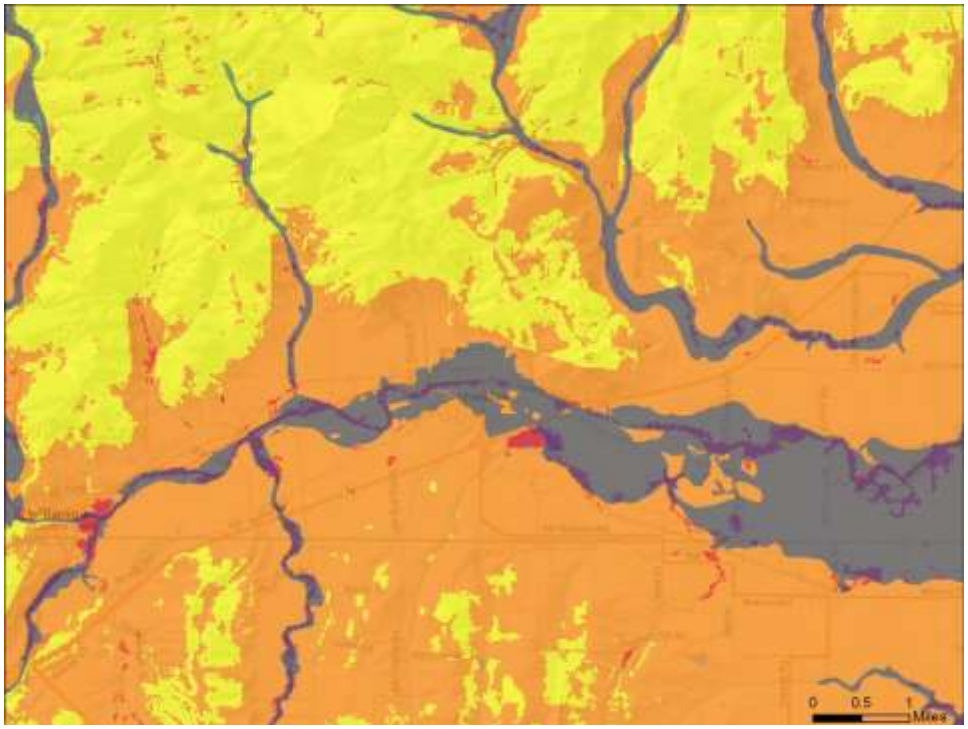
Flow accumulation = 0.097

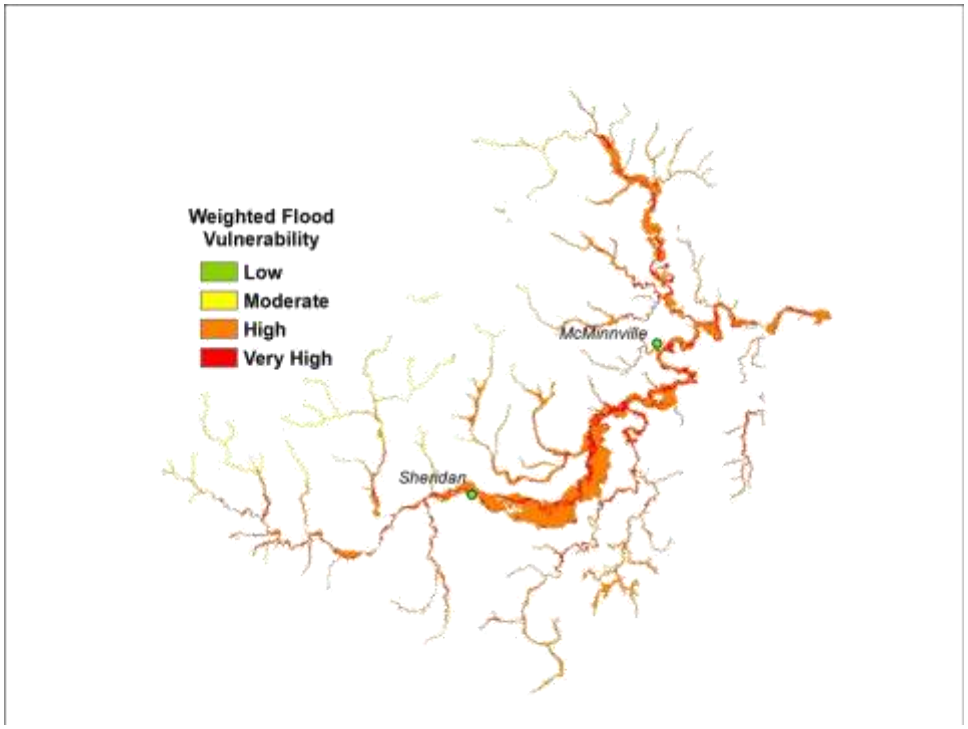
Rainfall intensity = 0.097

Geology = 0.193

Land use/cover = 0.193

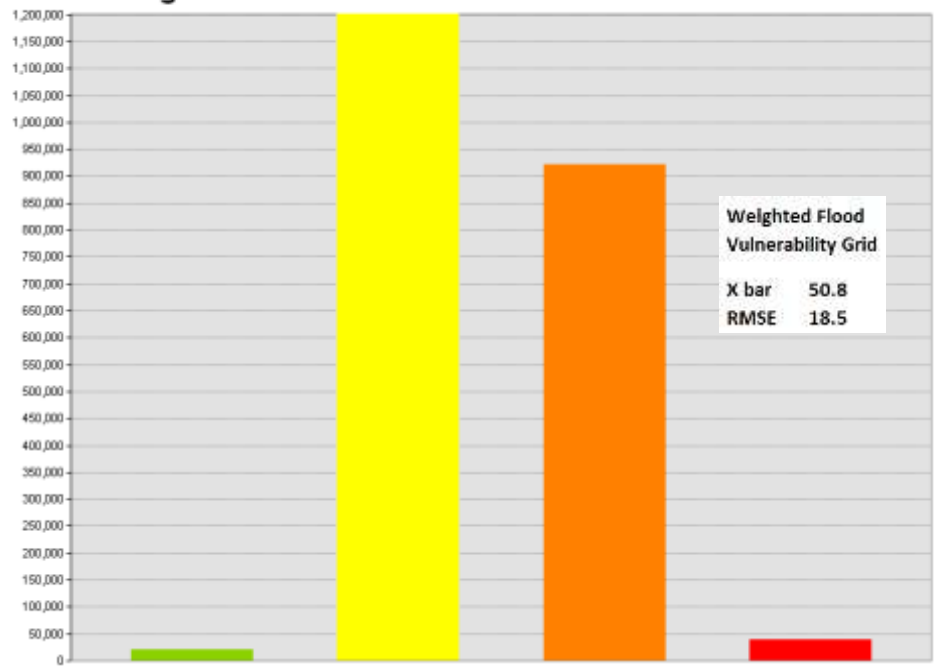



0 0.5 1
Miles


Weighted Flood Vulnerability
Low
Moderate
High
Very High
McMinnville
Sheridan

Histogram of values within 100 year flood zone

Histogram of modeled values in the Yamhill Watershed



T-Test

- A 1 tailed T-Test with unequal variance was performed with the assumption that the entire watershed has significantly lower values than only values inside the 100 year FEMA flood zone.
- $p = 0.000$

Limitations

- Does not include flood management structures
- Classification scheme is not tied to discharge rates
- Historic flood data not included
- Slope artifacts

Conclusions

- The model underestimated the "very high" flood vulnerability
- High standard deviation of modeled values within the 100 year FEMA flood zone
- Statistically significant results inside 100 year FEMA flood zone
- In "data poor" areas this method can highlight very general relative flood risk, needs improvement to support decision making.

References

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THANK YOU
ANY QUESTIONS?