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EPA/600/R-11/058a
August 2011
External Review Draft

SFEP Report Tables and Figures

Table 1-1. Breakout group participants for the expert elicitation workshop (see Appendix B for further details on selection criteria and credentials)

Sediment Retention Group	Community Interactions Group
Dave Cacchione U.S. Geological Survey	**Letitia Grenier** San Francisco Estuary Institute
John Callaway University of California, San Francisco	**Jessica (Jessie) Lacy** U.S. Geological Survey
Chris Enright California Department of Water Resources	**Michelle Orr** Philip Williams & Associates
Bruce Jaffe U.S. Geological Survey	**Diana Stralberg** Point Reyes Bird Observatory Conservation Science
Lester McKee San Francisco Estuary Institute	**Stuart Siegel** Wetlands and Water Resources
Dave Schoellhamer U.S. Geological Survey	**Lynne Trulio** San Jose State University
Mark Stacey University of California, Berkeley	**Isa Woo** U.S. Geological Survey

Table 2-1. Summary of Climate Scenario A ("Lower-Range" Scenario) and Climate Scenario B ("Higher-Range" Scenario): averages for mid-century

		"Lower-Range" Scenario	"Higher-Range" Scenario
Temperature[a]	Annual Average[b]	+2.8°F (1.6°C)	+3.5°F (1.9 °C)
	Average Increase of Winter Temperature[c]	+2.5°F (1.4 °C)	+2.7°F (1.5 °C)
	Average Increase of Summer Temperature	+4.0°F (2.2 °C)	+4.5°F (2.5 °C)
	Extreme Heat Days[d]	+10 days/year	+16 days/year
Precipitation	Annual Change[e]	-4.5%	-7%
	Winter change	Reduced winter precipitation[f]	
	Heavy Events	Decline in frequency of precipitation events (exceeding 3mm/day) but not a clear signal in changes of precipitation intensity	
Sea Level	Total Increase for 2050[g]	+30 cm	+45 cm[h]
	Hourly Sea Level Exceedances[i]	1343	1438
Storms/Wind[j]		Tendency toward a decline in storms.[k] Projections suggest an increased tendency for heightened sea level events to persist for more hours. ENSO is not projected to increase in frequency or intensity.	
Snow Pack Change		For the Sacramento-San Joaquin watershed, April watershed-total snow accumulation projected to drop by 64% by 2060.[l]	
Spring Runoff		Spring runoff occurring earlier and reduced overall	
Seasonal Changes in Amount of Freshwater Inflow to the Bay from the Delta in 2060[m]		October through February: inflow +20% March through September: inflow -20%	

[a] Since the 1920s, minimum and maximum daily temperature have been observed to have increased in California with minimum temperature increasing at a greater rate accented by a small cooling trend in the summer (Cayan et al., 2009). These averages are for 2035-2064 projections relative to a 1961 to 1990 baseline for B1 and A2 emission scenarios.

[b] Approximate results using B1 and A2 emissions scenarios and three global climate models (PCM1, GFDL CM2.1, HadCM3) (CEC, 2006).

[c] These results are for Sacramento, California. This warming is projected to be more moderate along the coastline (50 km from the coast) rising considerably inland (Cayan et al., 2009). These averages are for 2035-2064 projections relative to a1961 to 1990 baseline for B1 and A2 emissions scenarios.

[d] Extreme heat days are defined as when the daily maximum temperature exceeds the 95th percentile of temperature from the 1961-1990 historical averages of May-September days. 1961-1990 extreme heat days are approximately 8 days/year based on model runs. Results are provided by Cayan et al. (2009) using three climate models (CNRM CM3, GFDL CM2.1, MICRO 3.2; with bias corrected spatial downscaling) for B1 and A2 emissions scenarios. Mid-century projections suggest hot daytime and nighttime temperatures increase in frequency, magnitude, and duration (Cayan et al., 2009). Extreme warm temperatures in California, historically a July and August phenomenon, will increase in frequency and magnitude likely beginning in June and may continue into September (Hayhoe et al., 2004; Gershunov and Douville, 2008; Miller et al., 2008).

[e] Results are averaged across 6 GCMs using the grid point nearest to Sacramento (Cayan et al., 2009) for B1 and A2 emissions scenarios.

[f] These results are provided by CEC (2008).

[g] Sea level rise relative to 2000 levels. This study applies Rahmstorf's methodology of estimating sea level rise as a function of rising temperatures. This study assumes sea level rise along the coast to be the same as global estimates given the observed rate of rise along the southern California coast has been about 17 to 20 cm per century similar to that of global sea level rise (assume no future changes in other factors that affect relative sea level rise such as changes in regional/local ocean circulation, ocean density, etc.) (Cayan et al., 2009). DMRS also provides recommended 2050 global sea level rise estimates relative to 1990 values: 11 cm (direct extrapolation of observed increased during the 20th century), 20 cm (low-end value of Rahmstorf and approx mid-range of IPCC TAR), 30 cm (approx mid-range of Rahmstorf and high-end of IPCC TAR); 41 cm (high end of Rahmstorf) (DMRS, 2007).

[h] The total difference between mean range and spring range of 1.7 ft (50.3 cm) is slightly larger than the higher-range scenario rise of 45 cm, based on the Point San Pedro tide station. http://tidesandcurrents.noaa.gov/tides10/tab2wc1a.html#128

[i] The hourly sea level exceedance is defined as the maximum duration (hours) when San Francisco sea level exceeds the 99.99th % level (140 cm above mean sea level) based on the GFDL climate change (A2) simulation using the Rahmstorf sea level scheme averaged 2 to 4 hours increase for mid-century (Cayan et al., 2009).

[j] These results are provided by Cayan et al. (2009).

[k] Storm is defined as sea level pressure (SLP) equaling or falling below 1005 millibar (mb).

[l] Results provided by the Bay-Delta watershed model driven by temperature projections from a parallel climate model under a ‘business-as-usual’ scenario relative to 1995-2005 (precipitation is assumed to remain consistent with today’s observations) (Knowles and Cayan, 2004).

[m] This study does account for reservoirs, in-stream valley diversions, and in-Delta withdrawals and assumes no future management adaptation or altered demand patterns (Knowles and Cayan, 2004).

Table 2-2. Coding scheme used during the workshop exercise to characterize influences. "Small" and "large" changes in variables are defined relative to the current range of variation for each variable, with "small" indicating that the variable is within its current range of variation and "large" indicating that the variable has moved outside its current range of variation

Option	Type and Degree of Influence Definition
0	No influence: We know that changes in X have no effect on changes in Y, holding all other variables constant.
1	Unknown influence: We don't know whether an increase in X will increase, decrease, or have no effect on Y.
2	Proportional increase: A large increase in X is likely to cause a large increase in Y. A small increase is likely to cause a small increase.
3	Proportional decrease: A large decrease in X is likely to cause a large decrease in Y. A small decrease is likely to cause a small decrease.
4	Inverse decrease: A small increase in X is likely to cause a small decrease in Y. A large increase in X is likely to cause a large decrease in Y.
5	Inverse increase: A small decrease in X is likely to cause a small increase in Y. A large decrease in X is likely to cause a large increase in Y.
6	A small increase in X is likely to cause a large increase in Y.
7	A small increase in X is likely to cause a large decrease in Y.
8	A large increase in X is likely to cause a small increase in Y.
9	A large increase in X is likely to cause a small decrease in Y.
10	A small decrease in X is likely to cause a large increase in Y.
11	A small decrease in X is likely to cause a large decrease in Y.
12	A large decrease in X is likely to cause a small increase in Y.
13	A large decrease in X is likely to cause a small decrease in Y.

Table 2-3. Coding scheme used during the workshop exercise to characterize interactive influences

Interactive Influence	Definition
Independence	The effect of X on Y is independent of Z (default situation)
Synergy	The effect of X on Y increases with increase in Z
AND Gate	The effect of X on Y happens only with large Z
NOR Gate	The effect of X on Y happens only with small Z
Competition	The effect of X on Y decreases with increase in Z

Table 2-4. Coding scheme used during the workshop exercise to characterize confidence

Confidence	Definition
LH	Low evidence, High agreement = Established but incomplete
LL	Low evidence, Low agreement = Speculative
HH	High evidence, High agreement = Well established
HL	High evidence, Low agreement = Competing explanations

Table 2-5. Sediment Retention variable definitions clarified during group discussion

Variable	Definition Agreed Upon by Group
Land use/ land change: impervious cover	Surfaces that reduce the ability of water to enter soil or substrate
Freshwater inflow	from local watersheds and the Delta, influence on Net Organic Accumulation depends on total or mean flow, influence on Sediment Flux depends on peak flow
Sediment flux	amount and rate
Vegetative production: net organic accumulation	net of plant production and decomposition

Table 2-6. Sediment Retention group influence judgments; columns A-Z represent individual influences (arrows) in the influence diagram and rows represent individual respondents: dark green = agreement on influence type and degree, light green = agreement on type but not degree, gray = no agreement; within columns, green numbers = same (majority) grouping of type (though degree may be different), pink numbers = disagreement about type, red outline = threshold response

CURRENT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
Resp. 1	2/3	4/5	4/5	4/5	0	2/3	9/12	4/5	9/12	2/3	8/13	2/3	2/3	2/3	4/5	2/3	2/3	6/11	9/12	1	2/3	2/3	9/12	4/5	2/3	2/3
Resp. 2		4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	2/3	2/3	2/3	2/3	2/3	2/3	2/3	2/3	2/3	6	2/3	2/3	2/3	2/3	4/5	1	2/3
Resp. 3	3	4	7	4	4	4	6	7	2/3	6/11	8	6/11	6/11	2/3	1	2/3	2/3	3	2/3	1	8/13	2/3	2	9|10	2/3	6/11
Resp. 4	2	9	9	9	8	9	9	1	1	2	8	2	2	2	1	2	2	6	2	4	2	2	8	4	2	2
Resp. 5	2/3	4/5	4/5	4/5	0	8/13	8/13	2/3	2/3	6/11	8/13	2/3	1	2/3	2/3	8/13	2/3	1	6/11	6/11	6/11	8/13	6/11	6/11	6/11	2/3
Resp. 6		4	4	4	8	8	7	8	9	2	8	2	8	2	9	2	2	2	8	2	2	2	3	0	2	
Resp. 7	2/3	2/3	4	4	8	9	9	9	2/3	6/11	2/3	2/3	2/3	2/3	2/3	2/3	4/5	2/3	2/3	2/3	2/3	2/3	7	3^4	2/3	2/3
SCENARIO A	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
Resp. 1	2/3	4/5	4/5	4/5	0	2/3	9/12	4/5	9/12	8/13	8/13	8/13	2/3	2/3	8/13	2/3	2/3	6/11	9/12	1	2/3	2/3	9/12	4/5	2/3	8/13
Resp. 2		4/5	4/5	4/5	1	1	1	4/5	4/5	2/3	8	2/3	2/3	2/3	7	2/3	2/3	2/3	6	6	2/3	2/3	6	4/5	1	2/3
Resp. 3		4	7	4	6	4	6	7	2/3	2/3	8	6/11	6/11	6	1	2/3	2/3	3	2/3	1	2/3	2/3	2	9|10	2/3	3
Resp. 4	2	9	9	9	8	9	9	1	1	2	8	2	2	2	1	2^8	2	6	2	4	2	2	8	4	2	2^4
Resp. 5	3	4	4	4	0	8/13	8/13	2/3	2/3	6	8	3	1	2	3	8/13	2/3	1	6	6	6/11	8/13	6/11	6/11	6/11	2
Resp. 6		1	4	4	0	8	7	8	9	2	2	2	8	0	2	8	8	2	8	7	8	8	2	0	1	2
Resp. 7	2/3	2/3	9^7	4	8	9	9	9	2/3	6/11	2	2/3	2/3	2	2/3	2/3	2	2/3	2/3	2/3	8	2/3	6	4/5	2/3	6
SCENARIO B	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
Resp. 1	2/3	4/5	4/5	4/5	0	2/3	9/12	4/5	9/12	8/13	8/13	8/13	2/3	2/3	8/13	2/3	2/3	6/11	9/12	1	2/3	2/3	9/12	4/5	2/3	8/13
Resp. 2		4/5	4/5	4/5	1	1	1	4/5	4/5	2/3	8	2/3	2/3	2/3	7	2/3	2/3	2/3	6	6	2/3	2/3	6	4/5	1	2/3
Resp. 3		4	7	4	6	4	6	7	2/3	2/3	8	6/11	6/11	6	1	2/3	2/3	3	2/3	1	2/3	2/3	2	9|10	2/3	3
Resp. 4	2	9	9	9	8	9	9	1	1	2	8	2	2	2	1	2^8	2	6	2	4	2	2	8	4	2	4
Resp. 5	3	4	4	4	0	8/13	8/13	2/3	2/3	6	8	3	1	2	3	8/13	2/3	1	6	6	6/11	8/13	6/11	6/11	6/11	2
Resp. 6		1	4	4	0	8	7	8	9	6	8	6	2	0	9	2	2	6	2	4	7	2	6	8	1	6
Resp. 7	2/3	2/3	9^7	4	8	9	9	9	2/3	6/11	2/3	2/3	2/3	2	2/3	2/3	2	2/3	0	2/3	8	2/3	6	0	2/3	2

Table 2-7. Sediment Retention group confidence for influences with agreement: NA = No agreement; HH = High evidence, High agreement; HL = High evidence, Low agreement; LH = Low evidence, High agreement; LL = Low evidence, Low agreement

	A	B	C	D	F	G	H	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
CURRENT	HH	HH	HH	HH	NA	NA	NA	HH	HH	HH	HH	HH	NA	HH	HH	HH	NA	NA	HH	HH	NA	NA	NA	HH
SCENARIO A	NA	HH	LH	LH	NA	LL	NA	HH	LL	NA	HH	HH	NA	HH	HH	NA	NA	NA	HH	HH	NA	NA	NA	NA
SCENARIO B	NA	HH	LH	LH	NA	LL	NA	HH	LL	NA	HH	HH	NA	HH	HH	NA	LL	NA	HH	HH	NA	NA	NA	NA

Table 2-8. Sediment Retention group interactive influences with agreement under current conditions and Climate Scenarios A and B: NA = No agreement; HH = High evidence, High agreement; HL = High evidence, Low agreement; LH = Low evidence, High agreement; LL = Low evidence, Low agreement; () = Number of respondents

						CURRENT		CLIMATE A		CLIMATE B	
Interaction	**Variable X**	**on**	**Variable Y**	**with**	**Variable Z**	**Interactive Influence**	**Confidence**	**Interactive Influence**	**Confidence**	**Interactive Influence**	**Confidence**
M+N	Tides	on	Inundation Regime	with	Relative Sea Level	Synergy (3)	NA	NA	NA	NA	NA
P+Z	Tides	on	Sediment Flux	with	Wind / Waves	Synergy (3)	NA	Synergy (3)	NA	Synergy (3)	NA
Q+R	Sediment Flux	on	Net Mineral Accumulation	with	Sediment Size	Synergy (5)	HH (3)	Synergy (3)	NA	Synergy (3)	NA
Q+S	Sediment Flux	on	Net Mineral Accumulation	with	Inundation Regime	Synergy (5)	HH (3)	Synergy (4)	NA	Synergy (4)	NA
R+S	Sediment Size	on	Net Mineral Accumulation	with	Inundation Regime	Synergy (3)	NA	NA	NA	NA	NA

Table 2-9. Community Interactions variable definitions clarified during group discussion

Variable	Definition Agreed Upon by Group
Water management	reservoir management, upstream operations
Restoration	restoration and management of former Bay lands
Land use change	impervious surface, shoreline armoring, freshwater demand, retaining sea level rise accommodation space (land conservation to prevent development)
Freshwater inflow	annual hydrograph from local watersheds and the Delta (includes winter storm frequency and intensity)
Sediment supply	total mass of sediment (physical material coming into the system from local watersheds and the delta)
Landscape mosaic	includes ponds, diked wetlands, seasonal wetlands, muted tidal wetlands and is spatially explicit (metric: amount of energy needed per day; probability of mortality)
Wind/waves	wave power (spring and summer predominant winds, storm events)
Water quality	nutrients, contaminants, salinity
Inundation regime*	tides, bathymetry
Sediment resuspension and deposition	mass of sediment deposited or removed from mudflat
Bed sediment characteristics and quality	grain size, bulk density, chemical contamination
Extent of mudflats (acre hours)	metric: acre hours
Predators and disturbance (anthropogenic)	predators: % shorebird population and numbers taken; Anthropogenic disturbance includes all human activity in or adjacent to system that is affecting it (e.g., hiking, biking, recreational, commercial traffic, clamming)
Shorebird prey community	biomass, energetics
Shorebirds	winter abundance of shorebirds in San Francisco Bay

*** On Day 2, "inundation regime" was split into two variable boxes: "tides and hydrodynamics" and "mudflat bathymetry", with the addition of accompanying arrows. Judgments for these new arrows under current conditions were made before the group proceeded with judgments under the climate scenarios.**

Table 2-10. Community Interactions group influence judgments; columns A-KK represent individual influences (arrows) in the influence diagram and rows represent individual respondents: dark green = agreement on influence type and degree, light green = agreement on type but not degree, gray = no agreement; within columns, green numbers = same (majority) grouping of type (though degree may be different), pink numbers = disagreement about type, red outline = threshold response

