Climate Change Scenarios and Adaptation Strategies

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Vermont is projected to undergo huge changes within the mid to next century due to natural climate shifts and increases in greenhouse gas emissions.

- ✓ Higher average temperatures
- ✓ Increased precipitation
- ✓ Longer growing seasons
- ✓ Changes in snow and ice cover

Question

- What is the pattern of interdependence between the impact chains that flow from climate change drivers?

- Does this pattern reveal any key strategies or critical developments around which the whole system changes?

In mid-November of 2012, a climate change scenario development workshop for the Lake Champlain Basin took place.
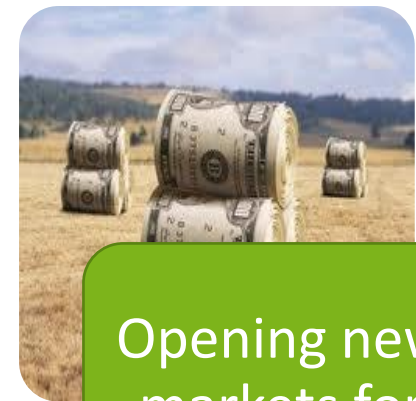
Participants included 122 people from…

Business

Government

Higher Ed

Nonprofits

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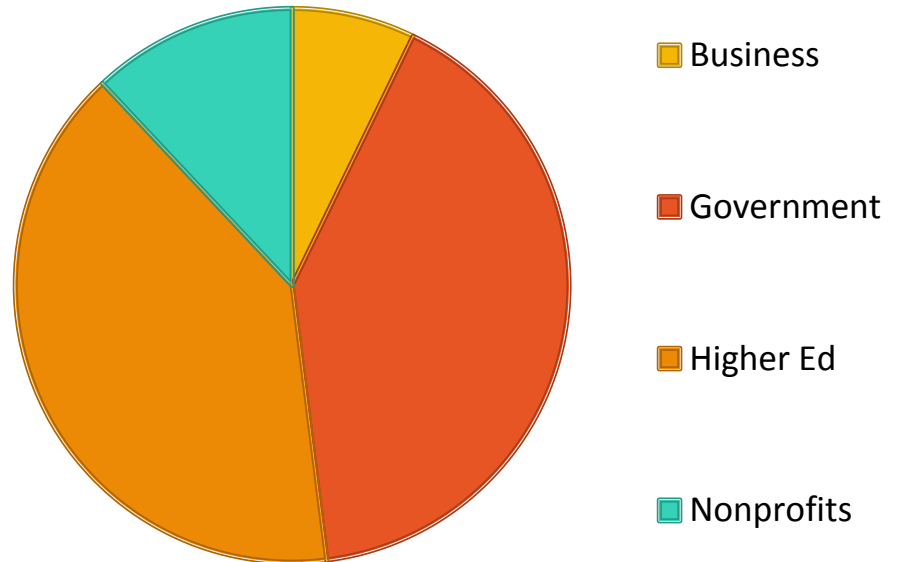
AN EXAMPLE SCENARIO:
AS A RESULT INCREASED TEMPERATURES...

Growing seasons are extended...

New crops may be grown...

Opening new markets for region's farmers

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Network Concepts

- What is a Network?

- What is Centrality?
  - In-Degree Centrality

 - Betweenness Centrality

  - Out-Degree Centrality

Methods

- Clean the data gathered from the workshop in Microsoft Excel

- Validated data was analyzed in UCINET and *ORA for network measures and structures

