

A photograph of a wetland landscape. In the foreground, there is a stream flowing through a field of moss and numerous white, fluffy flowers. The background shows a dense forest of trees under a clear blue sky. A semi-transparent white box with a black border is overlaid on the upper portion of the image, containing the title text.

Rapid Prototyping for Wetland Restoration

Refuge Background: Canaan Valley NWR

- Established in 1994 : founding legislation (in part) the Emergency Wetland Resources Act 1986
- Founding Documents Emphasize
 - Rare plant communities
 - Ecological Integrity
 - Wetland protection

Wetland Restoration Problem Statement:

How do we manage embankments¹ to achieve natural flow regimes² within wetland habitats of Canaan Valley NWR while not exceeding budgetary, political and/or legal constraints.

¹ Embankments include natural and artificial structures which alters hydrology...roads, trails, railroad grades, beaver.

² Surrogate for biological integrity, diversity and environmental health

Decision Complexity and Need For SDM Approach

- High Risk Factors
 - Invasive species; Uncertainty
- Main railgrade could affect largest peatland on Refuge and State Significance
- Multiple locations of railgrades with different potential outcomes
- Political Context



Erosion-head-cutting
into bog

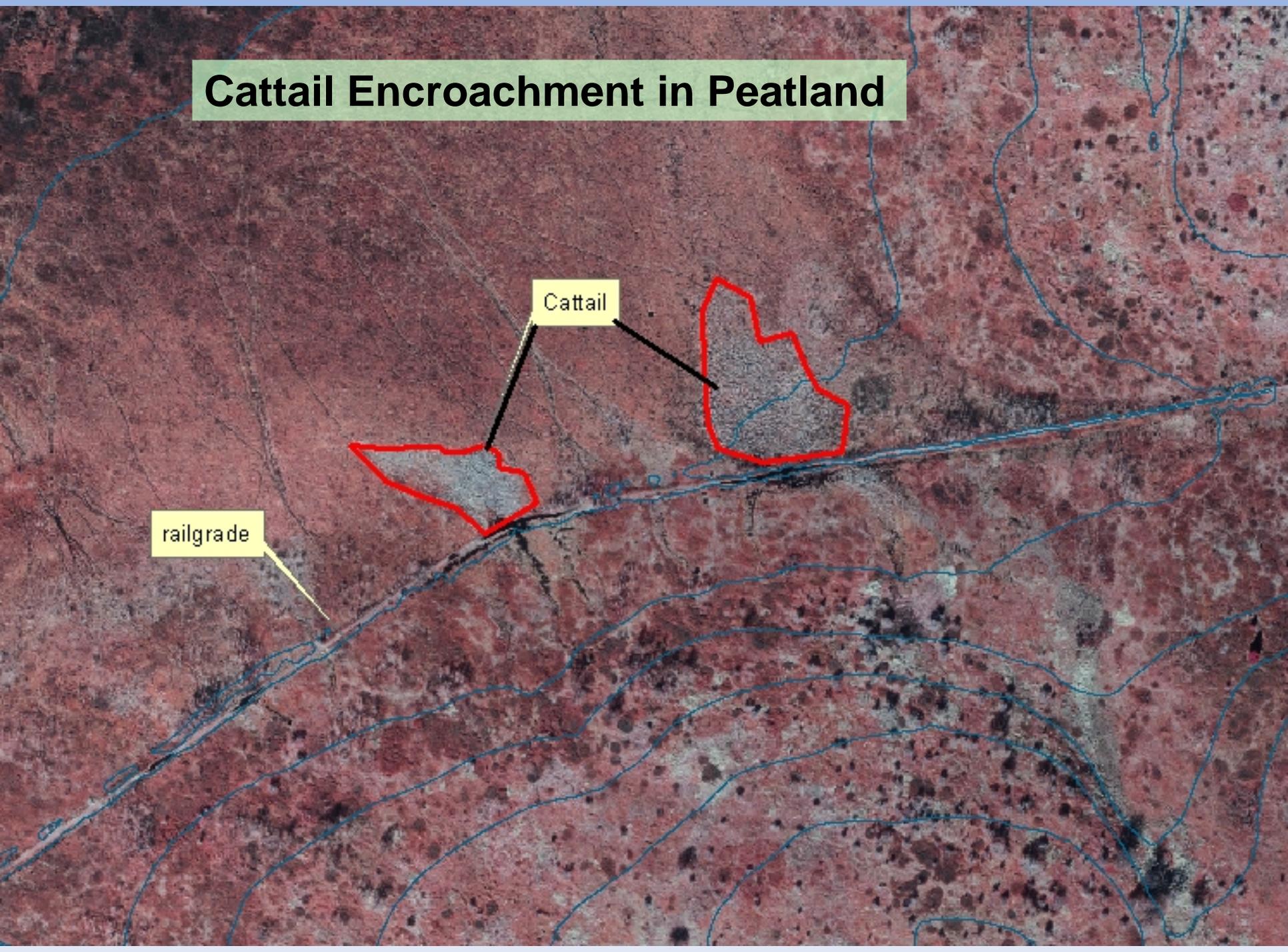
Ponding

Beaver Pond Establishment on South Side Of Railgrade Through Center of Refuge Wetlands

Railgrade



Cattail Encroachment in Peatland



Cattail

railgrade

Altered Flows

Railgrade

Ponding water channeling parallel with grade



Objectives : Fundamental and Means

1) Invasive Species

- Prevent new occurrences
- Reduce existing cover

2) Natural Flows

- Restore Natural Flow magnitude, timing (seasonal), variability

3) Habitats

- Minimize risk to rare communities in footprint of project.

4) Public Support

- Maximize Public Acceptance

5) Cost

- Minimize cost (implementation, monitoring, maintenance)