CURRENT	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	BB	CC	DD	EE	FF	GG	HH	JJ	KK
Resp. 1	3	3	9	4/5	1	8	1	8	2	1	2/3	1	2	1	1	2/3	2	12	3	0	2/3	2/3	2/3	2/3	2/3	2/3	4/5	2/3	2/3	2/3	2/3	4/5	2/3	2/3		
Resp. 2	2/3	2/3		4	7	3	7	8^9	2	9	2^8	2		6^7	6	8	2		7		2	4	4	6^7	2	2	5	7^4	7^4	2	2	7	8	2	7	3
Resp. 3	4/5	4/5	4	3	2	2	7	7	2/3	4|10	2/3	2/3	2/3	1	6/11	2/3	2/3	2/3	2/3	8/13	8/13	4/5	2/3	4|10	2/3	2/3	4|10	8/13	2/3	6/11	2/3	9/12	2/3^6/11	2/3	6/11	2/3^6/11
Resp. 4	3	3	2	5	3	2	2	3	2	2	2	2		8	6	8	2	2	2	2	2	2	7	7	2		10	8	2	2	2	9	2	2	2	2
Resp. 5	4	4	8	4	6	4	2	4	2/3	1	8	2	8	2	2	8	2	2	2	2/3	2/3			6				2/3	2/3	2/3	2/3	4/5	2/3	7	11	
Resp. 6	2	2	2	9	6	7	7	9	2	8	8				6	2	2		8		2	2	2	7	6		3	3	7|3	6	6	8	2	2	6	
Resp. 7	2	1	8^9	1	6	2	6	2						1	2				2								4	3	5^11	6	2	7	2			
SCENARIO A	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**	**AA**	**BB**	**CC**	**DD**	**EE**	**FF**	**GG**	**HH**	**JJ**	**KK**
Resp. 1	3	3	9	4/5	1	8	1	8	2	1	2/3	1	2	1	6	2/3	2	12	3	0	2/3	2/3	2/3	2/3	2/3	2/3	4/5	2/3	2/3	2/3	2/3	7	2/3	2/3		
Resp. 2	2	3		7	7	7	7	8^9	3	4	2^6	6		6^7	6	8	2		7		2	4	4	6^7	6	2	5	7^4	7^4	2	2	7	2	2	7	3
Resp. 3			9	3	6		7	7	11					1	6/11	2/3	8				7		11	7	2/3					6/11		2		2/3	6/11	6/11
Resp. 4	3	11	2	7	11	7	2	3	2	2	6	2	3	2	6	6	2	2	2		2	2	7	7	2		10	8	2	10	2	7	10	2	11	2
Resp. 5	4	4	8	4	6	4	2	4	2/3	6^7	13^0	8	8	2	2	8	2	2	2	2/3	2/3			6				2/3	2/3	2/3	2/3	4/5	2/3	7	11	
Resp. 6	4	4	2	9	2					4	3^13				3		2		3					7|3	3		12	2^8	2^8	2^6	2	2	2	11	11	
Resp. 7			2		7		10	6		12				2	6				11					7	6		4	11	11	11	11	7	2			
SCENARIO B	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**	**AA**	**BB**	**CC**	**DD**	**EE**	**FF**	**GG**	**HH**	**JJ**	**KK**
Resp. 1	3	3	9	4/5	1	8	1	8	2	1	2/3	1	2	1	6	2/3	2	12	3	0	2/3	2/3	2/3	2/3	2/3	2/3	4/5	2/3	2/3	2/3	2/3	7	2/3	2/3		
Resp. 2	2^6	3|7		7	7	7	7	8^9	7|3	4	2^6	6		6^7	6	6	2		7		2	4	4	6^7	6	2	10	7	7	6	2	7	6	2	7	3
Resp. 3			9	3	6		7	7	11					1	6/11	2/3	8				7		11	7	2/3					6/11		6		2/3	6/11	6/11
Resp. 4	3		2		11		2	3	2	2		2	3	2	6		2	2	2		2	2	7	7	2		10	8	2	10	2	7	10	2		2
Resp. 5	4	4	8	4	6	4	2	4	2/3	6^7	13^0	8	8	2	2	8	2	2	2	2/3	2/3			6				2/3	2/3	2/3	2/3	4/5	2/3	7	11	
Resp. 6	4^7	4^7	2	9	2^6					4	3^13				11		2		3					7	3^11		12^3	2^8	2^8	6	2	2^6	2	11	11	
Resp. 7			2		7		10	6		12				7	6				11					7	2		4	11	11	11	11	7	2			

Table 2-11. Community Interactions group confidence for influences with agreement: NA = No agreement; HH = High evidence, High agreement; HL = High evidence, Low agreement; LH = Low evidence, High agreement; LL = Low evidence, Low agreement

	A	B	C	D	E	F	I	K	L	O	P	Q	S	U	X	Y	AA	BB	CC	DD	EE	FF	GG	HH	JJ
CURRENT	HH	HH	NA	LH	HH	NA	HH	NA	NA	LH	NA	HH	NA	HH	HH	NA	NA	LH	HH	HH	HH	NA	HH	NA	HH
SCENARIO A	HH	NA	NA	NA	NA	NA	NA	NA	NA	LH	NA	NA	NA	HH	HH	HH	NA	NA	NA	HH	HH	LH	NA	NA	HH
SCENARIO B	NA	NA	NA	NA	NA	NA	NA	NA	NA	LH	NA	NA	NA	HH	HH	HH	NA	NA	NA	HH	HH	LH	NA	NA	HH

Table 2-12. Adaptation strategies and associated top pathways for management (see section 3.2 for pathways). SG=Sediment Retention Green pathway; SB=Sediment Retention Blue pathway; SP=Sediment Retention Purple pathway; CG=Community Interactions Green pathway; CB=Community Interactions Blue pathway; CP=Community Interactions Purple pathway

Adaptation Strategies	Pathways
Start restoration soon to achieve functions of mature marshes, including attainment of threshold elevations for organic accumulation, ahead of sea level rise	SG, CG
Plan for the temporal progression of habitats (e.g., by establishing habitats that will thrive under future climate conditions)	SG, CG
Plan for the spatial progression of restoration (e.g., consider impacts of broaching Suisun Marsh levees on downstream estuary restoration efforts)	SG, CG
Maintain adjacent transitional uplands to allow for local marsh migration	CG
Move restoration focus from fringing marshes to where there is available space for multiple habitats	CG
Create mosaics of habitats where there are opportunities for migration upslope	CG
Plan restoration projects to provide connectivity	CG
Sort sites with restoration potential based on where there is flexibility in management	CG
Support resilience by restoring habitat complexity and facilitating high-energy parts of the system such as tides, wind-driven waves, and freshwater flows	SB, SP, CG
Develop policies that encourage removing or preventing barriers to marsh migration and discourage new development on lands where there is restoration potential	CG
Move highways and railroads that are barriers to marsh migration where there is otherwise space for marsh expansion/migration	CG
Preserve habitats that are unlikely to persist under future climate conditions as interim habitats until alternate habitats that serve the same ecosystem functions can be established	CG
Practice integrated water management, including water conservation, as a priority	SG, SP, CB
If it is not possible to make maintaining marsh salinity a top priority for Delta freshwater storage policies, plan for the restoration of tidal wetlands further up the estuary	SG, CG
Develop methods to move sediment into the bay, to keep pace vertically with sea level rise	SB, SP, CB, CP
Develop methods to reduce wave action on the front side of marshes	SB, CB
Adjust policies that prevent coarse sediment from entering the bay (e.g., for streams that don’t support salmonids, change policies to allow an increase in sediment load)	SG, SP, CG
Involve authorities in flood control districts to recouple streams to wetlands	SP, CG
Monitor change at the landscape scale to assess management effectiveness	SB, CG
Develop rapid response plans for catastrophes (e.g., levee breaks), with the political and scientific bases in place to respond properly	SB, CG

Table 3-1. Sediment Retention group crosswalk for comparison of influence type and degree, sensitivity and relative impact for current conditions and climate scenarios. NA = No agreement; Prop = Proportional; Disprop = Disproportional; L = Low sensitivity; I = Intermediate sensitivity; H = High sensitivity; H-trend = No agreement but trending toward high sensitivity; X = High relative impact; ↑ = Increasing relative impact from current; () = Number of respondents; Ranking column orders the influences according to completeness of information

				CURRENT			CLIMATE A			CLIMATE B			
Influence	**Variable X**	**on**	**Variable Y**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Ranking**
N	Relative Sea Level	on	Inundation Regime	Direct Prop (7)	I (7)	X	Direct Prop (5)	I (5)	X [threshold]	Direct Prop (5)	I (5)	X [threshold]	1
Z	Wind / Waves	on	Sediment Flux	Direct Prop (5)	I (5)	X	Direct Prop (4)	I (5)	↑ [threshold]	Direct Prop (4)	I (5)	↑ [threshold]	1
M	Tides	on	Inundation Regime	Direct Prop (4)	I (4)	X	Direct Prop (4)	I (4)	X	Direct Prop (5)	I (5)	X	2
U	Net Organic Accumulation	on	Net Accretion / Erosion	Direct Prop (5)	I (5)	X	Direct Prop (4)	I (4)	↑	Direct Prop (4)	I (4)	↑	2
B	Water Resource Management: Reservoir Management	on	Freshwater Inflow	Inverse Prop (5)	I (6)		Inverse Prop (4)	I (5)	↑	Inverse Prop (4)	I (5)	↑	3
A	Water Resource Management: Delta Outflow	on	Freshwater Inflow	Direct Prop (5)	I (5)		Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		4
C	Water Resource Management: Reservoir Management	on	Sediment Flux	Inverse Prop (5)	I (5)		Inverse Prop (4)	I (4)		Inverse Prop (4)	I (4)		4
D	Water Resource Management: Reservoir Management	on	Sediment Size	Inverse Prop (6)	I (6)		Inverse Prop (6)	I (6)		Inverse Prop (6)	I (6)		4
K	Relative Sea Level	on	Tides	Direct Disprop, weak (5)	L (5)		Direct Disprop, weak (5)	L (5)		Direct Disprop, weak (6)	L (6)		4
L	Freshwater Inflow	on	Sediment Flux	Direct Prop (6)	I (6)		Direct Prop (5)	I (5)		Direct Prop (4)	I (4)		4
P	Tides	on	Sediment Flux	Direct Prop (6)	I (6)		Direct Prop (4)	I (4)		Direct Prop (5)	I (5)		4
Q	Sediment Flux	on	Net Mineral Accumulation	Direct Prop (6)	I (7)		Direct Prop (6)	I (6)		Direct Prop (7)	I (7)		4
V	Net Mineral Accumulation	on	Net Accretion / Erosion	Direct Prop (6)	I (7)		Direct Prop (5)	I (6)		Direct Prop (6)	I (7)		4

				CURRENT			CLIMATE A			CLIMATE B			
Influence	**Variable X**	**on**	**Variable Y**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Ranking**
Y	Net Organic Accumulation	on	Net Mineral Accumulation	Direct Prop (5)	I (5)		Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		4
J	Wind / Waves	on	Sediment Size	Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		Direct (7)	H-trend		5
R	Sediment Size	on	Net Mineral Accumulation	Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		Direct (6)	H-trend		5
G	Water Resource Management: Channelization	on	Sediment Size	Inverse (5)	L (4)		Inverse (5)	L (4)		Inverse (4)	L (4)		6
W	Inundation Regime	on	Wind / Waves	Direct (5)	NA		Direct (6)	H-trend		Direct Disprop, strong (4)	H (4)		6
X	Net Accretion / Erosion	on	Inundation Regime	Inverse (4)	I (4)		Inverse Prop (4)	I (4)		Inverse (4)	NA		6
T	Inundation Regime	on	Net Organic Accumulation	Direct (4)	I (4)	X	NA	H-trend	X	NA	NA	X	7
F	Water Resource Management: Channelization	on	Sediment Flux	Inverse (4)	L (4)		NA	L (4)		NA	L (4)		8
O	Freshwater Inflow	on	Net Organic Accumulation	NA	I (4)	X	Direct (4)	NA	X	NA	NA	X	8
S	Inundation Regime	on	Net Mineral Accumulation	Direct (6)	NA		Direct (6)	NA		Direct (5)	H-trend		8
H	Land Use / Land Cover Change: Impervious Cover	on	Sediment Flux	Inverse (4)	NA		Inverse (4)	NA		Inverse (4)	NA		9
I	Land Use / Land Cover Change: Impervious Cover	on	Sediment Size	NA	I (4)		NA	I (4)		NA	I (4)		9
E	Water Resource Management: Channelization	on	Freshwater Inflow	NA	NA		NA	NA	↑	NA	NA	↑	10

Table 3-2. Community Interactions group crosswalk for comparison of influence type and degree, sensitivity and relative impact for current conditions and climate scenarios. NA = No agreement; Prop = Proportional; Disprop = Disproportional; L = Low sensitivity; I = Intermediate sensitivity; H = High sensitivity; H-trend = No agreement but trending toward high sensitivity; ↑ = Increasing relative impact from current; () = Number of respondents; Ranking column orders the influences according to completeness of information

				CURRENT			CLIMATE A			CLIMATE B			
Influence	**Variable X**	**on**	**Variable Y**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Ranking**
O	Landscape Mosaic	on	Shorebirds	Direct Disprop, strong (4)	H (4)	Primary	Direct Disprop, strong (5)	H (5)	↑	Direct Disprop, strong (6)	H (6)	↑	1
GG	Shorebird Prey Community	on	Shorebirds	Direct Prop (5)	I (6)	Secondary	Direct Prop (5)	I (5)	↑	Direct Prop (4)	I (4)	↑	1
Q	Wind / Waves	on	Sediment Resuspension / Deposition	Direct Prop (6)	I (6)		Direct Prop (5)	I (5)	↑	Direct Prop (5)	I (5)	↑	2
S	Water Quality	on	Shorebird Prey Community	Direct Prop (5)	I (6)		Direct Prop (4)	I (4)	[threshold]	Direct Prop (4)	I (4)	[threshold]	2
DD	Extent of Mudflat	on	Shorebirds	Direct Prop (4)	I (4)	Primary	Direct (6)	H-trend	Primary	Direct Disprop, strong (4)	H (5)	Primary	2
EE	Extent of Mudflat	on	Shorebird Prey Community	Direct Prop (6)	I (6)		Direct Prop (5)	I (5)	↑	Direct Prop (5)	I (5)	↑	2
U	Tides and Hydrodynamics	on	Sediment Resuspension / Deposition	Direct Prop (5)	I (5)		Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		3
Y	Sediment Resuspension / Deposition	on	Extent of Mudflat	Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		3
FF	Predators and Disturbance	on	Shorebirds	Inverse (6)	NA	Secondary	Inverse Disprop, strong (4)	H (4)	↑	Inverse Disprop, strong (4)	H (5)	↑	3
HH	Sediment Resuspension / Deposition	on	Mudflat Bathymetry	Direct Prop (5)	I (5)		Direct Prop (4)	I (4)		Direct Prop (4)	I (4)		3
BB	Bed Sediment Characteristics	on	Shorebirds	Direct Prop (4)	I (4)	Tertiary	Direct (5)	NA	[threshold]	Direct (5)	H-trend	[threshold]	4

				CURRENT			CLIMATE A			CLIMATE B			
Influence	**Variable X**	**on**	**Variable Y**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Ranking**
E	Restoration	on	Landscape Mosaic	Direct (5)	H (4)		Direct (4)	H (5)	↑	Direct (4)	H (5)	↑	5
I	Freshwater Inflow	on	Sediment Supply	Direct Prop (6)	I (6)		Direct Prop (4)	I (4)		Direct (4)	NA		5
X	Tides and Hydrodynamics	on	Extent of Mudflat	NA	H (4)		Inverse Disprop, strong (4)	H (5)		Inverse Disprop, strong (4)	H (6)		5
AA	Extent of Mudflat	on	Predators and Disturbance	Inverse Prop (4)	I (4)		Inverse (5)	NA	↑	Inverse (4)	H-trend	↑	5
D	Restoration	on	Sediment Supply	Inverse Prop (4)	I (5)		Inverse (5)	H-trend		Inverse (4)	NA		6
CC	Bed Sediment Characteristics	on	Shorebird Prey Community	Direct Prop (5)	I (4)		Direct (5)	H-trend		Direct (5)	NA		6
JJ	Mudflat Bathymetry	on	Extent of Mudflat	Direct (4)	H (4)		Direct Disprop, strong (4)	H (5)		NA	H (4)		6
A	Water Management	on	Freshwater Inflow	Direct Prop (5)	I (7)		NA	I (5)		NA	H-trend		7
B	Water Management	on	Sediment Supply	Direct Prop (4)	I (6)		NA	I (4)		NA	H-trend		7
K	Freshwater Inflow	on	Tides and Hydrodynamics	Direct (6)	NA		Direct (5)	NA	↑ [threshold]	Direct (4)	NA	↑ [threshold]	7
F	Land Use Change	on	Sediment Supply	Direct Prop (4)	I (5)		NA	H-trend		NA	NA		8
G	Land Use Change	on	Landscape Mosaic	NA	H (4)		NA	H-trend		NA	H-trend		9
L	Sediment Supply	on	Sediment Resuspension / Deposition	Direct Prop (4)	I (4)		NA	NA		NA	NA		9
P	Wind / Waves	on	Tides and Hydrodynamics	Direct (6)	NA		Direct (5)	NA		Direct (4)	NA		9
W	Sediment Resuspension / Deposition	on	Bed Sediment Characteristics	NA	I (4)		NA	H-trend		NA	H-trend		9
C	Restoration	on	Tides and Hydrodynamics	NA	NA		Direct (4)	NA		Direct (4)	NA		10

				CURRENT			CLIMATE A			CLIMATE B			
Influence	**Variable X**	**on**	**Variable Y**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Influence**	**Sensitivity**	**Relative Impact**	**Ranking**
N	Landscape Mosaic	on	Predators and Disturbance	NA	NA		NA	H-trend		NA	H-trend		10
V	Bed Sediment Characteristics	on	Sediment Resuspension / Deposition	NA	I (5)		NA	NA		NA	NA		11
H	Land Use Change	on	Water Quality	NA	NA		NA	NA		NA	NA		12
J	Freshwater Inflow	on	Water Quality	NA	NA		NA	NA		NA	NA		12
M	Sediment Supply	on	Bed Sediment Characteristics	NA	NA		NA	NA		NA	NA		12
R	Water Quality	on	Bed Sediment Characteristics	NA	NA		NA	NA		NA	NA		12
T	Sediment Resuspension / Deposition	on	Tides and Hydrodynamics	NA	NA		NA	NA		NA	NA		12
Z	Extent of Mudflat	on	Sediment Resuspension / Deposition	NA	NA		NA	NA		NA	NA		12
KK	Mudflat Bathymetry	on	Sediment Resuspension / Deposition	NA	NA		NA	NA		NA	NA		12

Table B-1. Sediment Retention breakout group participants, affiliations, and qualifications

Name	Affiliation	Qualifications
Dave Cacchione	U.S. Geological Survey	Emeritus oceanographer for USGS. Research on sediment transport, ocean-bottom boundary layers, erosion, wave effects in San Francisco Bay area. Expertise in sediment processes and wave impacts on coastal areas.
John Callaway	University of California, San Francisco	Research on wetland ecology and restoration in San Francisco Bay. Expertise in wetland restoration, wetland plant ecology, and sediment dynamics.
Chris Enright	California Department of Water Resources	Chief Water Resources Engineer for Suisun Marsh Branch of California Department of Water Resources. Expertise in water resources planning, management, and sediment dynamics.
Bruce Jaffe	U.S. Geological Survey	Research on historical sedimentation and geomorphic evolution of the San Francisco Estuary. Expertise in sediment transport.
Lester McKee	San Francisco Estuary Institute	Research on transport, transformation, and loadings of sediments, nutrients and contaminants in San Francisco Bay area watersheds. Expertise in sediment transport, hydrology, and nutrients.
Dave Schoellhamer	U.S. Geological Survey	Research on suspended-sediment transport in San Francisco Bay and Delta. Expertise in estuarine physics, sediment transport, and hydrology.
Mark Stacey	University of California, Berkeley	Research on transport and mixing in estuarine and coastal environments. Expertise in sediment transport and environmental fluid mechanics.