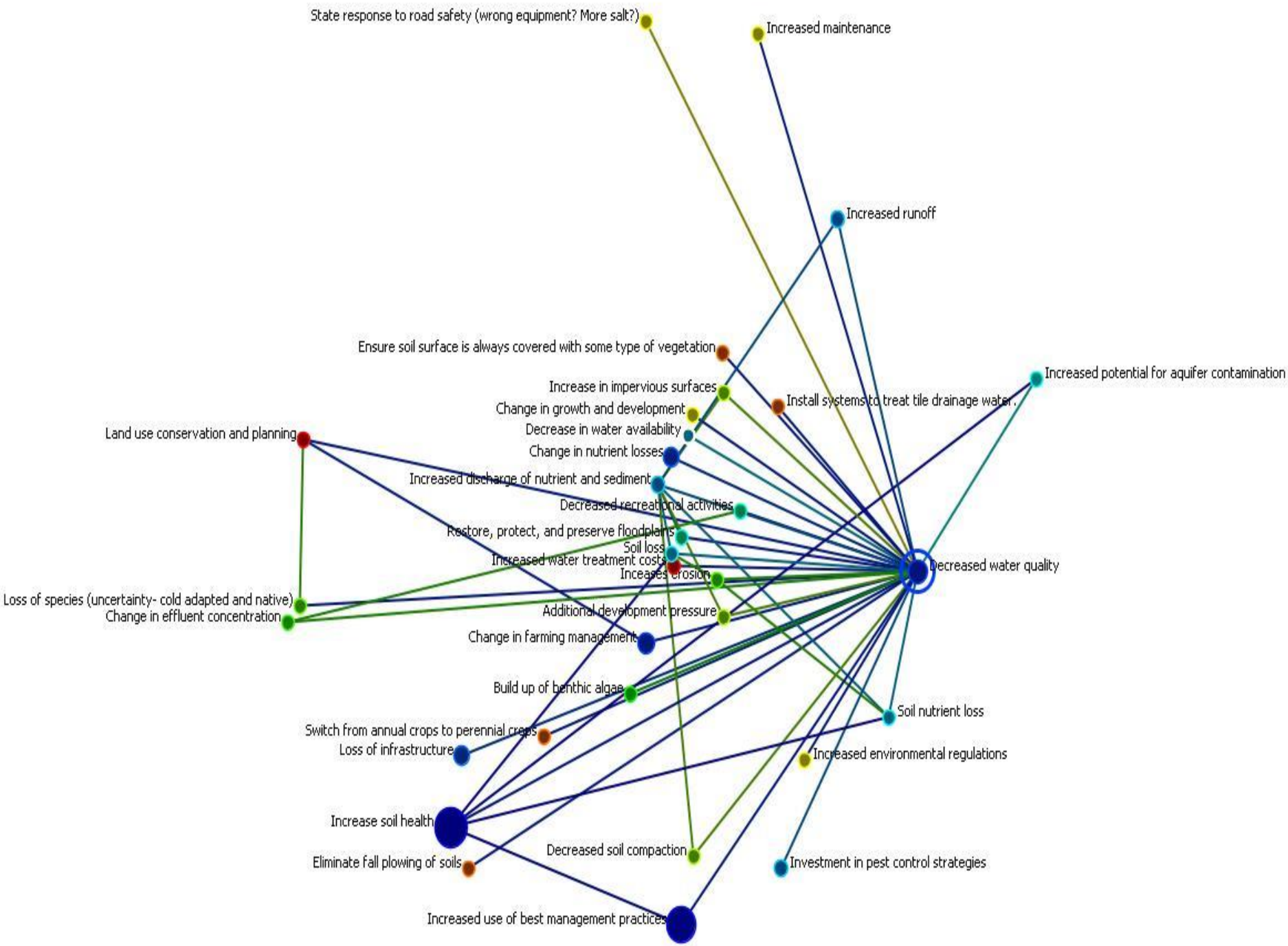- Network measures reveal key drivers and most likely impacts