Alternatives

Toe Slope Parallel or Perpendicular to flow

Valley Floor Parallel or Perpendicular to flow

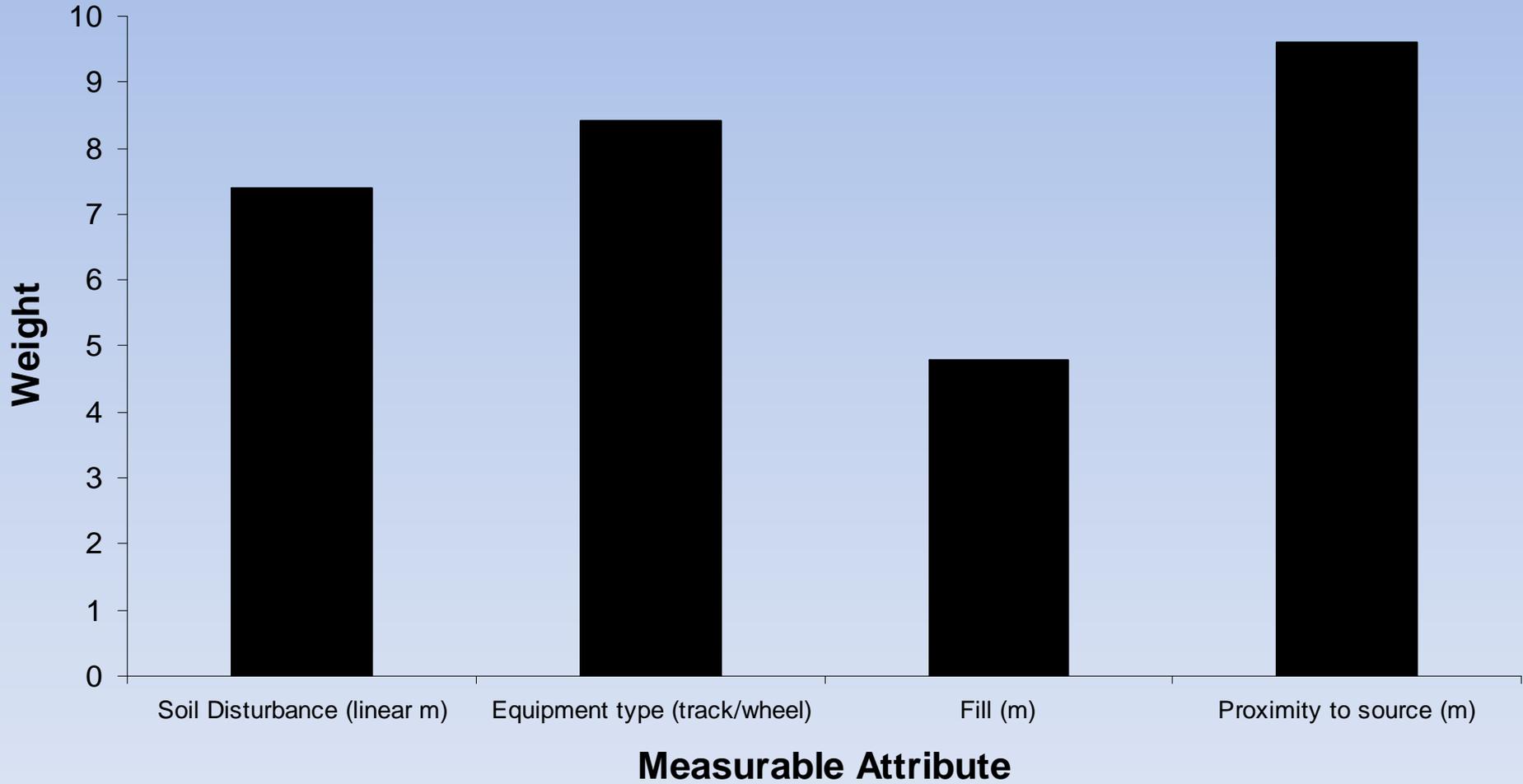
Management Alternatives

1. No Action – allows natural deterioration with no filling of ditches
2. Total Removal
3. Partial removal
 - Culverts
 - Sectional Removal
4. Permeable fill replacement
5. Maintain embankment
6. Replace with boardwalk (for existing public use trails)

Consequences: Invasives

Location	Action	Embankment Length(m)	Soil Disturbance (linear m)	Equipment type (track/wheel)	Fill (m)	Proximity to source (m)
Toe Slope	No action	50	0	0	0	0
Toe Slope	Total Removal	50	50	2 backhoe	0	0
Toe Slope	Partial Removal 10%	50	5	1 bobcat	0	0
Toe Slope	Culvert	50	5	2 backhoe	0	0
Toe Slope	Permeable Fill	50	50	3 backhoe + truck	50	0
Toe Slope	Maintain Grade	50	0	0	0	0
Toe Slope	Add boardwalk	50	50	3 backhoe + truck	0	0
Valley	No action	1200	0	0	0	0
Valley	Total Removal	1200	1200	5 all equipment	0	0
Valley	Partial Removal 10%	1200	120	2 backhoe	1080	0
Valley	Culvert	1200	120	2 backhoe	1200	0
Valley	Permeable Fill	1200	1200	5 all equipment	1200	0
Valley	Maintain Grade	1200	50	0	0	0