Table B-2. Community Interactions breakout group participants, affiliations, and qualifications

Name	Affiliation	Qualifications
Letitia Grenier	San Francisco Estuary Institute	Research on tidal marsh food web structure, song sparrow fitness and behavior, monitoring of biota in the South Bay Salt Ponds. Expertise in tidal marsh ecology.
Jessica (Jessie) Lacy	U.S. Geological Survey	Research on interaction between aquatic vegetation and hydrodynamics. Expertise in sediment transport, estuarine hydrodynamics, and aquatic ecosystems.
Michelle Orr	Philip Williams & Associates	Water resources engineer involved with coastal marsh geomorphology, hydraulic and sediment transport modeling, and tidal channel dynamics. Expertise in wetland restoration planning and design.
Diana Stralberg	Point Reyes Bird Observatory Conservation Science	Research on modeling avian distributional responses to climate, vegetation, and land use patterns. Expertise in landscape ecology and avian species.
Stuart Siegel	Wetlands and Water Resources	Consulting on wetlands technical and regulatory issues in the San Francisco Bay area. Expertise in wetland and aquatic ecology, wetland restoration and management.
Lynne Trulio	San Jose State University	Research on tidal salt marsh restoration and wildlife management in the San Francisco Bay. Expertise in tidal marsh ecology and restoration.
Isa Woo	U.S. Geological Survey	Research on tidal marsh foodwebs, trophic interactions, and wetland restoration. Expertise in wetland restoration and management.

Table B-3. Example of expert elicitation handout for influences under current conditions (Sediment Retention group)

Instructions: Please assess the effect of X on Y by selecting the appropriate "degree of influence" and its associated "confidence".

	Current Conditions					
	Variable X		**Variable Y**	**Degree of influence (Please select 0-13)**	**Confidence (LH, LL, HH, HL)**	**Notes**
Relationship A	Water Resource Management: Delta Outflow	on	Freshwater Inflow			
Relationship B	Water Resource Management: Reservoir Management	on	Freshwater Inflow			
Relationship C	Water Resource Management: Reservoir Management	on	Sediment Flux			
Relationship D	Water Resource Management: Reservoir Management	on	Sediment Size			
Relationship E	Water Resource Management: Channelization	on	Freshwater Inflow			
Relationship F	Water Resource Management: Channelization	on	Sediment Flux			
Relationship G	Water Resource Management: Channelization	on	Sediment Size			

Table B-4. Example of expert elicitation handout for influences under climate scenarios (Community Interactions group)

Instructions: Please assess the effect of X on Y by selecting the appropriate "degree of influence" and its associated "confidence".

				Climate Scenario A		**Climate Scenario B**		
	Variable X		**Variable Y**	**Degree of influence (Please select 0-13)**	**Confidence (LH, LL, HH, HL)**	**Degree of influence (Please select 0-13)**	**Confidence (LH, LL, HH, HL)**	**Notes**
Relationship A	Water Management	on	Freshwater Inflow					
Relationship B	Water Management	on	Sediment Supply					
Relationship C	Restoration	on	Tides and Hydrodynamics					
Relationship D	Restoration	on	Sediment Supply					
Relationship E	Restoration	on	Landscape Mosaic					
Relationship F	Land Use Change	on	Sediment Supply					
Relationship G	Land Use Change	on	Landscape Mosaic					

Table B-5. Example of expert elicitation handout for interactive influences under climate scenarios (Sediment Retention group)

Instructions: Please assess the effect of X on Y with Z by selecting the appropriate "interactive influence" and its associated "confidence".

						Climate Scenario A		**Climate Scenario B**		
	Variable X	**on**	**Variable Y**	**with**	**Variable Z**	**Interactive Influence**	**Confidence (LH, LL, HH, HL)**	**Interactive Influence**	**Confidence (LH, LL, HH, HL)**	**Notes**
Example 1: Relationship A+B	*Water Resource Management: Delta Outflow*	*on*	*Freshwater Inflow*	*with*	*Water Resource Management: Reservoir Management*					
Example 2: Relationship Q+R	*Sediment Flux*	*on*	*Net Mineral Accumulation*	*with*	*Sediment Size*					

Figure ES-1. Selected ecosystem processes for the pilot vulnerability assessment.

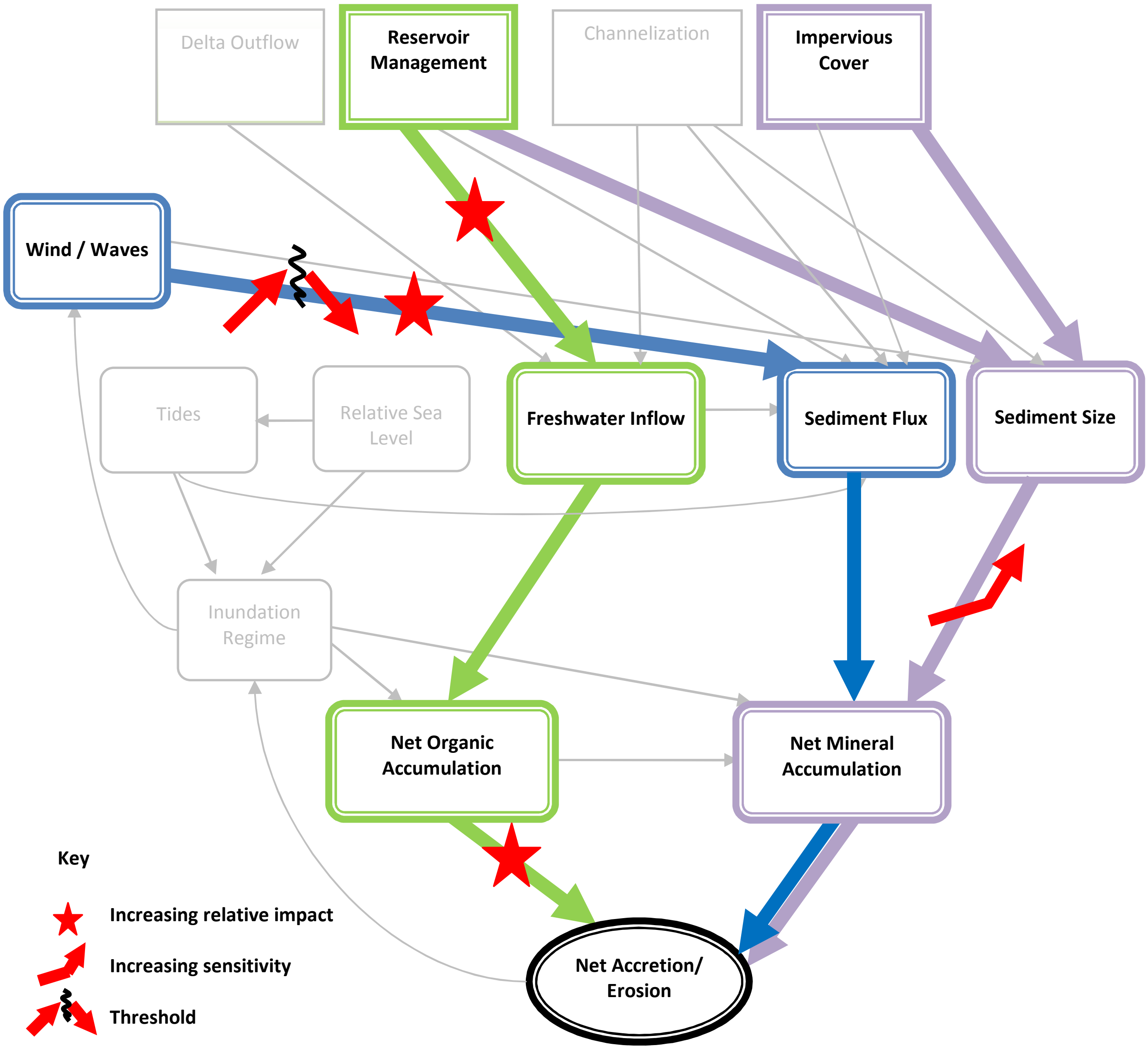


Figure ES-2. Top pathways for management of the Net Accretion/Erosion endpoint. Colors are used to distinguish different pathways. Red symbols highlight potential changes under future climate conditions.

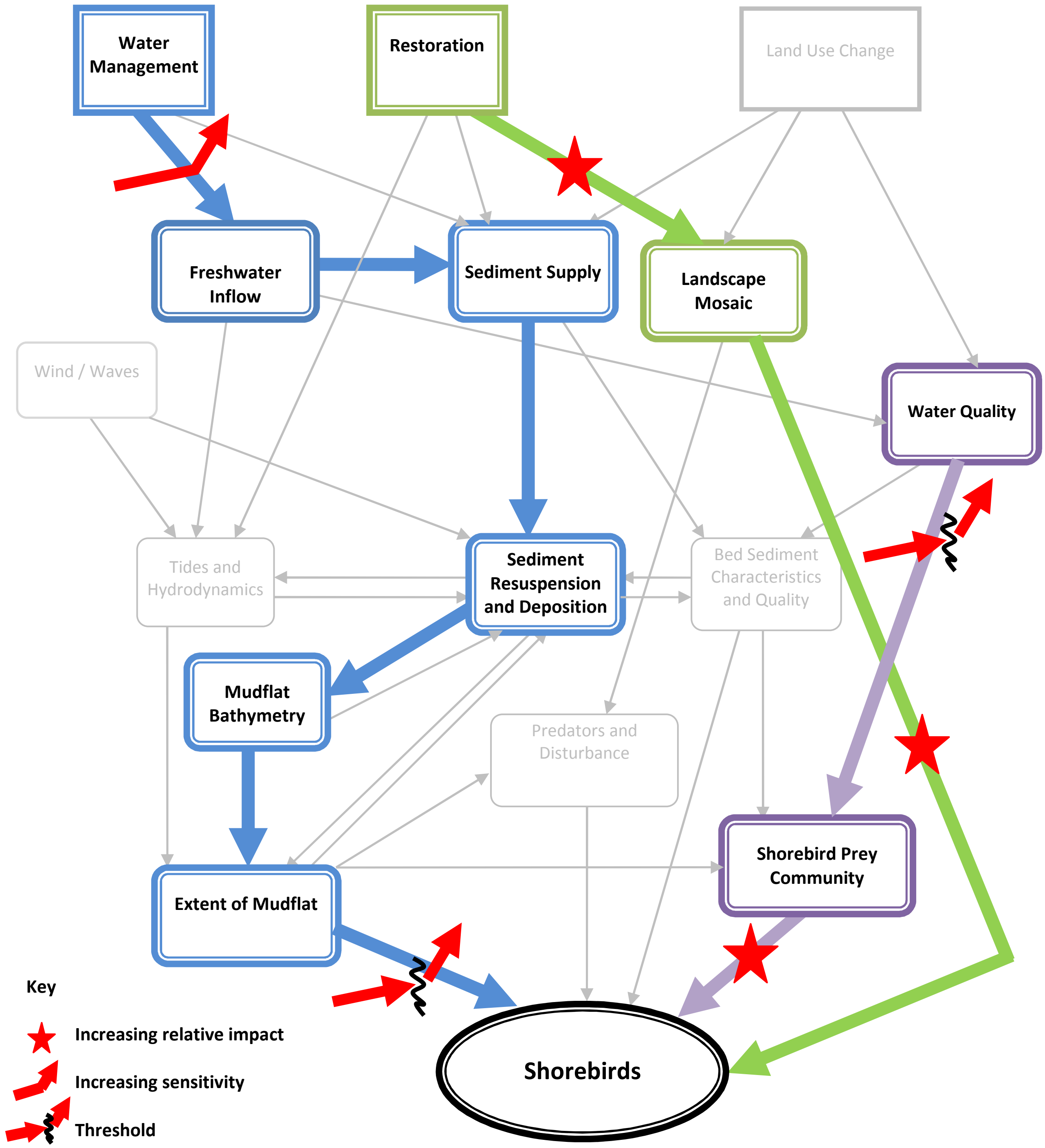
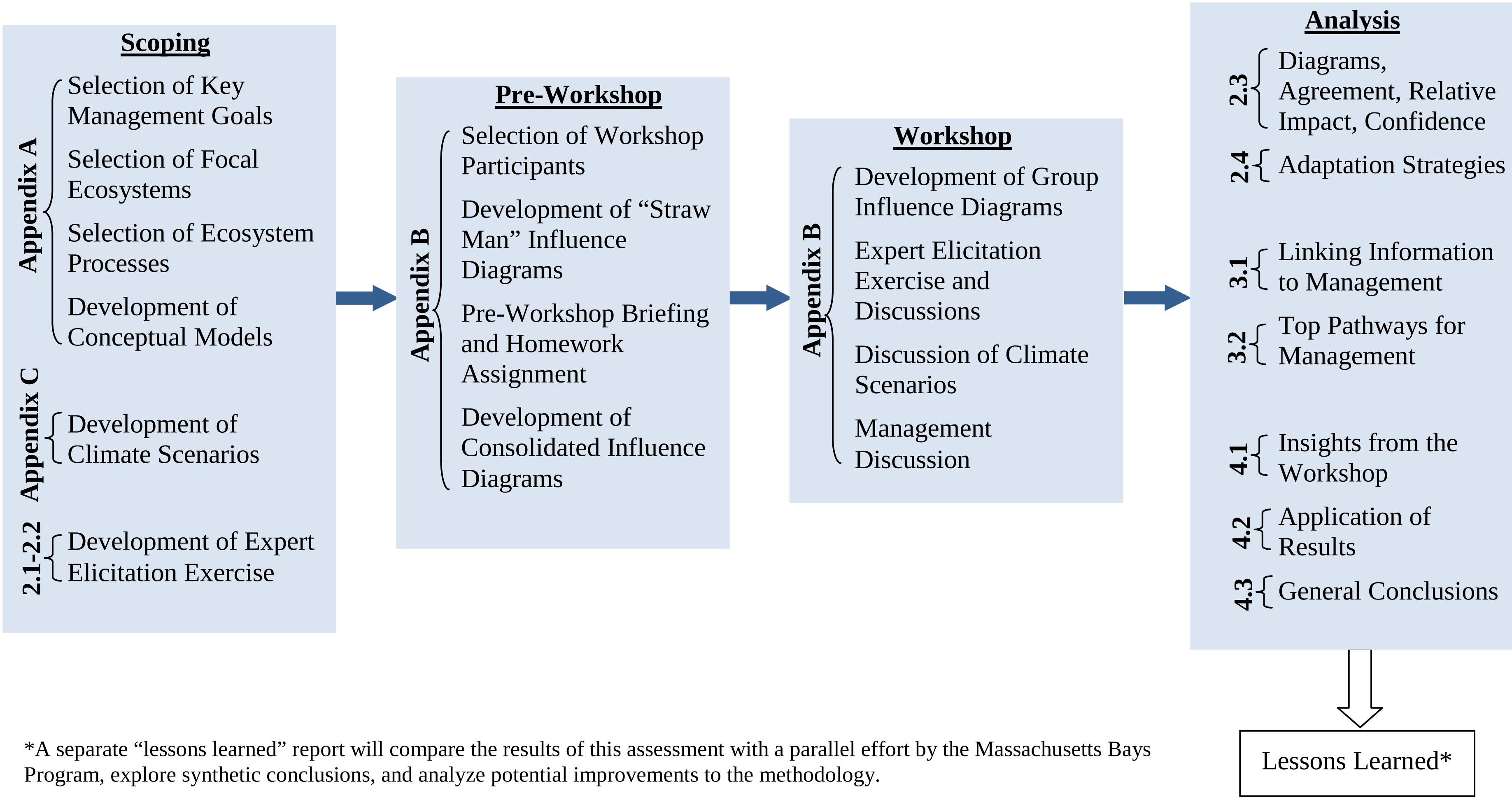


Figure ES-3. Top pathways for management of the Shorebirds endpoint. Colors are used to distinguish different pathways. Red symbols highlight potential changes under future climate conditions.



*A separate "lessons learned" report will compare the results of this assessment with a parallel effort by the Massachusetts Bays Program, explore synthetic conclusions, and analyze potential improvements to the methodology.

Figure 1-1. Vulnerability assessment process.

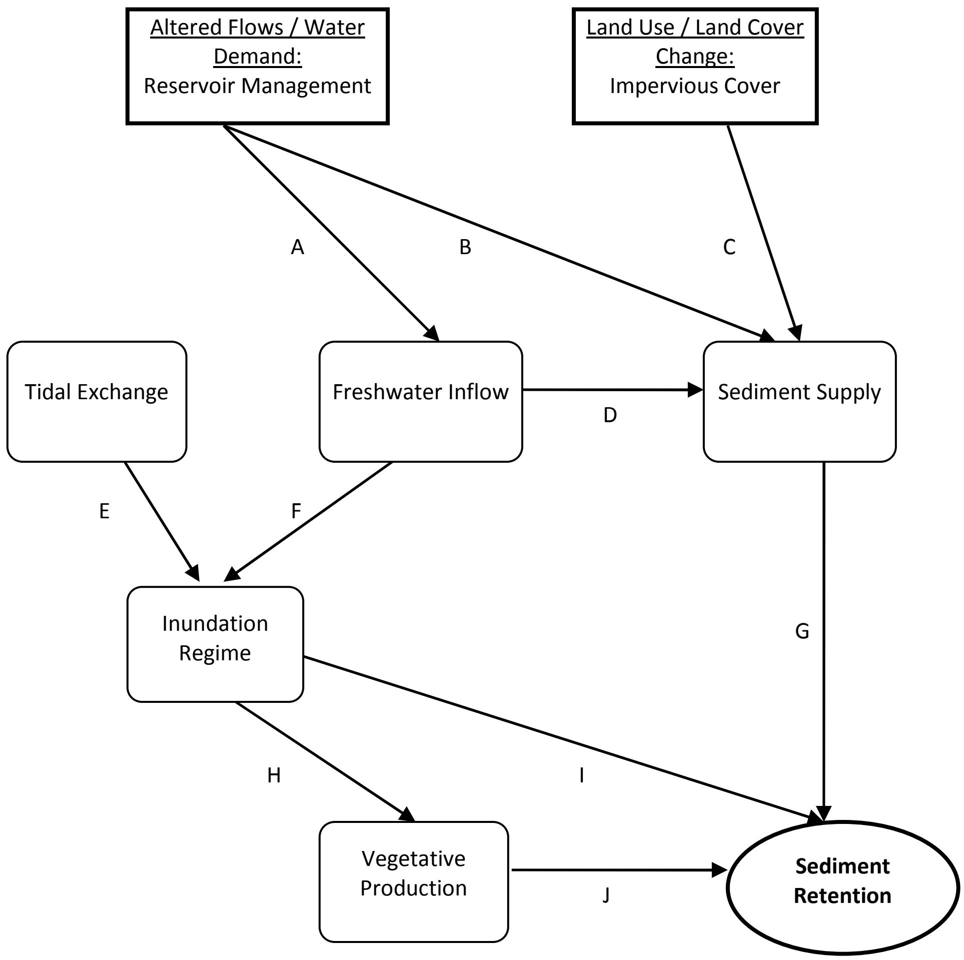


Figure 2-1. Simplified influence diagram for sediment retention.