2D Visualization
Decreased Water Quality

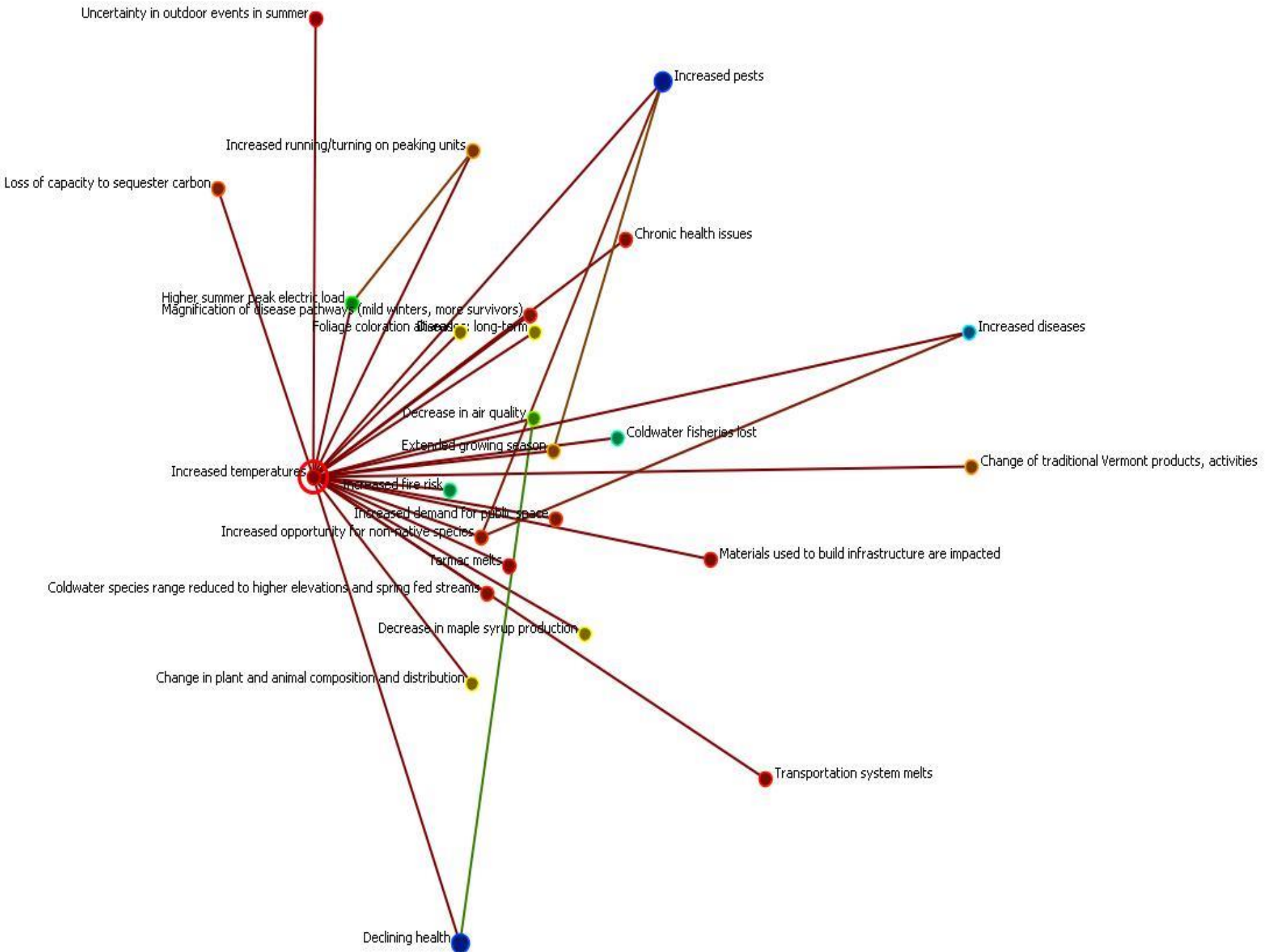|	Climate Drivers	First Order Impact	Second Order Impact	Third Order Impact	Fourth Order Impact	Fifth Order Impact
323	Increased loss of snow and ice cover	Increased winter runoff from farms	Increased discharge of nutrient and sediment	Decreased water quality	Eliminate fall plowing of soils	NRCS state programs are already in place
324	Increased seasonality in precipitation	Increased winter runoff from farms	Increased discharge of nutrient and sediment	Decreased water quality	Install systems to treat tile drainage water.	NRCS state programs are already in place
325	Increased loss of snow and ice cover	Increased winter runoff from farms	Increased discharge of nutrient and sediment	Decreased water quality	Install systems to treat tile drainage water.	NRCS state programs are already in place
415	Increased temperatures AND Increased seasonality in precipitation	increased winter runoff	Increased discharge of nutrient and sediment	Decreased water quality		
440	Loss of snow and ice cover	Extended low flows from lack of snowpack and spring rains	Build up of benthic algae	Decreased water quality		