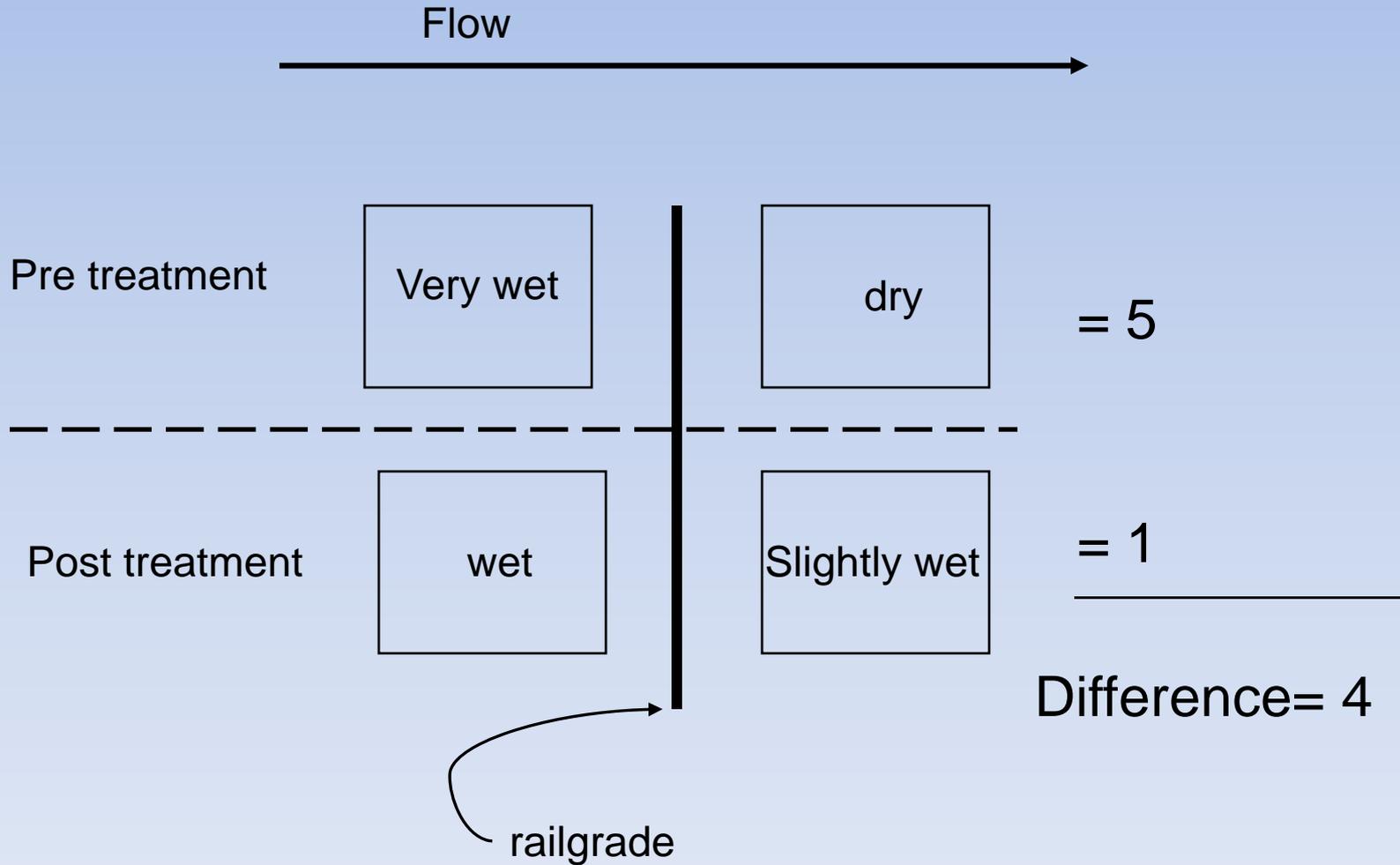
Invasive Risk



Consequences: Invasives

Location	Action	Soil Disturbance (linear m)	Equipment type (track/wheel)	Fill (m)	Proximity to source (m)	Weighted Sum
	weights	7.4	8.4	4.8	9.6	
Toe Slope	No action	0.00	0.00	0.00	9.60	9.60
Toe Slope	Total Removal	0.30	3.36	0.00	9.60	13.26
Toe Slope	Partial Removal 10%	0.03	1.68	0.00	9.60	11.31
Toe Slope	Culvert	0.03	3.36	0.00	9.60	12.99
Toe Slope	Permeable Fill	0.30	5.04	0.19	9.60	15.13
Toe Slope	Maintain Grade	0.00	0.00	0.00	9.60	9.60
Toe Slope	Add boardwalk	0.30	5.04	0.00	9.60	14.94
Valley	No action	0.00	0.00	0.00	9.60	9.60
Valley	Total Removal	7.10	8.40	0.00	9.60	25.10
Valley	Partial Removal 10%	0.71	3.36	4.15	9.60	17.82
Valley	Culvert	0.71	3.36	4.61	9.60	18.28
Valley	Permeable Fill	7.10	8.40	4.61	9.60	29.71
Valley	Maintain Grade	0.30	0	0	9.60	9.90