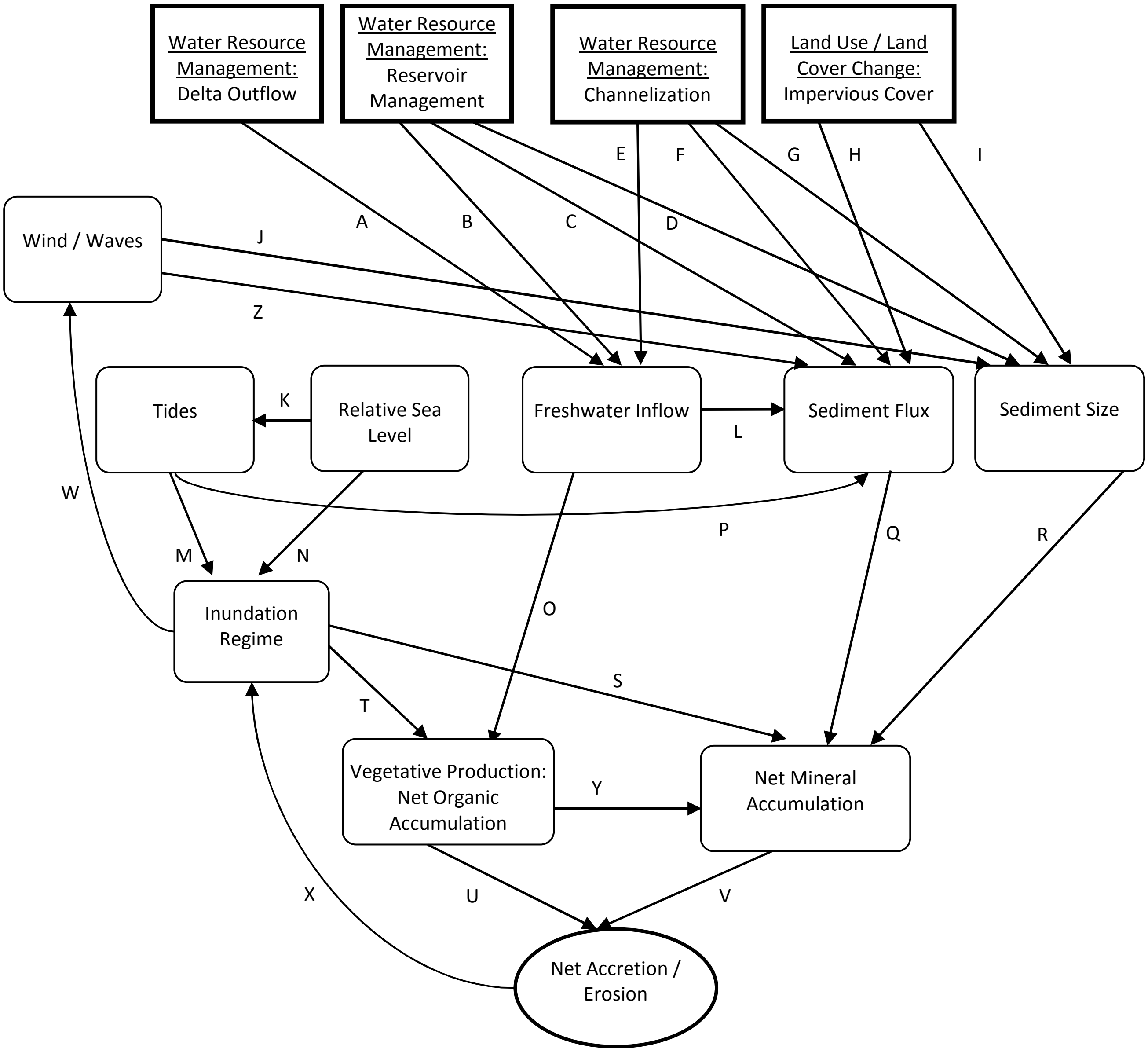


Figure 2-2. Sediment Retention group influence diagram.

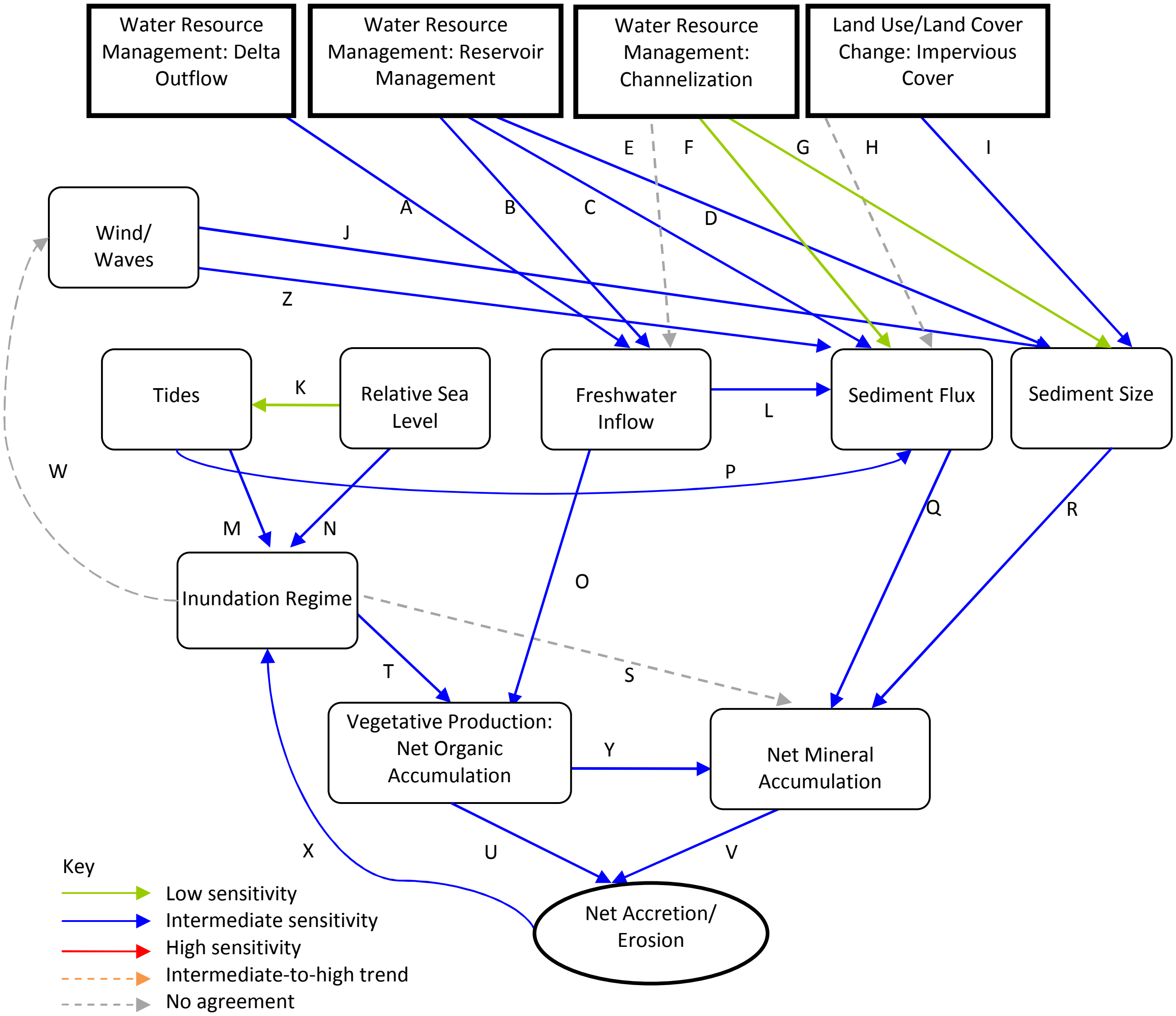


Figure 2-3. Sediment Retention group summary influence diagram of sensitivities under current conditions.

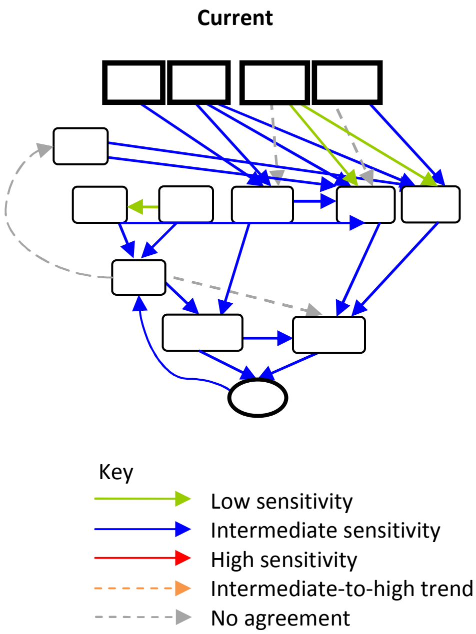


Figure 2-4. Sediment Retention group summary influence diagrams of sensitivities: variance across current conditions and two climate scenarios.

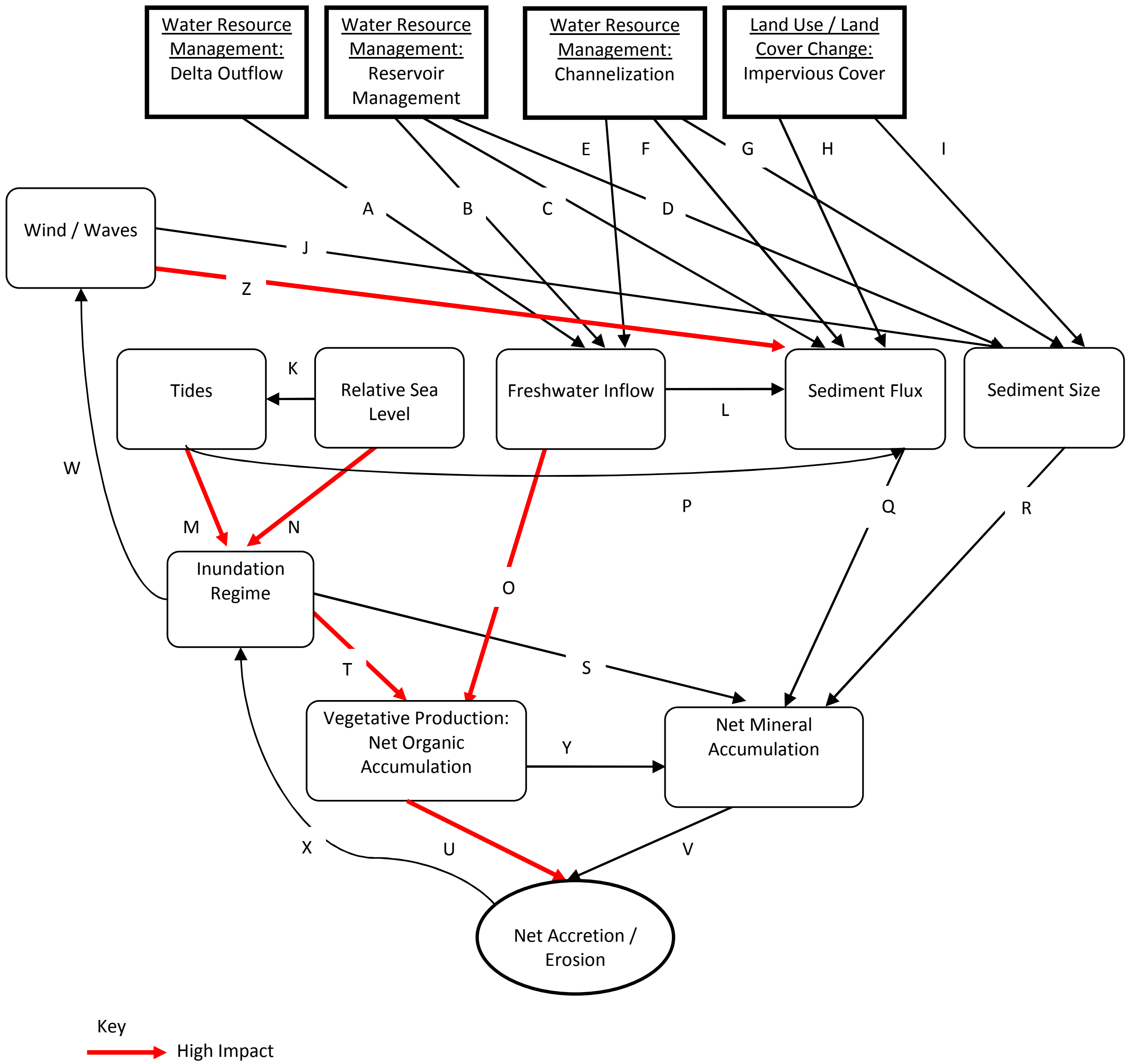


Figure 2-5. Sediment Retention influences indicated as having high *relative impact* under current conditions.

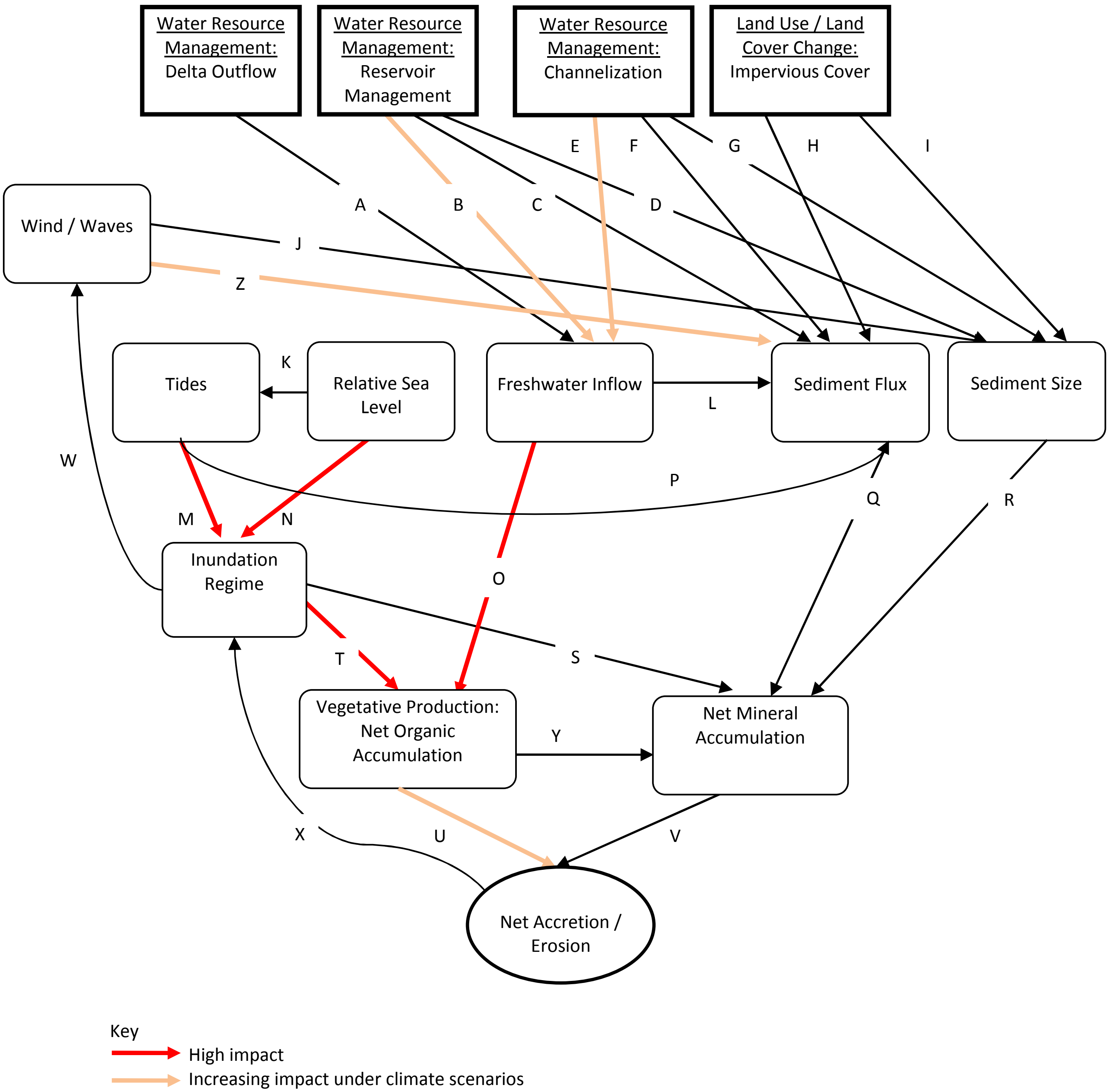


Figure 2-6. Sediment Retention group influences indicated as having high *relative impact* under climate scenarios.

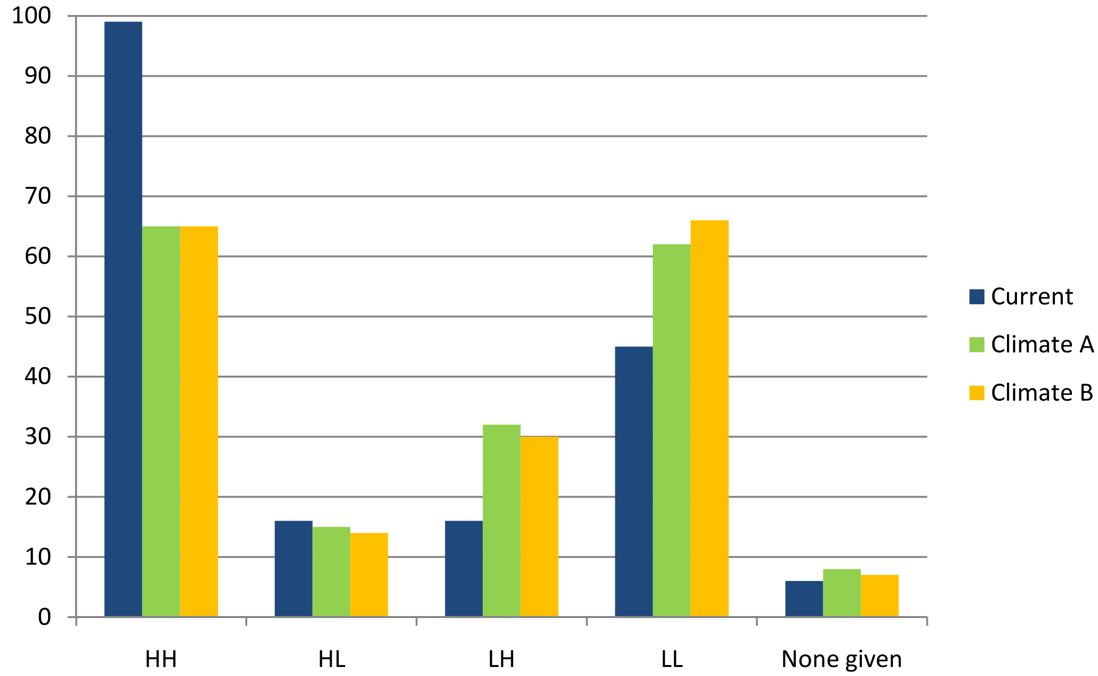


Figure 2-7. Sediment Retention group confidence results for all influences; HH = High evidence, High agreement; HL = High evidence, Low agreement; LH = Low evidence, High agreement; LL = Low evidence, Low agreement.