461	Loss of snow and ice cover	Increase soil health	Increased potential for aquifer contamination	Decreased water quality		
505	Increased population movement	Change in habitat	Investment in pest control strategies	Decreased water quality	Loss of species (uncertainty-cold adapted and native)	Preserve refugia
506	Increased population movement	Change in habitat	Investment in pest control strategies	Decreased water quality	Loss of species (uncertainty-cold adapted and native)	Preserve connectivity targeted land
507	Increased population movement	Change in habitat	Investment in pest control strategies	Decreased water quality	Loss of species (uncertainty-cold adapted and native)	Land use conservation and planning
804	Increased temperatures	Increased demand for public space	Additional development pressure	Decreased water quality		
807	Increased temperatures	Increased demand for public space	Increase in impervious surfaces	Decreased water quality		
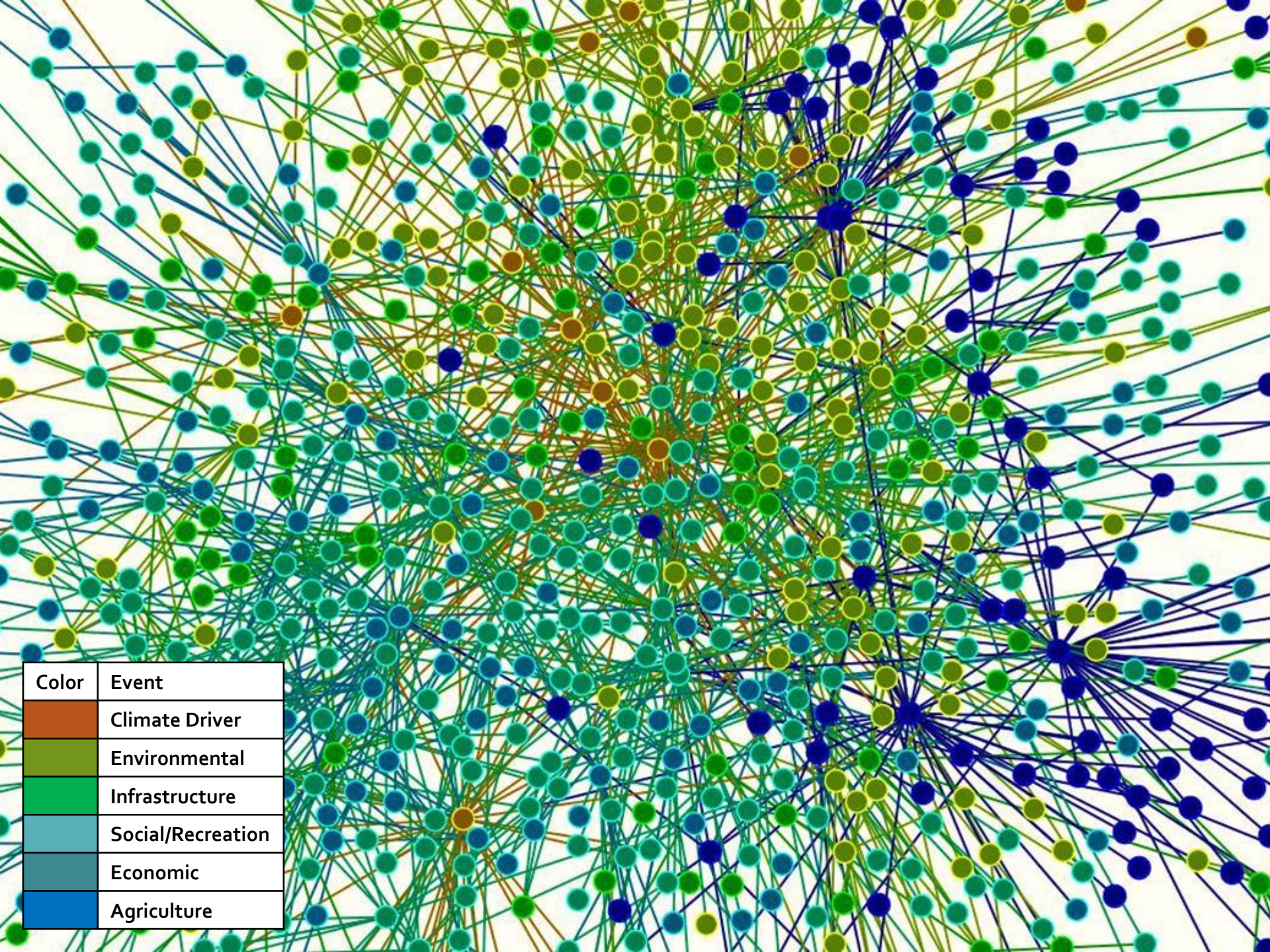
Color	Event
	Climate Driver
	Environmental
	Infrastructure
	Social/Recreation
	Economic
	Agriculture