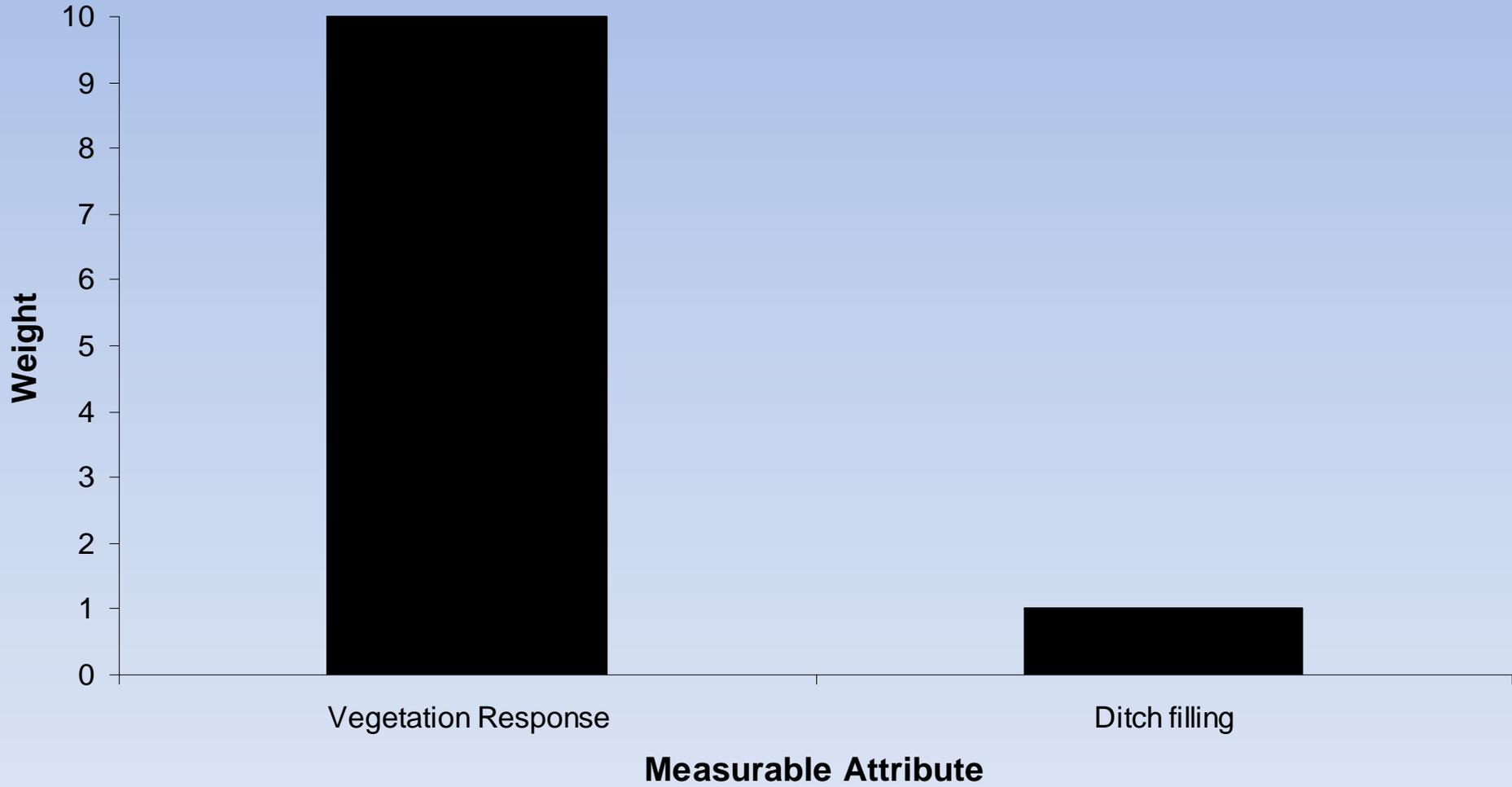
Consequences-Natural Flows



Consequences: Natural Flow

Location	Action	Pre veg community	Post veg community	Difference	Ditching (n=1, y=0)
Toe Slope	No action	2	2	0	1
Toe Slope	Total Removal	2	0	2	1
Toe Slope	Partial Removal 10%	2	1	1	1
Toe Slope	Culvert	2	1	1	1
Toe Slope	Permeable Fill	2	0	2	1
Toe Slope	Maintain Grade	2	2	0	1
Toe Slope	Add boardwalk	2	0	2	1
Valley	No action	5	5	0	0
Valley	Total Removal	5	0	5	1
Valley	Partial Removal 10%	5	2.5	2.5	1
Valley	Culvert	5	2.5	2.5	1
Valley	Permeable Fill	5	0	5	1
Valley	Maintain Grade	5	5	0	1