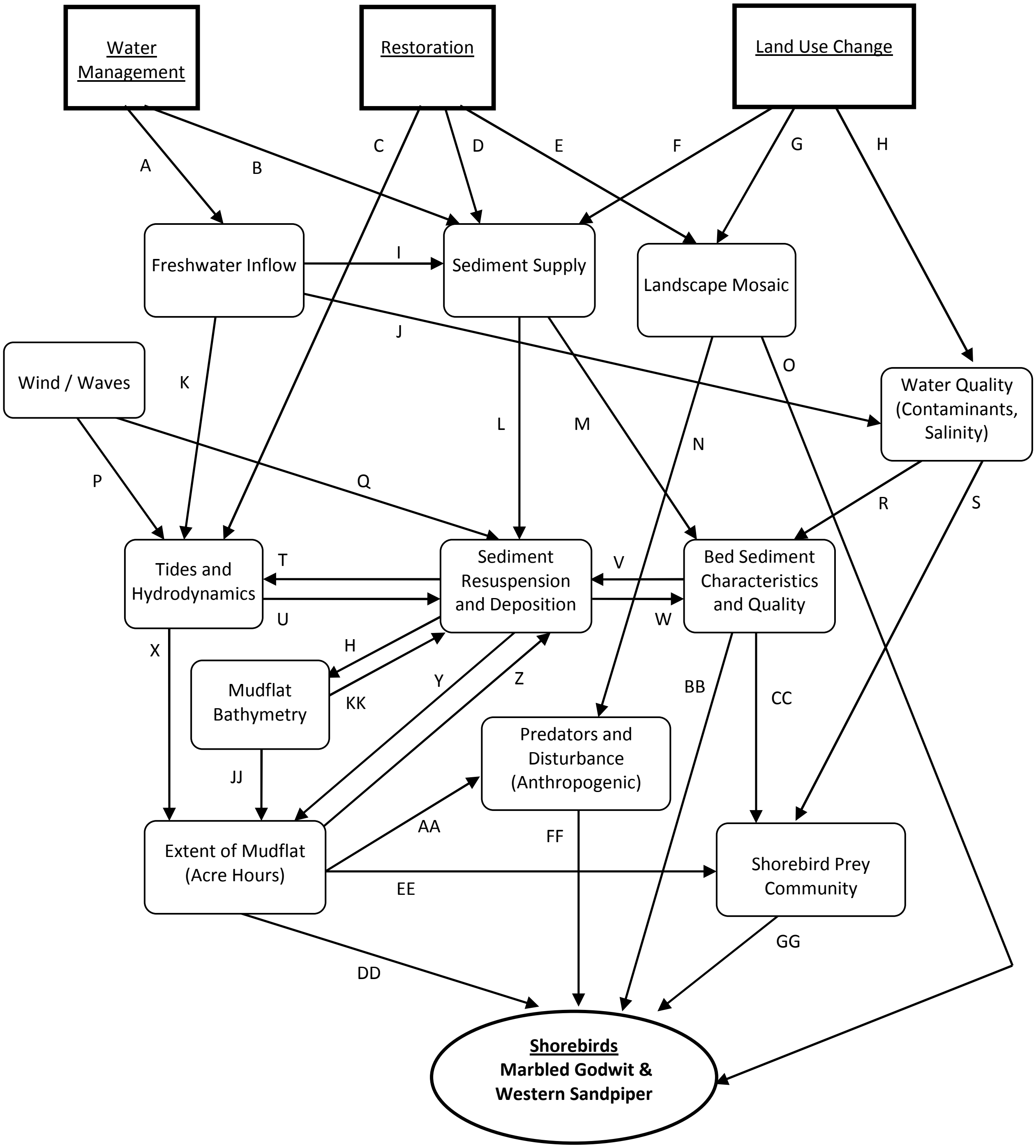


Figure 2-8. Community Interactions group influence diagram.

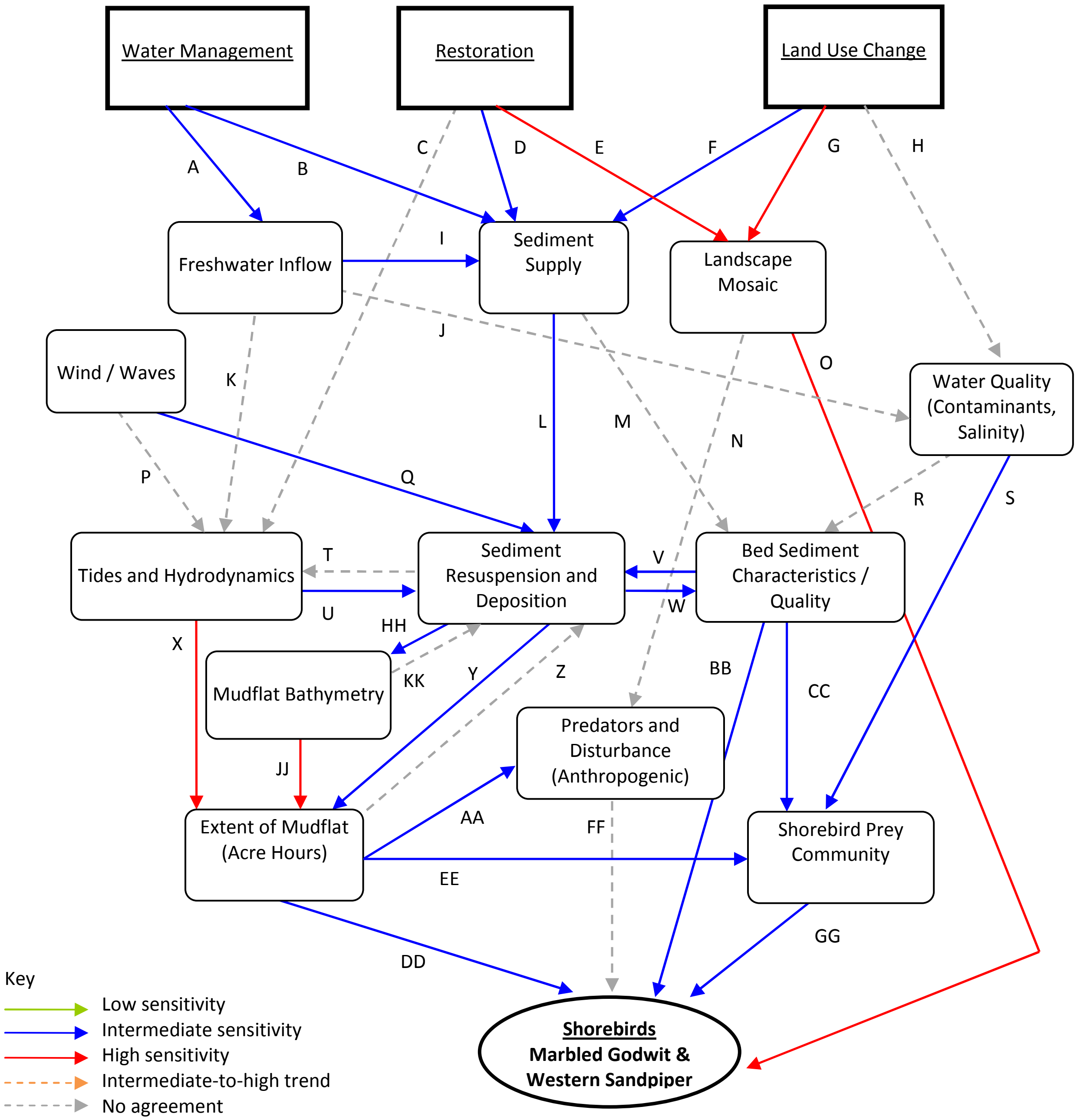


Figure 2-9. Community Interactions group summary influence diagram of sensitivities under current conditions.

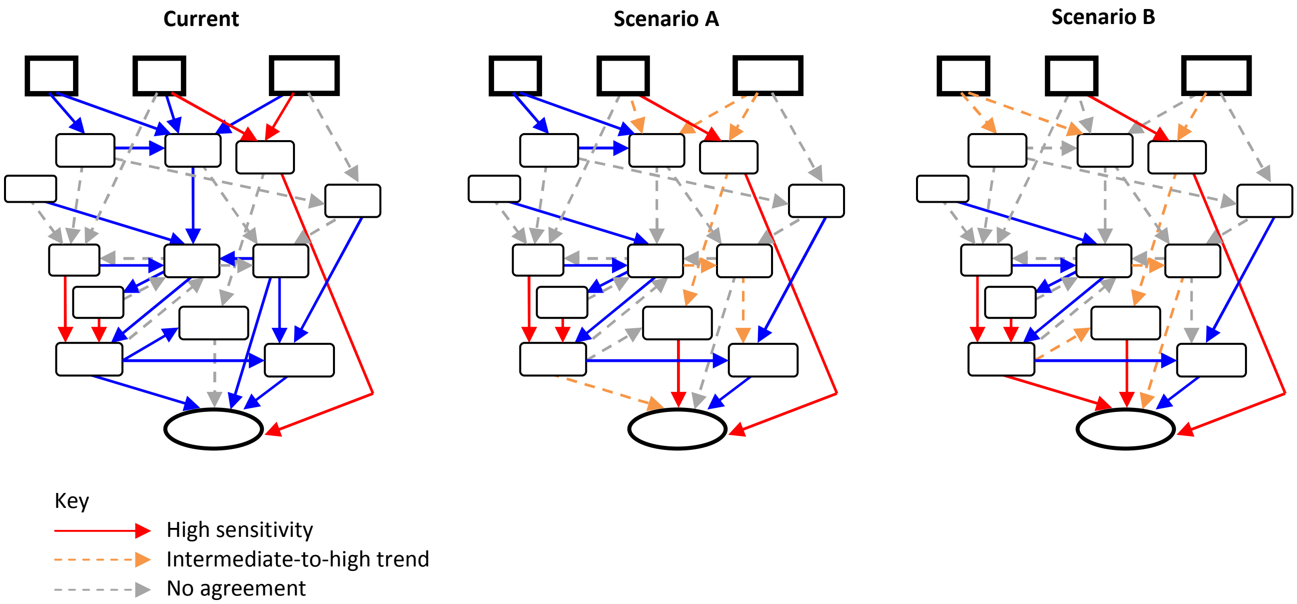


Figure 2-10. Community Interactions group summary influence diagrams of sensitivities: variance across current conditions and two climate scenarios.

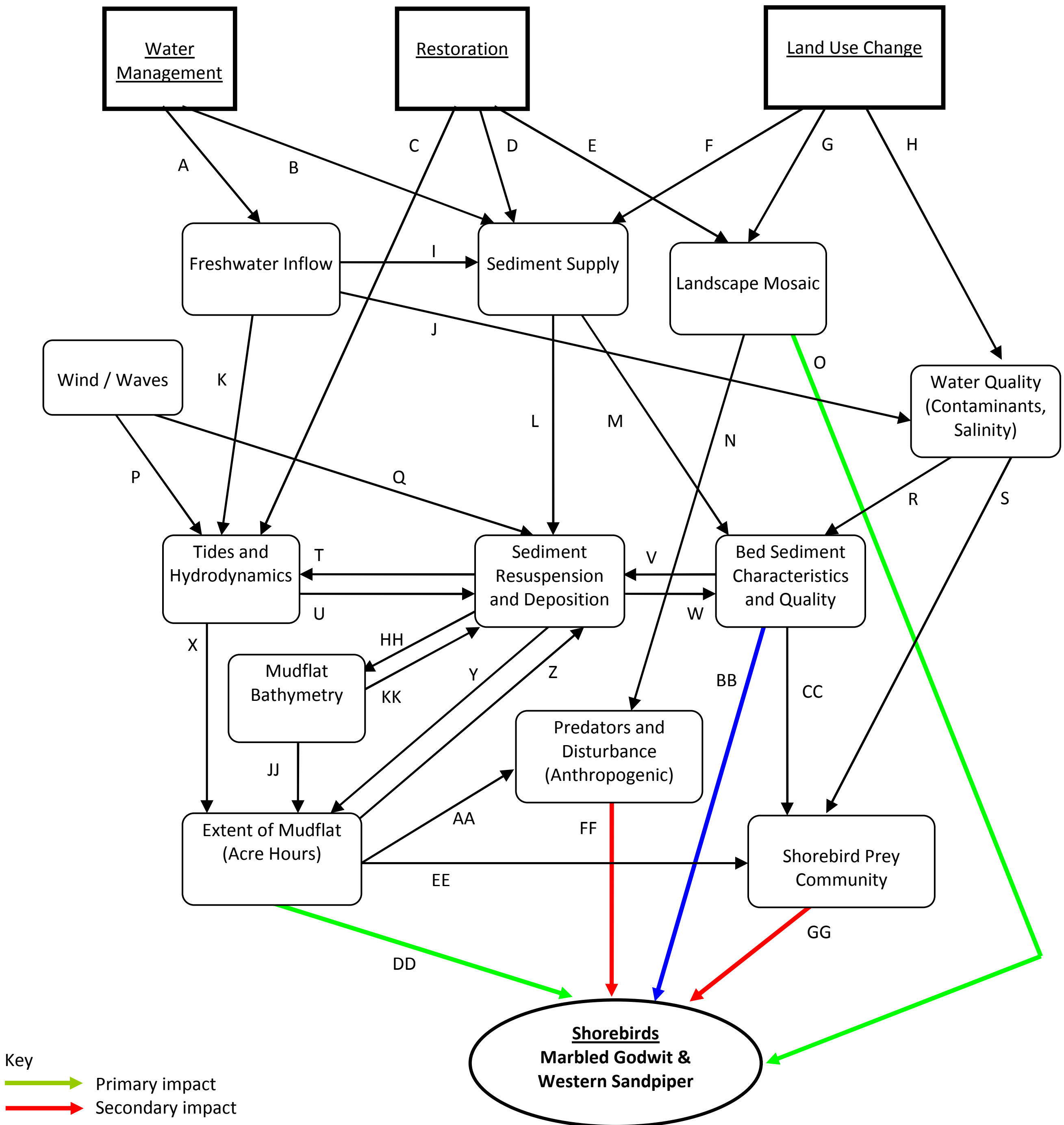


Figure 2-11. Community Interactions influences indicated as having high *relative impact* under current conditions.

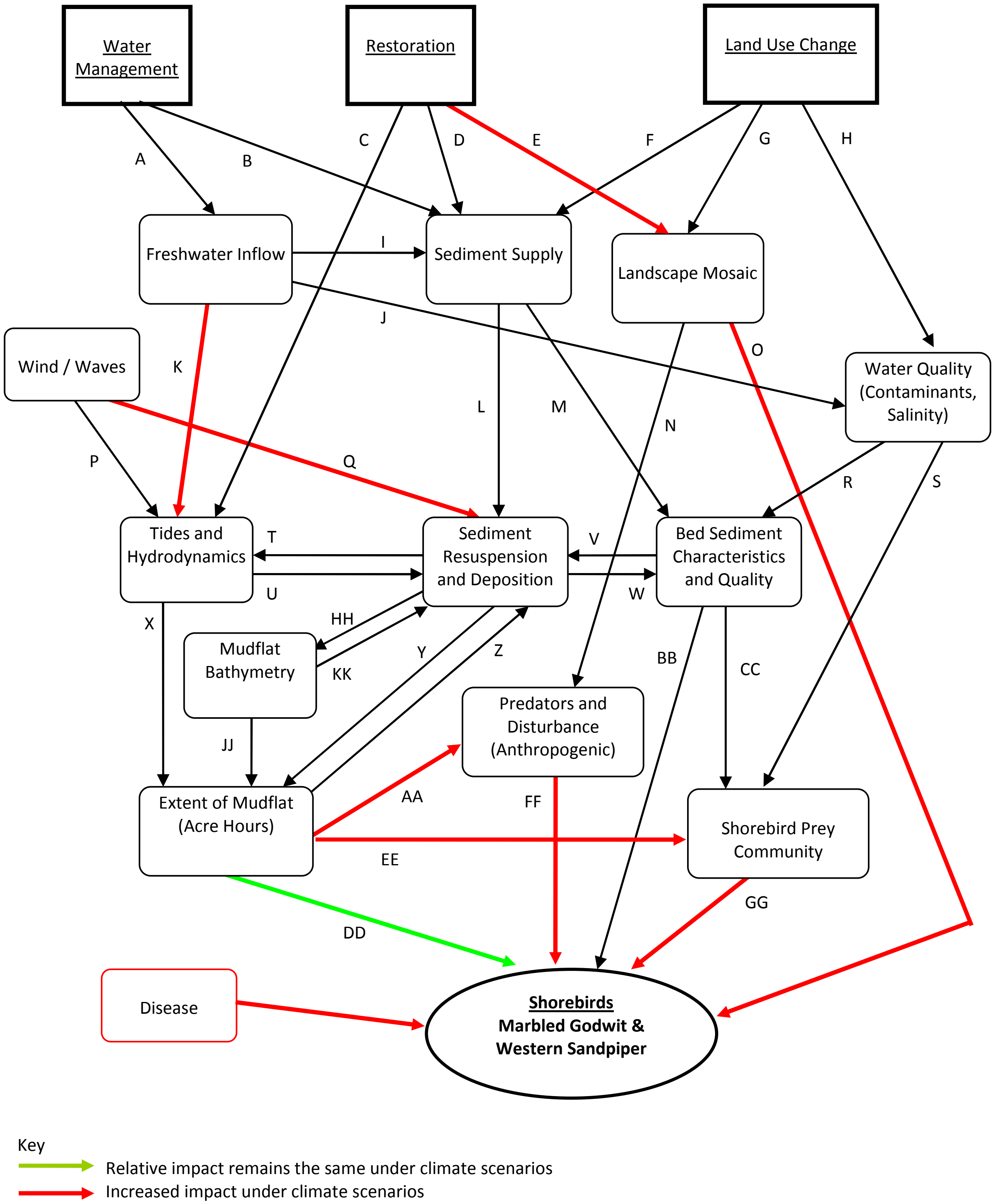


Figure 2-12. Community Interactions group influences indicated as having high *relative impact* under climate scenarios.