2D Visualization
Increased Temperatures

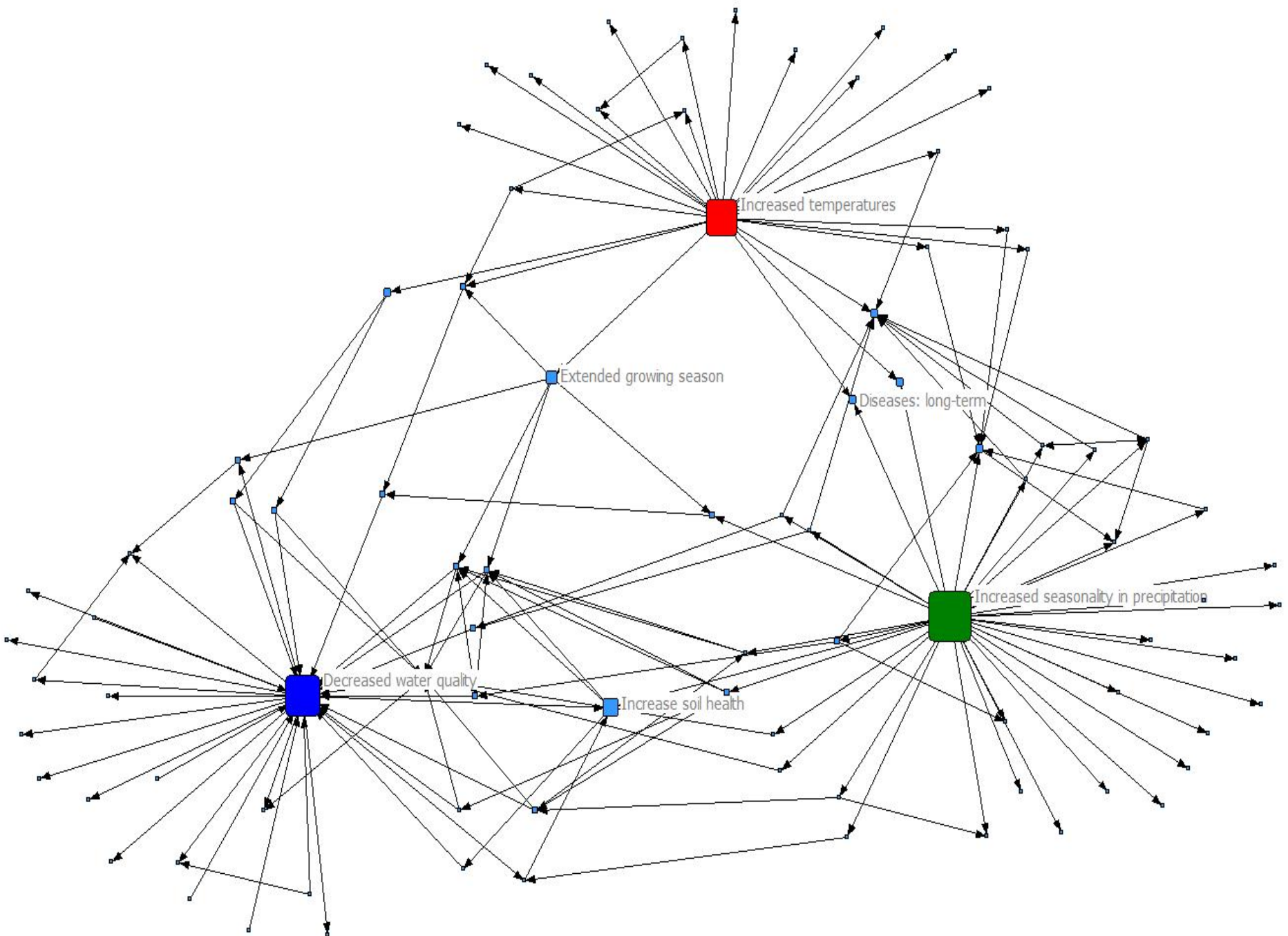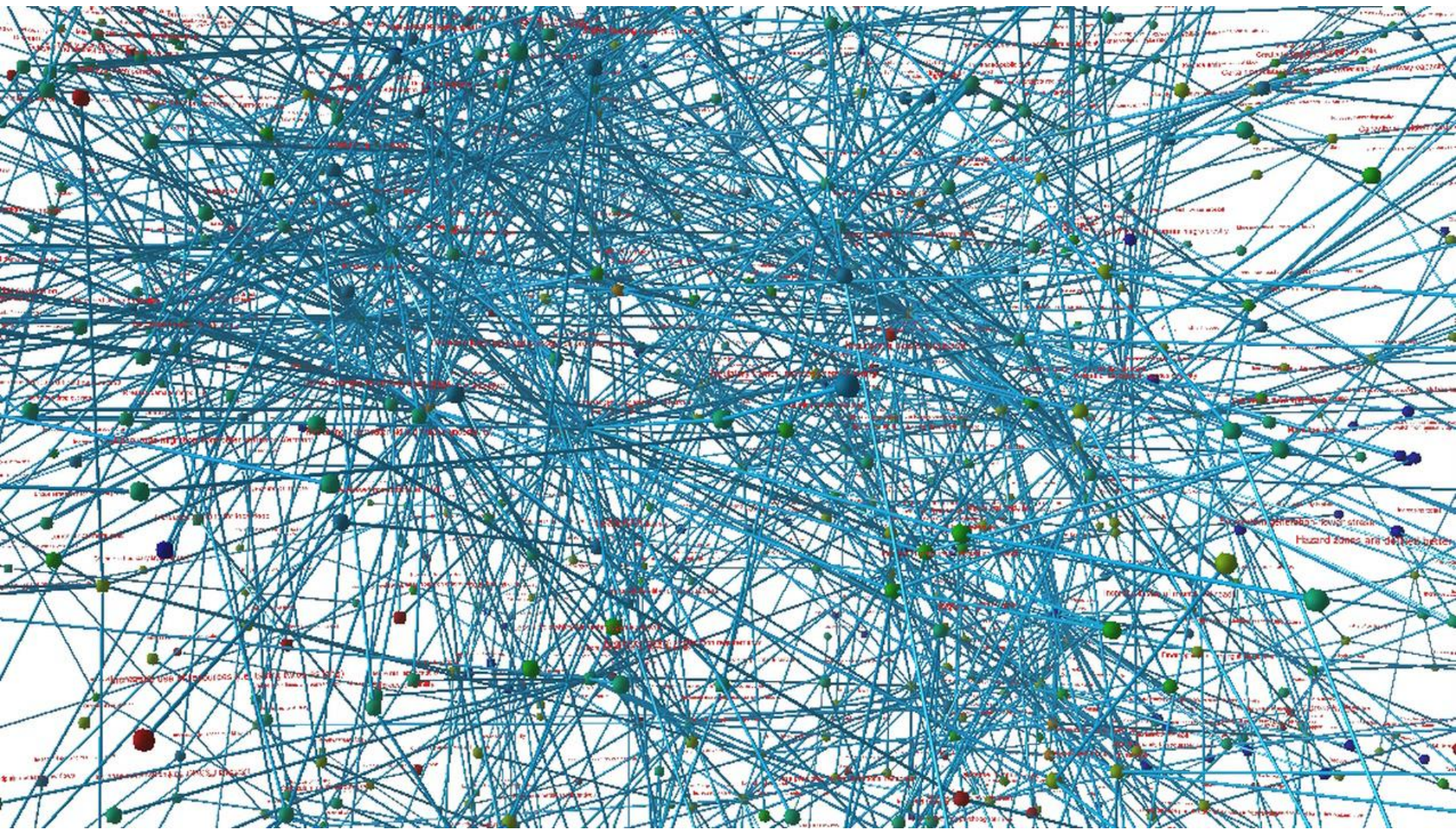|	Climate Drivers	First Order Impact	Second Order Impact	Third Order Impact	Fourth Order Impact	Fifth Order Impact
1						
342	Increased temperatures	Change in plant and animal composition and distribution	Change in tourism/recreation			
343	Increased temperatures	Coldwater fisheries lost	Increased fish migration			
344	Increased temperatures	Coldwater fisheries lost	Change in tourism/recreation			
345	Increased temperatures	Coldwater fisheries lost	Loss of small coldwater community type			
346	Increased temperatures	Coldwater species range reduced to higher elevations and spring fed	Loss of small coldwater community type	Water quality standard-biocondition exploitation changes		
347	Increased temperatures	Coldwater species range reduced to higher elevations and spring fed	Mussel, fish host disconnect	Loss of biodiversity		
348	Increased temperatures	Decrease in air quality	Increased incidence respiratory is	Decreased work and school productivity		
349	Increased temperatures	Decrease in air quality	Decreased visibility	Decreased tourist appeal		
350	Increased temperatures	Increased diseases	Greater incidence of zoonotic disease (i.e., Lyme disease)	Increased health care costs		
351	Increased temperatures	Increased pests	Greater incidence of zoonotic disease (i.e., Lyme disease)	Increased health care costs		
352	Increased temperatures	Increased diseases	Change in food web			
	Increased temperatures	Increased pests	Change in food web			