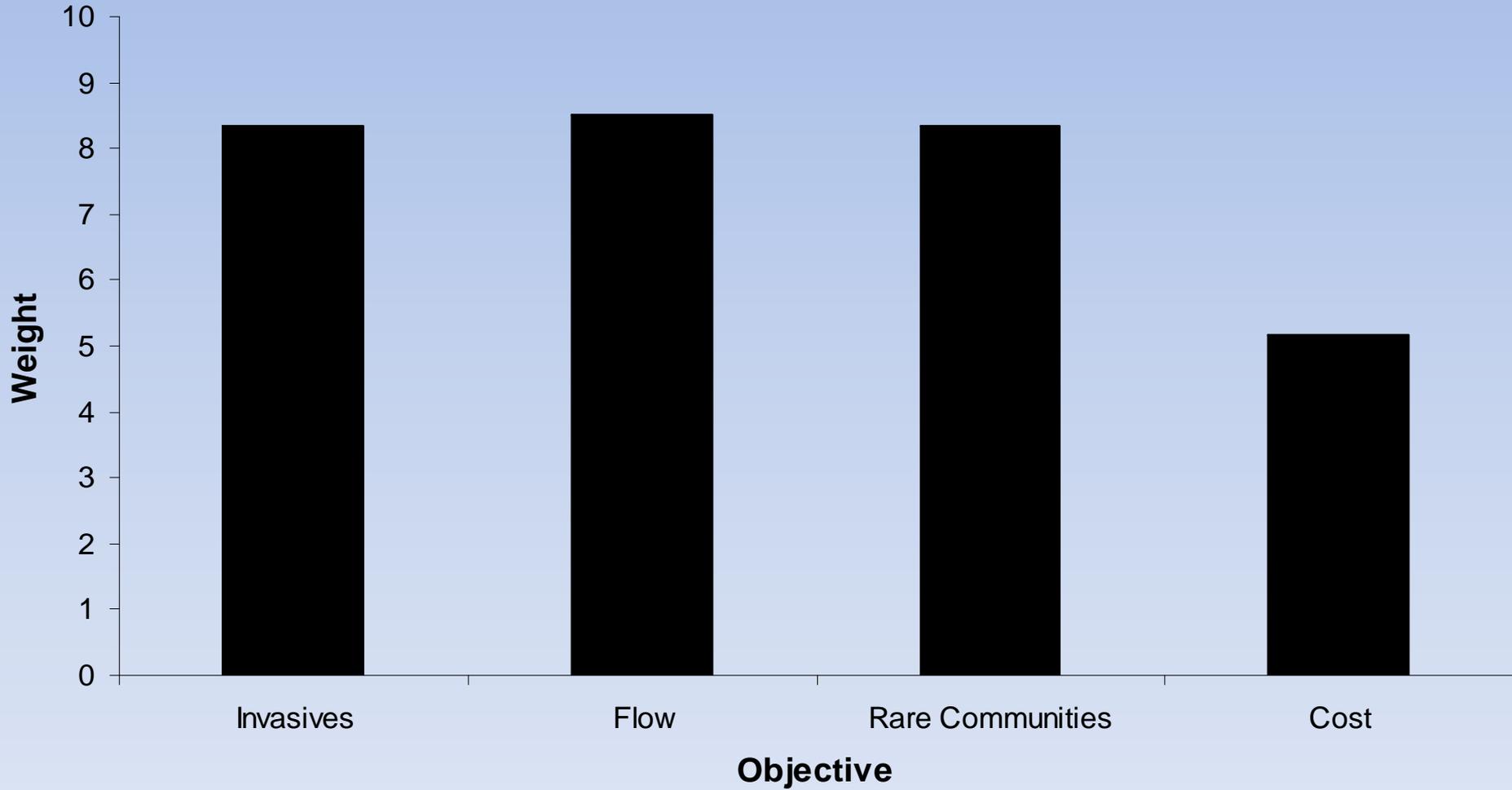
Natural Flow



Consequences: Natural Flow

Location	Action	Veg. response	Ditch Filling	Weighted Sum
	weights	10	1	
Toe Slope	No action	0	1	1
Toe Slope	Total Removal	4	1	5
Toe Slope	Partial Removal 10%	2	1	3
Toe Slope	Culvert	2	1	3
Toe Slope	Permeable Fill	4	1	5
Toe Slope	Maintain Grade	0	1	1
Toe Slope	Add boardwalk	4	1	5
Valley	No action	0	0	0
Valley	Total Removal	10	1	11
Valley	Partial Removal 10%	5	1	6
Valley	Culvert	5	1	6
Valley	Permeable Fill	10	1	11
Valley	Maintain Grade	0	1	1