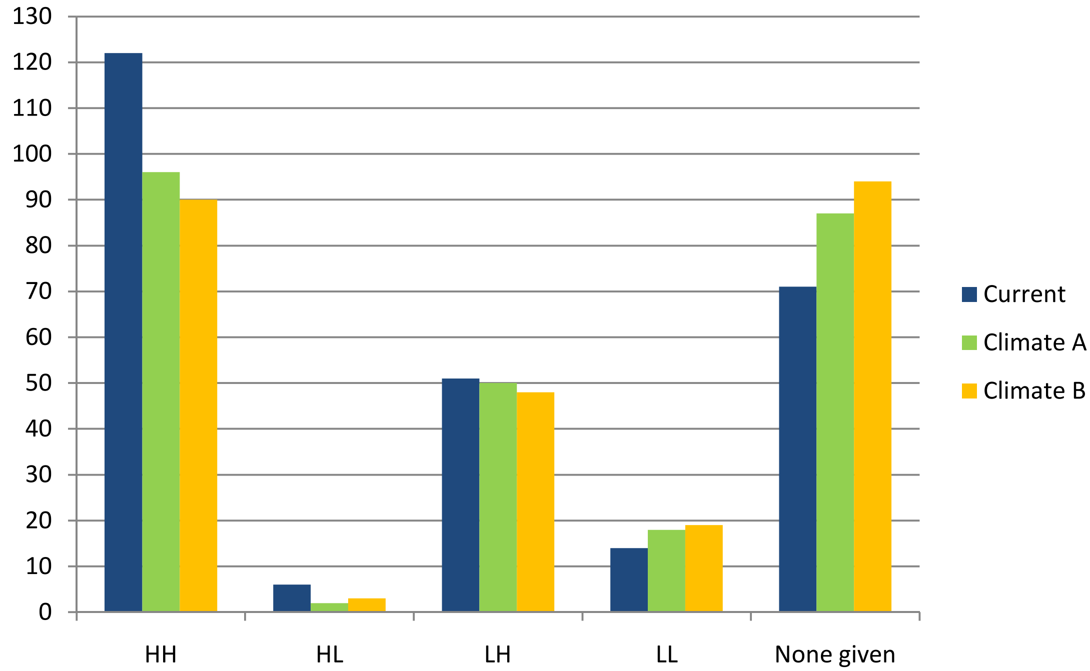


Figure 2-13. Community Interactions group confidence results for all influences; HH = High evidence, High agreement; HL = High evidence, Low agreement; LH = Low evidence, High agreement; LL = Low evidence, Low agreement.

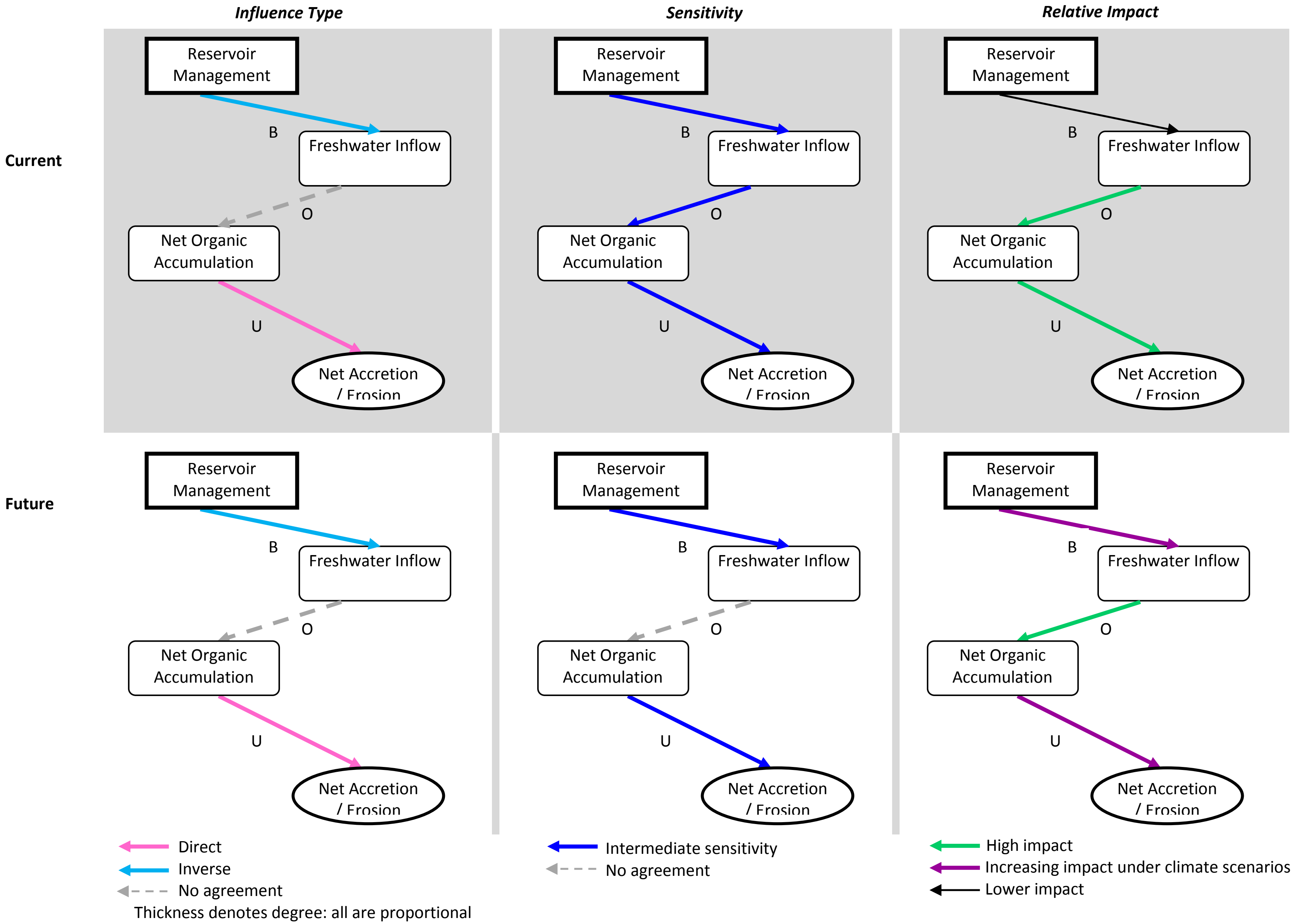


Figure 3-1. Sediment Retention example pathway. Future = Climate Scenario B.

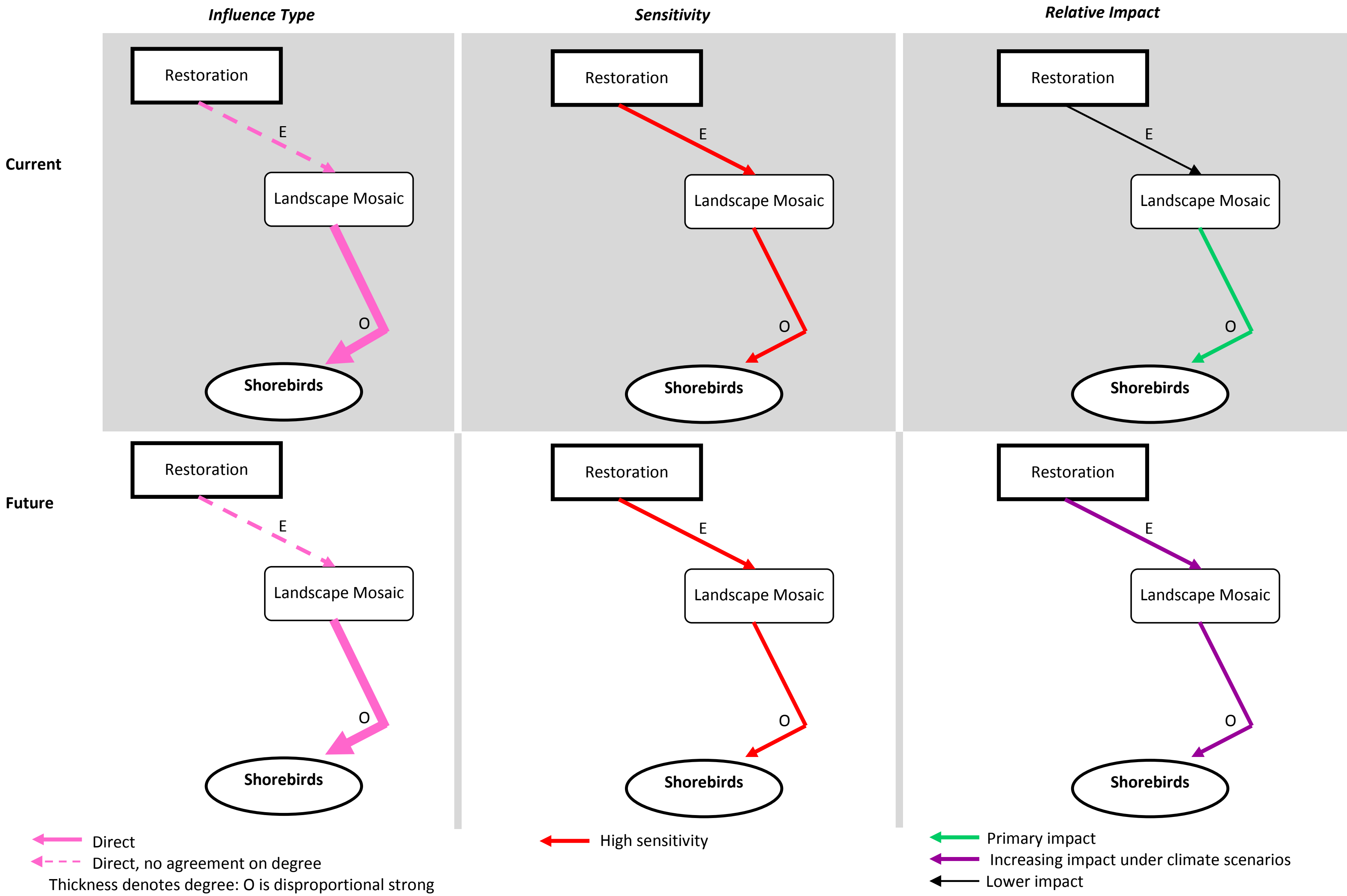


Figure 3-2. Community Interactions example pathway. Future = Climate Scenario B.

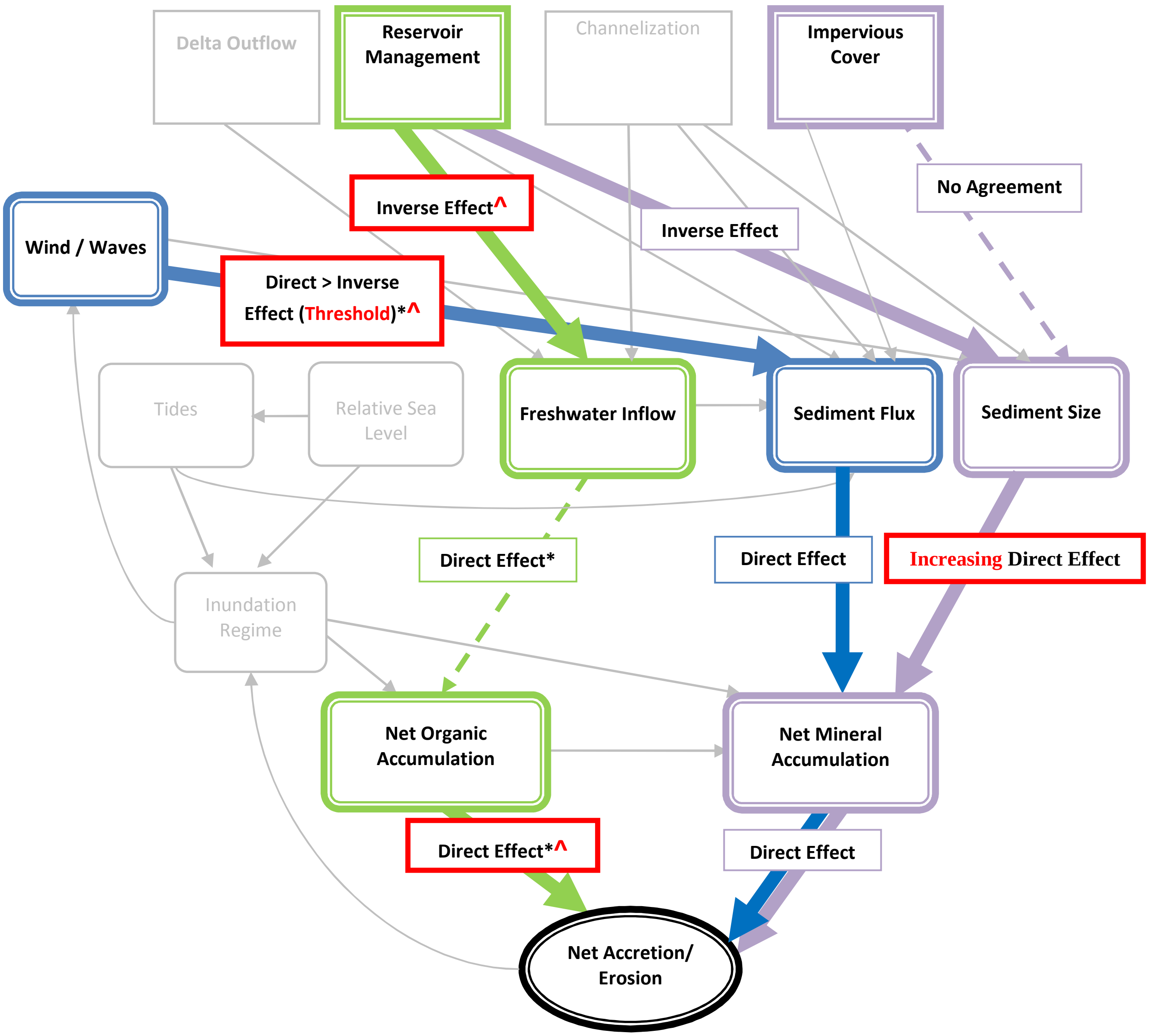


Figure 3-3. Top pathways for management of the Net Accretion/Erosion endpoint. Blue, green and purple colors are used to distinguish different pathways. Red boxes highlight changes under future climate conditions. * indicates high relative impact under current conditions. ^ indicates increasing relative impact under future conditions. A direct to inverse threshold occurs where there is a direct effect under current conditions that may shift to an inverse effect under future climate conditions. Dashed lines indicate inconsistent agreement across scenarios.

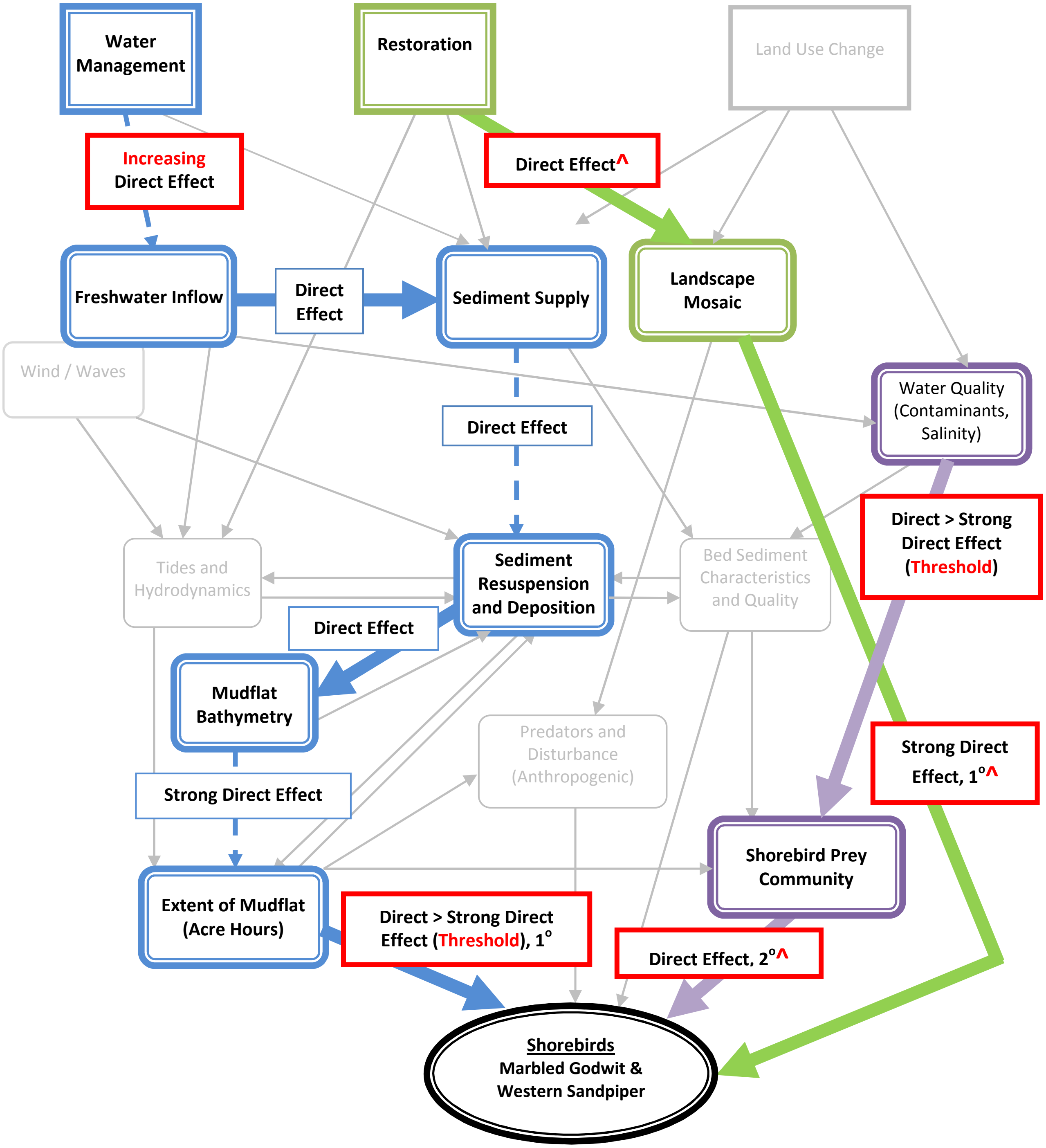


Figure 3-4. Top pathways for management of the Shorebirds endpoint. Blue, green and purple colors are used to distinguish different pathways. Red boxes highlight changes under future climate conditions. 1° and 2° indicate primary and secondary relative impact under current conditions, respectively. ^ indicates increasing relative impact under future conditions. A direct to strong direct threshold occurs where there is a direct effect under current conditions that may shift to a very strong direct effect under future climate conditions. Dashed lines indicate inconsistent agreement across scenarios.