2D Visualization
Increased Seasonality in Precipitation

|	Climate Drivers	First Order Impact	Second Order Impact	Third Order Impact	Fourth Order Impact	Fifth Order Impact
1						
289	Increased seasonality in precipitation	Uncertainty in surface water availability	Increased infrastructure costs			
290	Increased seasonality in precipitation	Uncertainty in groundwater availability	Lack of feelings of security within population	Civil unrest	Eminent domain	
291	Increased seasonality in precipitation	Uncertainty in groundwater availability	Lack of feelings of security within population	Civil unrest	Personal rights	
292	Increased seasonality in precipitation	Uncertainty in surface water availability	Lack of feelings of security within population	Civil unrest	Eminent domain	
293	Increased seasonality in precipitation	Uncertainty in surface water availability	Lack of feelings of security within population	Civil unrest	Personal rights	
294	Increased seasonality in precipitation	Uncertainty in groundwater availability	Lack of feelings of security within population	Civil unrest	Eminent domain	
295	Increased seasonality in precipitation	Uncertainty in groundwater availability	Lack of feelings of security within population	Civil unrest	Personal rights	
296	Increased seasonality in precipitation	Uncertainty in surface water availability	Lack of feelings of security within population	Civil unrest	Eminent domain	
297	Increased seasonality in precipitation	Uncertainty in surface water availability	Lack of feelings of security within population	Civil unrest	Personal rights	
298	Increased seasonality in precipitation	Uncertainty in groundwater availability	Increased demand for infrastructure in agriculture	Personal hygiene suffers		
299	Increased seasonality in precipitation	Uncertainty in groundwater availability	Increased demand for water storage	Personal hygiene suffers		
	Increased seasonality in	Uncertainty in surface	Increased demand for	Personal hygiene suffers		

Change in lake assimilative capacity

Shorter snow season

Increased seasonality in precipitation

Change in groundwater table elevation

Crop damage

Change to soil moisture

Change in planning outdoor events

Change in tourism/recreation

Change in demand for water supply quality

Diseases: long-term

Increase in severity of disaster damage

Longer, harder, quantities of more rain water

Loss of jobs, income/wages/wages

Use of less desirable land for infrastructure (energy)

Increased winter runoff

Less innovative project design

Change in functionality of drainage

Increased winter runoff from farms

Increases erosion

Increase in frequency of disaster damage

Change of traditional Vermont products, activities

Increased domestic violence

Uncertainty in groundwater availability

Change in amplitude of groundwater table elevation variation

Change in boundary layer moisture

Erosive force of rainfall events increase

Increased stress

Increased mental health impacts

Diseases: chronic

Farmers will be dealing with changing water supply in times of excess water or drought

Increased crime

Uncertainty in surface water availability

Change in Lake Hydrology

Change in functionality of drainage network

Increase soil health

Change in lake mixing

Increased temperatures

Extended growing season

Diseases: long-term

Increased seasonality in precipitation

Decreased water quality

Increase soil health

Total 3D Visual

Results
In-Degree Centrality

Rank	Agent	Links
1	Extended growing season	130
2	Declining health	86
3	Crop diversification	80
4	Increase soil health	64
5	Decreased water quality	61
6	Transportation network ceases to function	56
7	Long-term displacement	52
8	Loss of jobs, income/wages	50
9	Increased pests	48
10	Loss of infrastructure	46