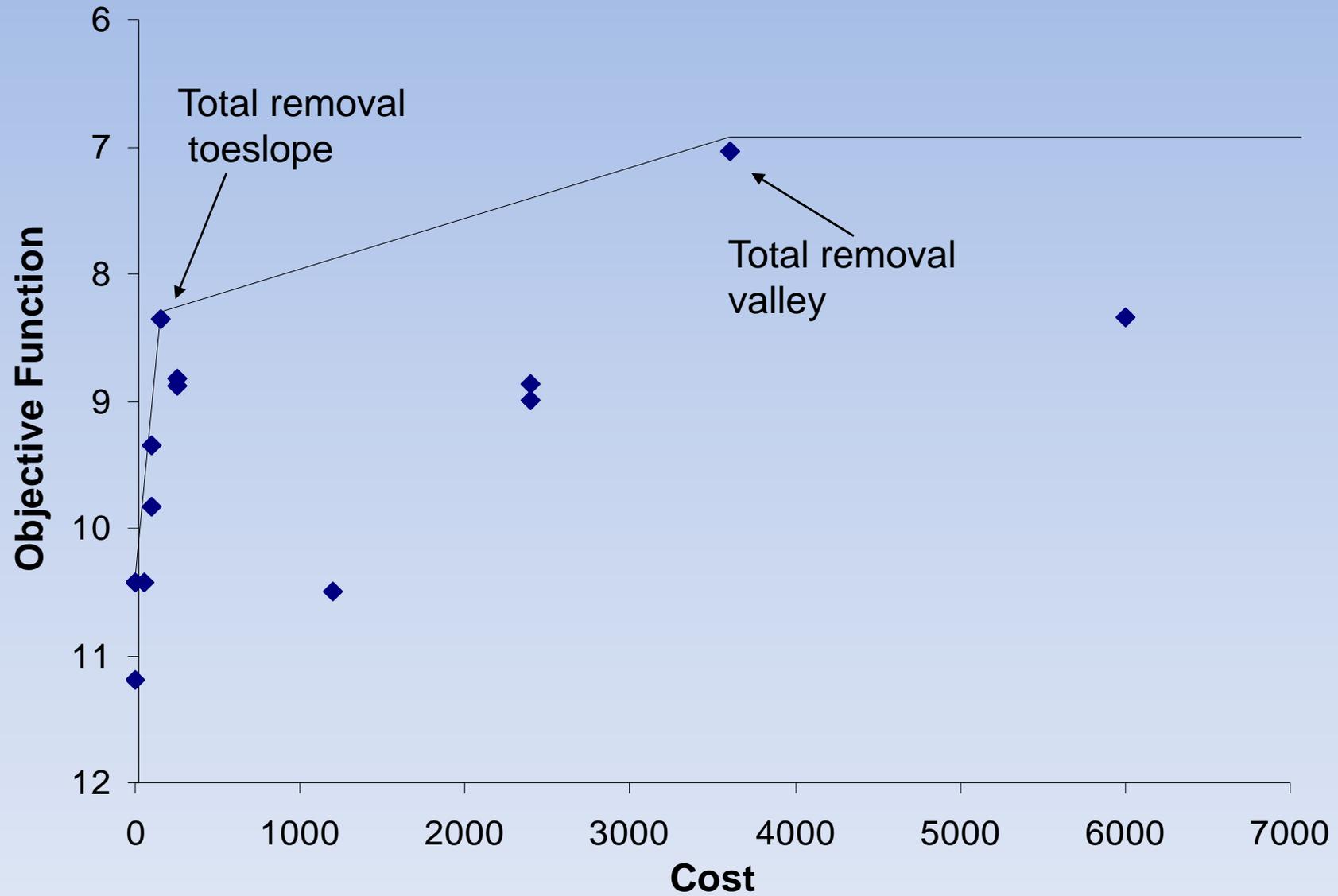
Objective Weights



Consequences: Summary

Location	Action	Invasives	Flow	Rare communities	Cost	Weighted Sum
	weights	8.33	8.50	8.33	5.17	
Toe Slope	Total Removal	3.72	4.64	0	0.13	8.48
Toe Slope	Add boardwalk	4.19	4.64	0	0.22	9.04
Toe Slope	Permeable Fill	4.24	4.64	0	0.22	9.09
Toe Slope	Partial Removal 10%	3.17	6.18	0	0.09	9.44
Toe Slope	Culvert	3.64	6.18	0	0.09	9.91
Valley	Total Removal	7.04	0.00	0	3.10	10.14
Toe Slope	No action	2.69	7.73	0	0.00	10.42
Toe Slope	Maintain Grade	2.69	7.73	0	0.04	10.46
Valley	Partial Removal 10%	5.00	3.86	0	2.07	10.93
Valley	Culvert	5.13	3.86	0	2.07	11.06
Valley	No action	2.69	8.50	0	0.00	11.19
Valley	Maintain Grade	2.78	7.73	0	1.03	11.54
Valley	Permeable Fill	8.33	0.00	0	5.17	13.50

Cost/Benefit



Where do we go from here?

- Finish Model with real information: retain expertise
- Revisit Objectives
- Refine-Revisit Decision Statement
- Define Research Needs based on areas of uncertainty
- Develop site specific alternatives
- Understanding that more time will be required by staff to fully work through a real model

A photograph of a field of flowers. On the left, there are yellow flowers with green foliage. On the right, there are purple flowers with green foliage. A blue speech bubble with a white outline is overlaid on the left side of the image, containing the text "Questions?".

Questions?

A blue speech bubble with a white outline is overlaid on the bottom right side of the image. It contains the text "ASK ADAM!".

ASK ADAM !