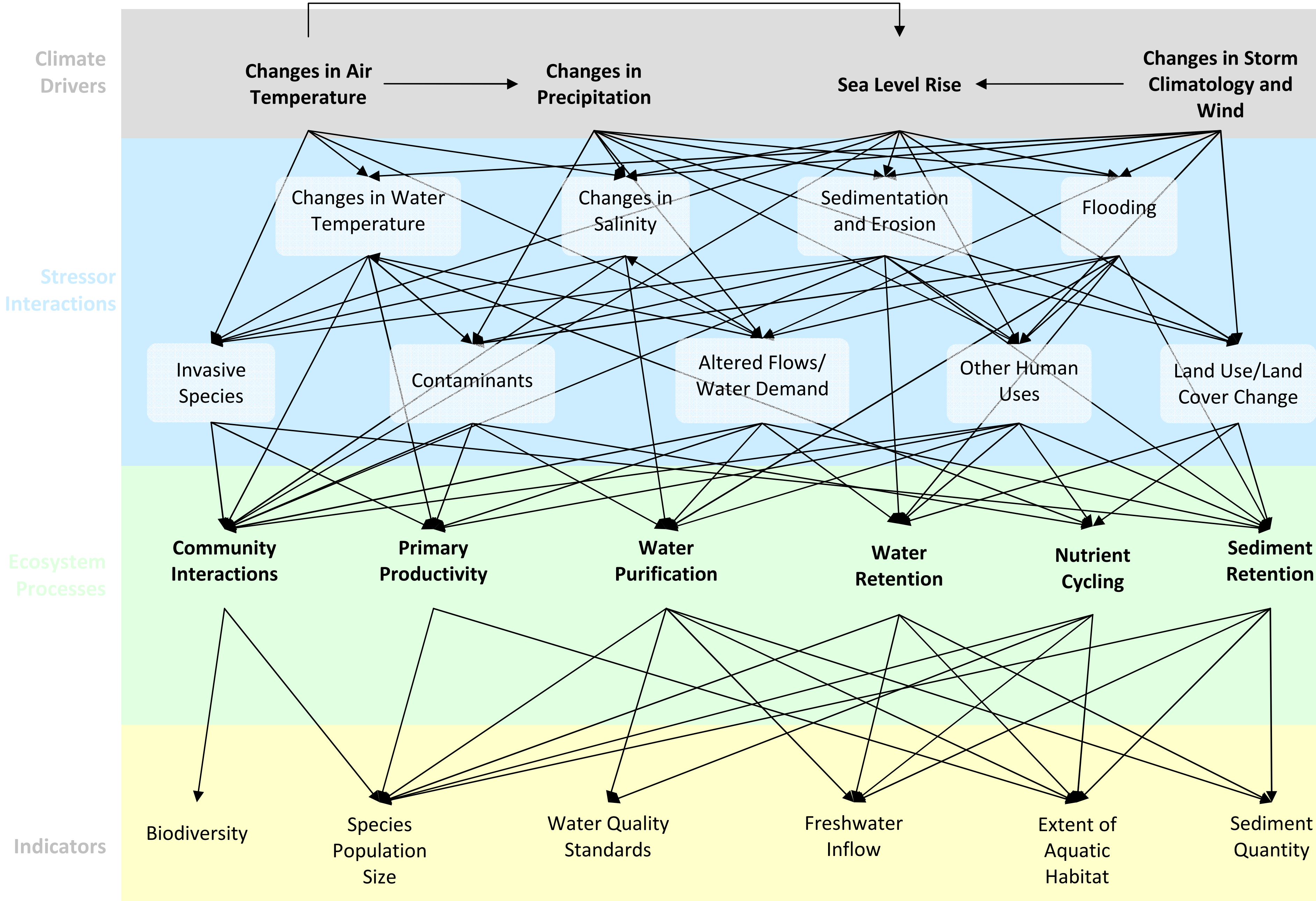


Figure A-1. Salt Marsh Conceptual Model.

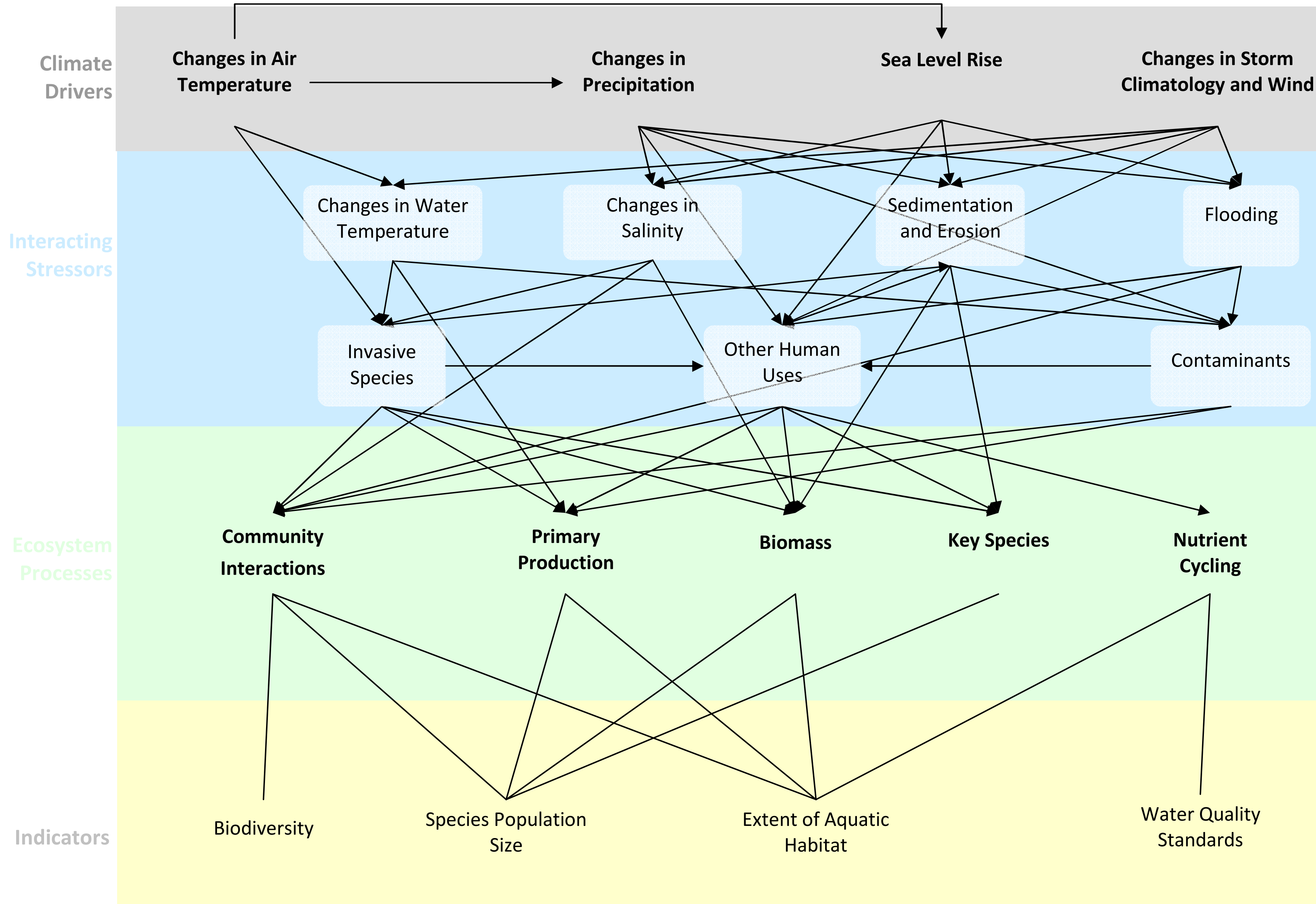


Figure A-2. Mudflat Conceptual Model.

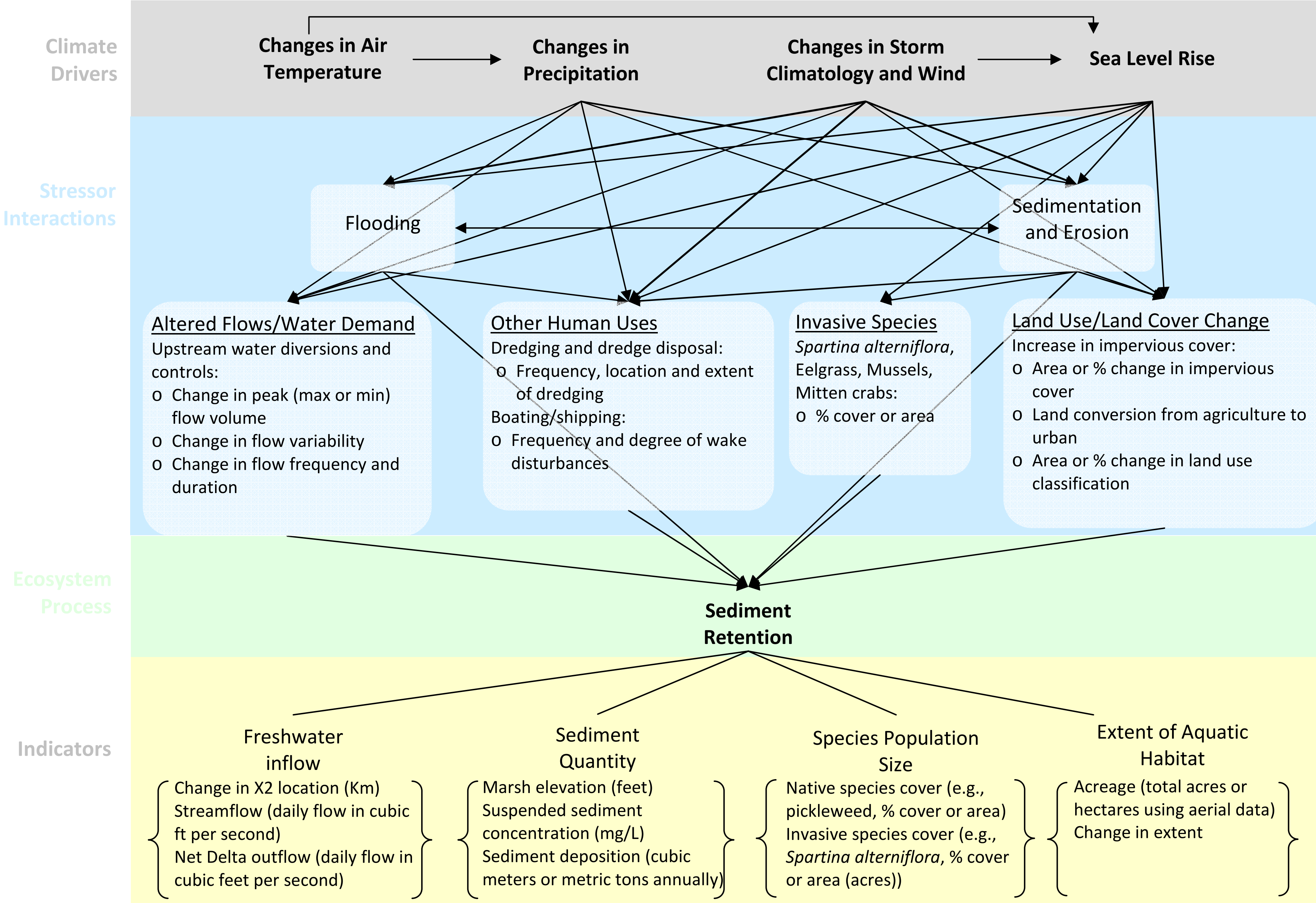


Figure A-3. Sediment Retention sub-model.

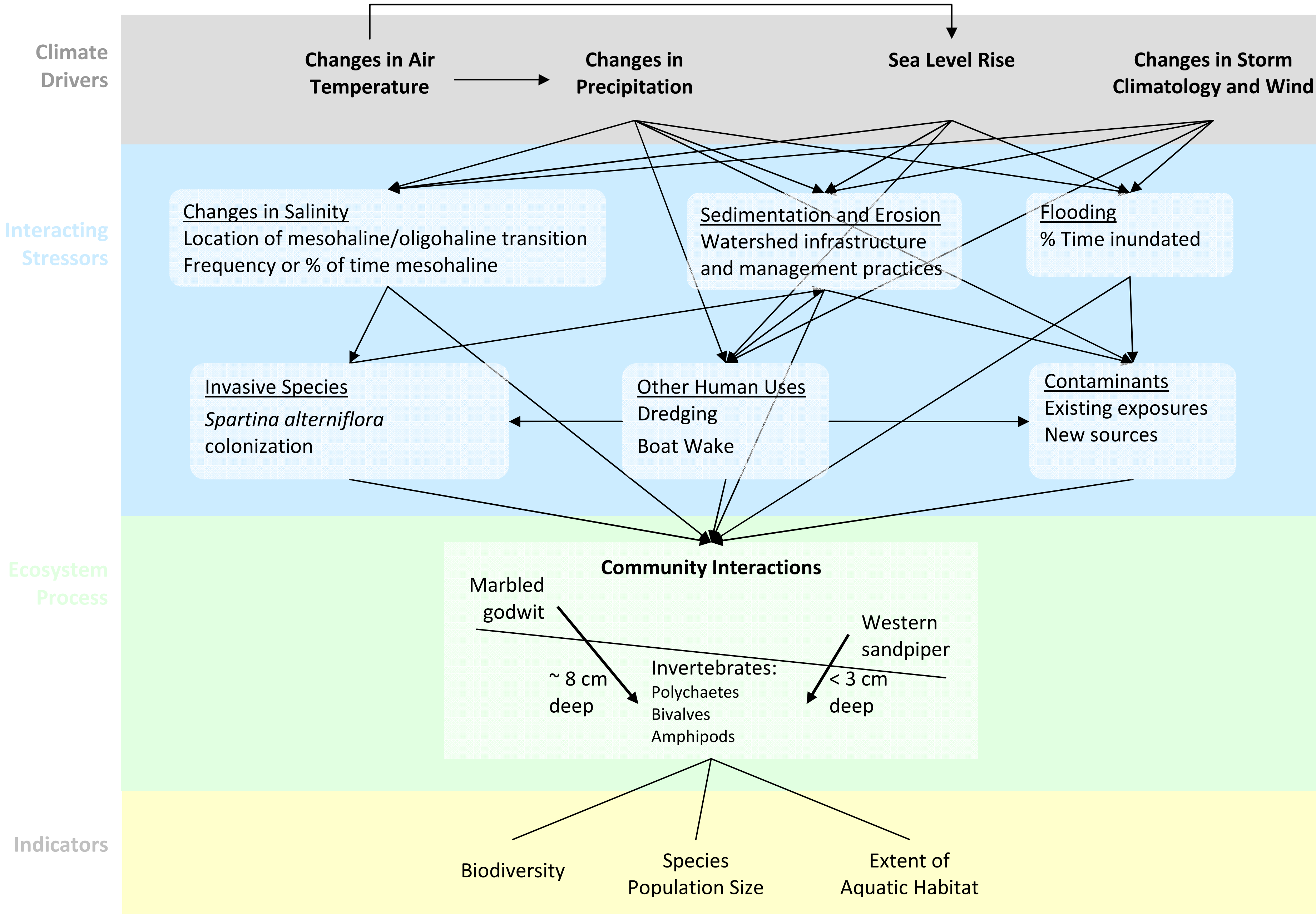


Figure A-4. Community Interactions sub-model.

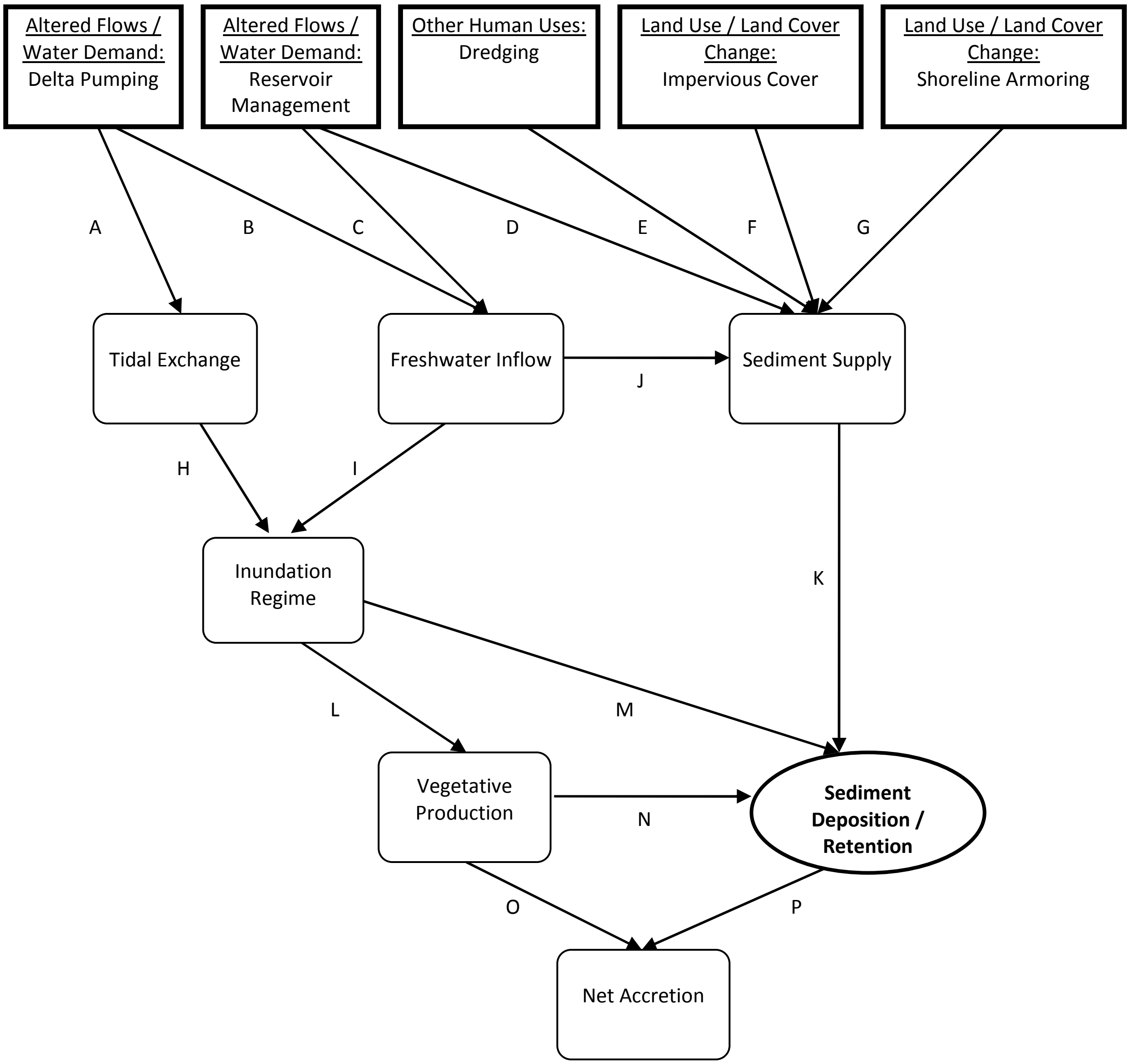


Figure B-1. Sediment Retention "straw-man" influence diagram.