Betweenness Centrality
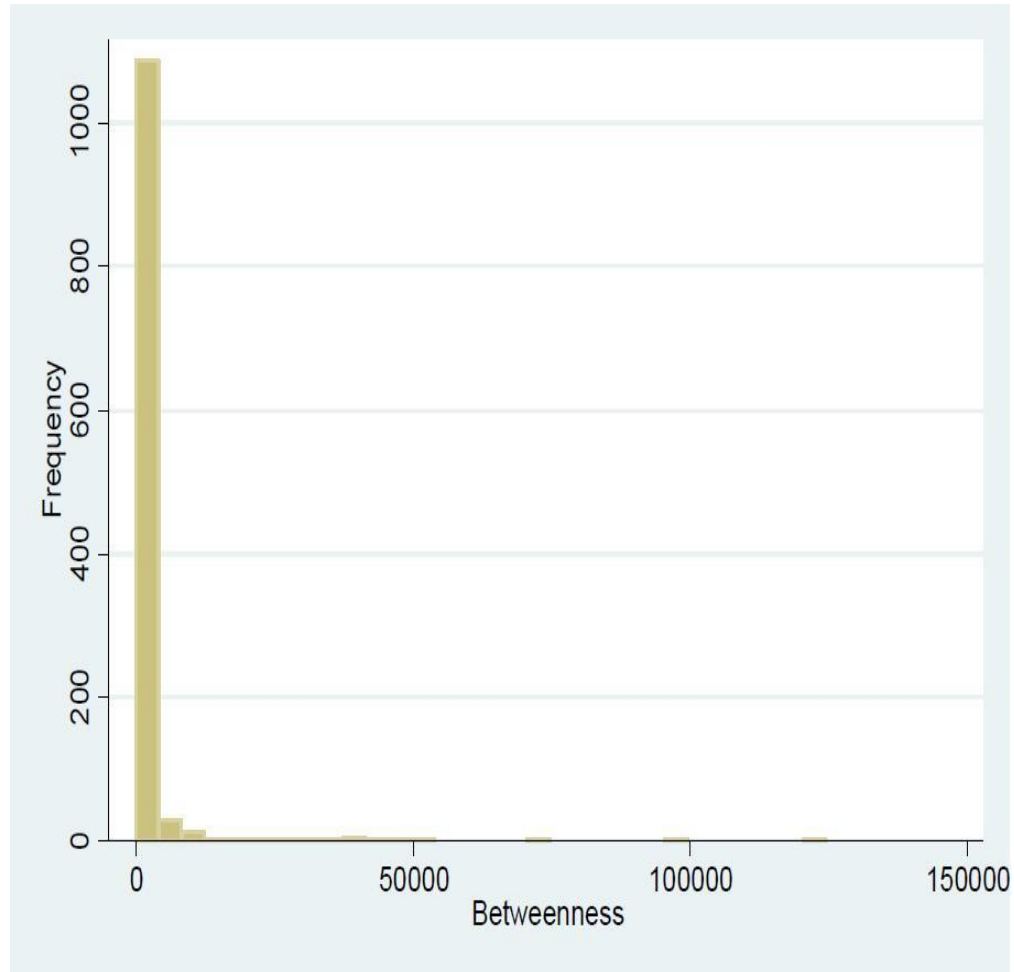
Results
Out-Degree Centrality

Rank	Agent	Links
1	Increased seasonality in precipitation	365
2	Increased flooding	364
3	Increased temperatures	266
4	Increased population movement	195
5	Combination of internal climate drivers	179
6	Extended growing season	130
7	Loss of snow and ice cover	82
8	Declining health	75
9	Crop diversification	66
10	Transportation network ceases to function	56

Summary

- If you know what events are going to happen, then start planning ahead to lessen the damage.

- Use the lists to figure out what Vermont should adapt to and plan accordingly.

- Key in on the nodes that have the highest and most influential connections to see where we can put our resources to research on.

Future work

- ❑ Integrate impact assessments into adaptive management plans.

- ❑ Re-involve stakeholders for further input

- ❑ Produce a risk assessment analysis of the critical scenarios

References

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➢ Carley, Kathleen M. Center for Computational Analysis of Social and Organizational Systems (CASOS), Institute for Software Research International (ISRI), School of Computer Science (SCS), and Carnegie Mellon University (CMU). 2001. *ORA. Pittsburgh, PA.

➢ Feinberg, Jonathan. Wordle - Beautiful Word Clouds. 2009

➢ Hanneman, Robert A. and Mark Riddle. 2005. Introduction to social network methods. Riverside, CA: University of California, Riverside (published in digital form at http://faculty.ucr.edu/~hanneman/)

➢ Regional Climate Change Scenario Development Workshop. November 13, 2012, Burlington, Vermont. Vermont EPSCoR, RACC, and NSF.

➢ Wasserman, Stanley, and Katherine Faust. *Social Network Analysis: Methods and Applications*. Cambridge: Cambridge UP, 1994. Print.

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