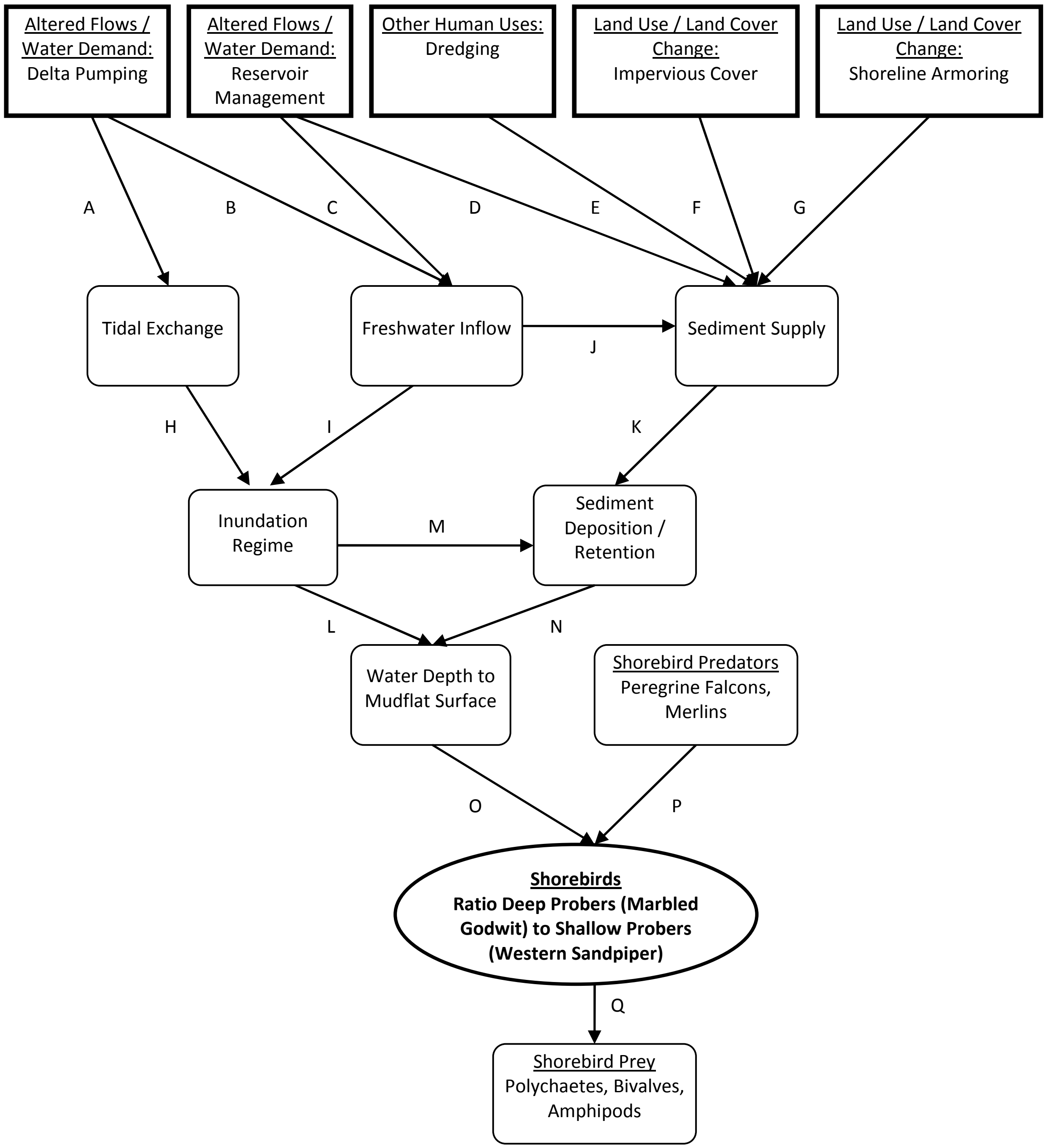


Figure B-2. Community Interactions "straw-man" influence diagram.

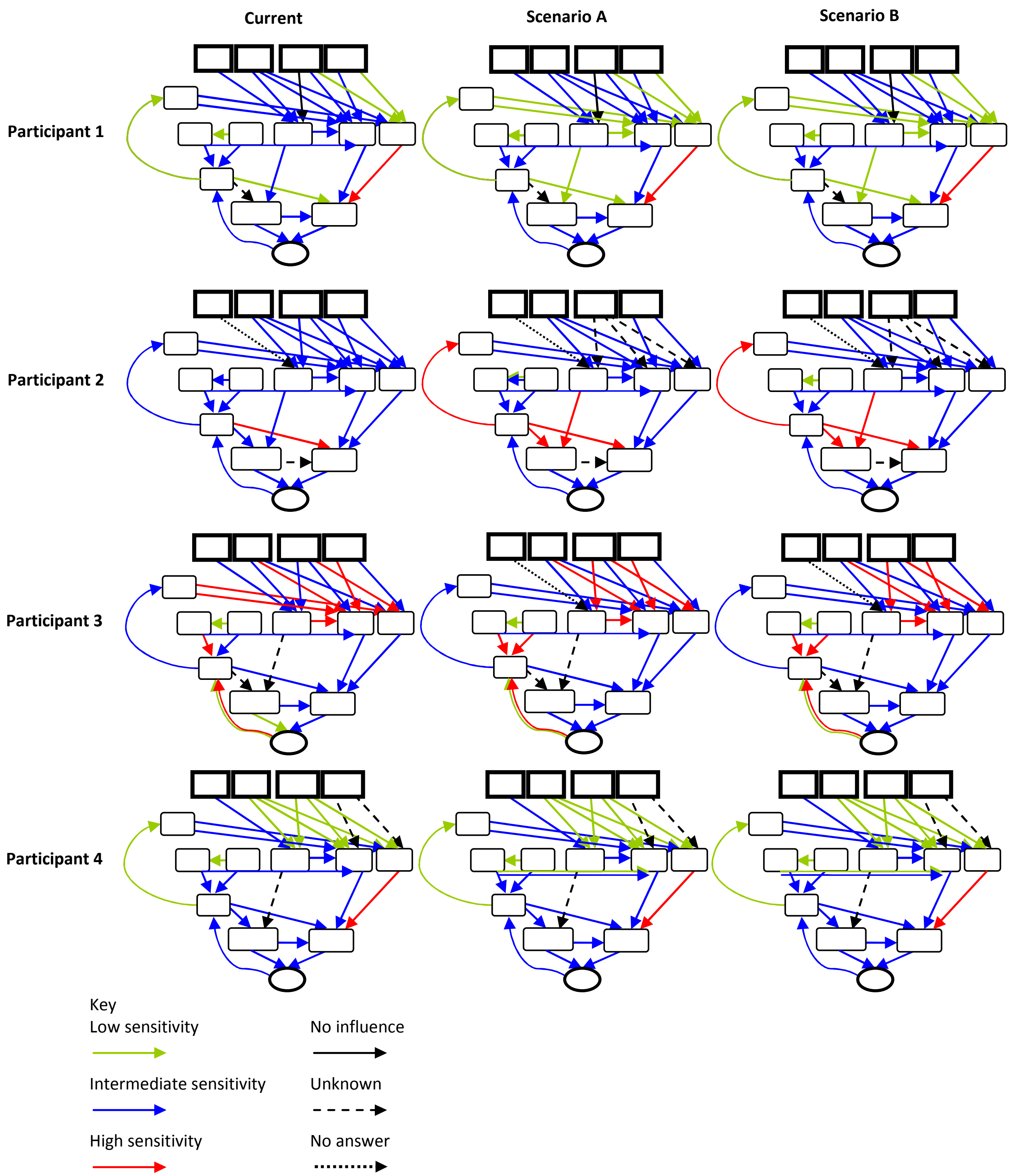


Figure B-3. Sediment Retention influence diagrams of sensitivities: variance across participants (continued on next page).

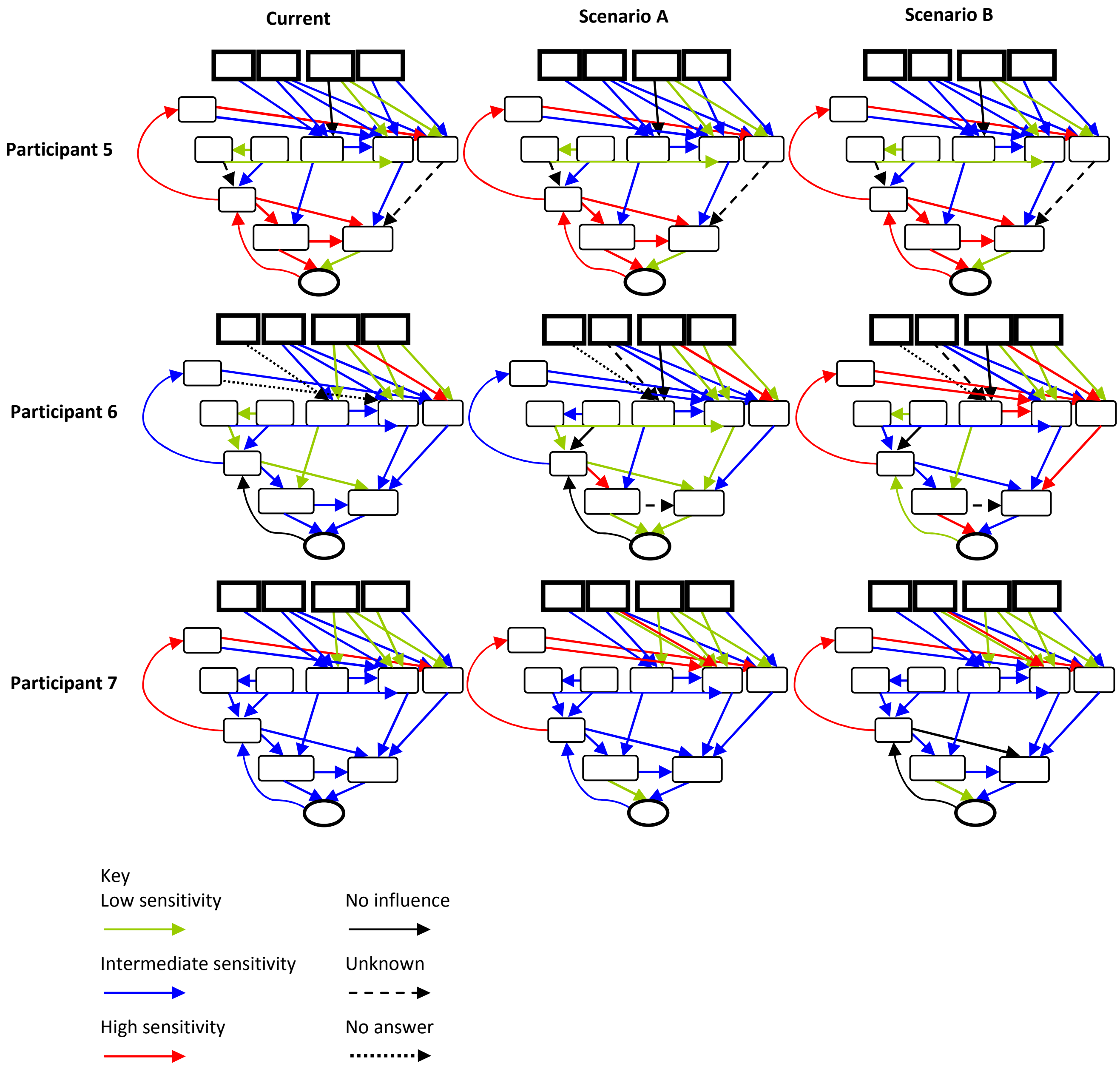


Figure B-3 (cont). Sediment Retention influence diagrams of sensitivities: variance across participants.

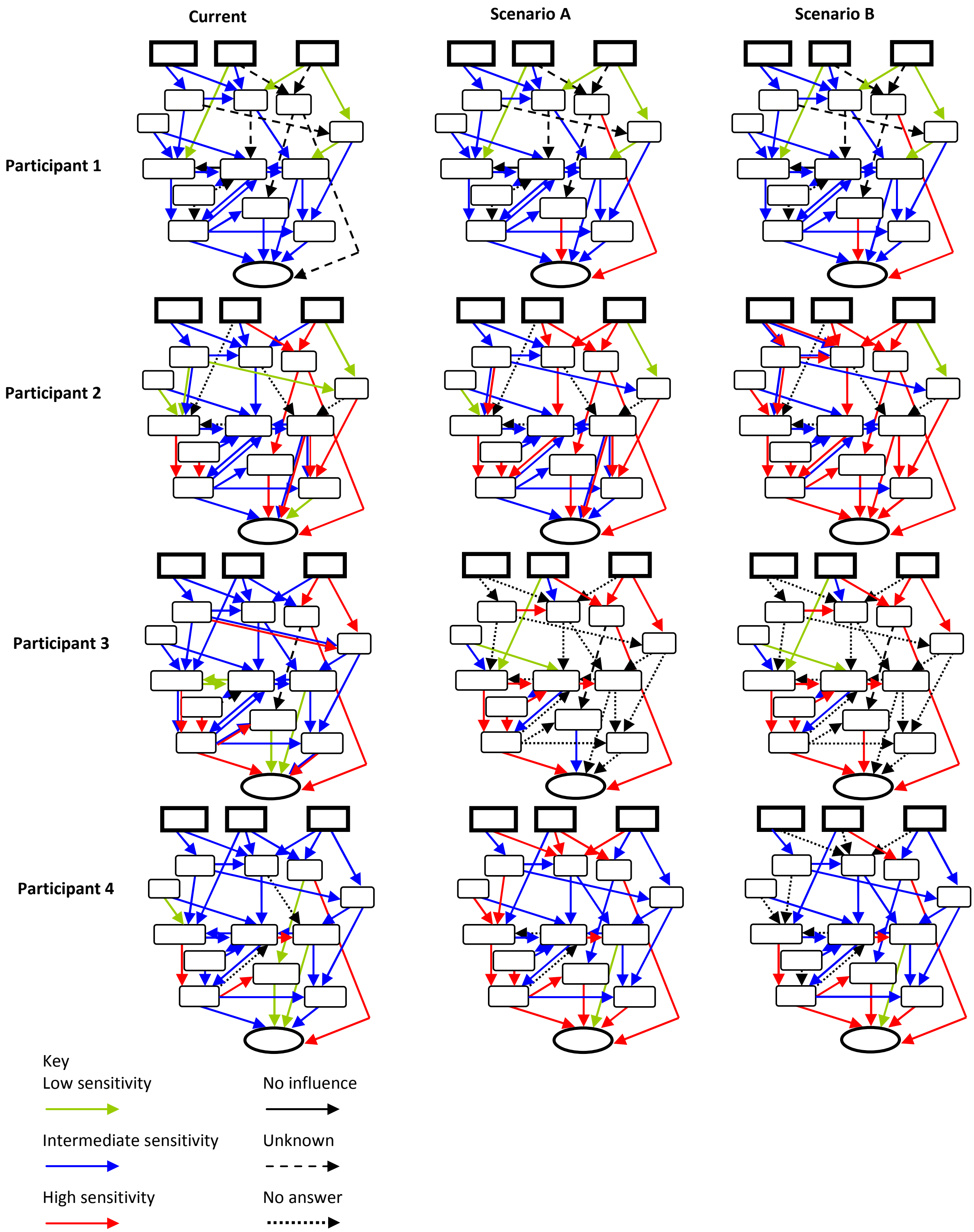


Figure B-4. Community Interactions influence diagrams of sensitivities: variance across participants (continued on next page).

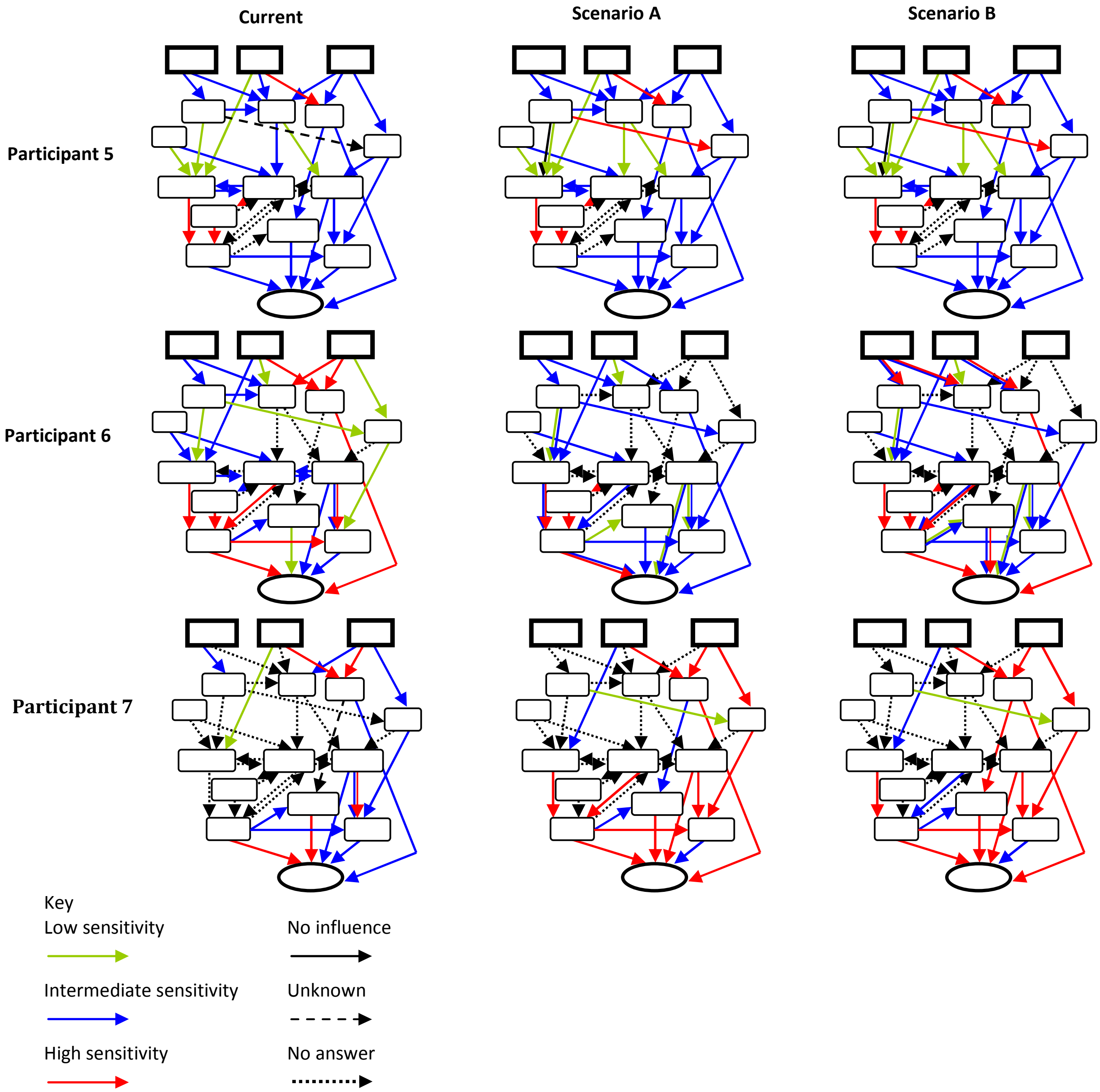


Figure B-4 (cont). Community Interactions influence diagrams of sensitivities: variance across participants.