

Hypotheses for emergent sandbar habitat, piping plovers, and least terns (DRAFT)

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The following document contains the hypotheses currently under development for the Missouri River Effects Analysis (EA) corresponding to piping plovers, least terns, and their habitats. The hypotheses are derived from the CEMs developed initially in July 2013 and reviewed and revised in several stages since then. This is a working document, subject to continued revision as the EA continues. The current diagrams for the CEMs are included in the first section of this document. The CEMs have been updated from previous versions during hypothesis development and to align more closely, when practical, with the CEMs developed for pallid sturgeon.

The hypotheses are divided into three sections: habitat, plover, and tern. Habitat hypotheses (denoted by H1, H2...) describe the effects of hydrology and geomorphology on the endpoints of suitable nesting/brood-rearing habitat and foraging habitat. Due to the large overlap at this level between habitat needs for terns and plovers, these hypotheses are presented for plovers and terns together, but can be evaluated separately for each species as necessary to acknowledge differences in habitat requirements and preferences. The plover hypotheses (P1, P2...) and tern hypotheses (T1, T2...) begin with reservoir level/river stage and area of suitable nesting/brood-rearing habitat and foraging habitat and end with elements of species performance, specifically the transitions between life stages (e.g. survival from eggs to chicks.)

This categorization of hypotheses allows for the hypotheses to be comprehensive while managing the complexity of relationships and reducing the need for repetition. Habitat availability mediates the effects of most hydrological/geomorphological changes on species performance, and many aspects of habitat availability are common between species. Thus any effect on habitat, in combination with other effects on habitat, affects species performance through several pathways.

Each section begins with a summary of the hypotheses and the relevant portion of the CEM diagram(s) covered by that set of hypotheses. On the following pages, each hypothesis is presented individually. In most cases, the main hypothesis is a pathway connecting several elements of the CEM. In those cases, the hypothesis is further broken down into intermediate hypotheses explaining the connection between each element of the CEM.

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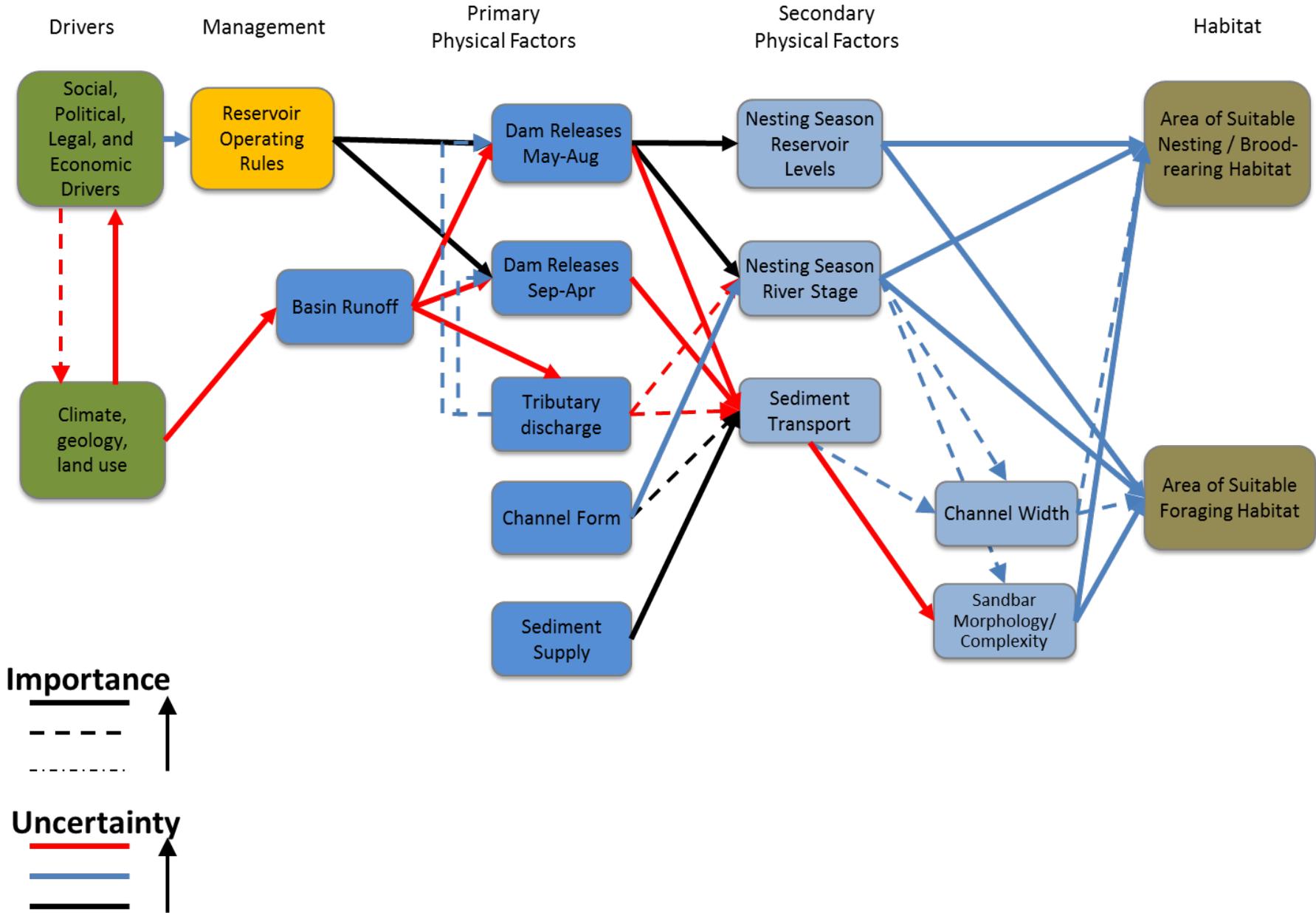
Intermediate hypotheses may include multiple related mechanisms within the overall pathway. Two additional columns represent the “Importance” and “Uncertainty” ratings represented in the CEMs by arrow color and line type. With each hypothesis, the relevant pathway in the CEM is highlighted in the diagram in yellow.

These hypotheses generally correspond with the “dominant hypotheses” being developed for pallid sturgeon. As the overall complexity of the system is less for birds than for sturgeon, we have not gone through a filtering process as is being done for the pallid sturgeon hypotheses. Because of the highly interrelated nature of the bird hypotheses, and the central role of habitat, further prioritization may not be necessary or informative for the development of quantitative models. Note that not all intermediate mechanisms will be explicitly modeled; their inclusion is primarily meant to explain the reasoning behind the hypotheses and allow for the inclusion of ancillary information.

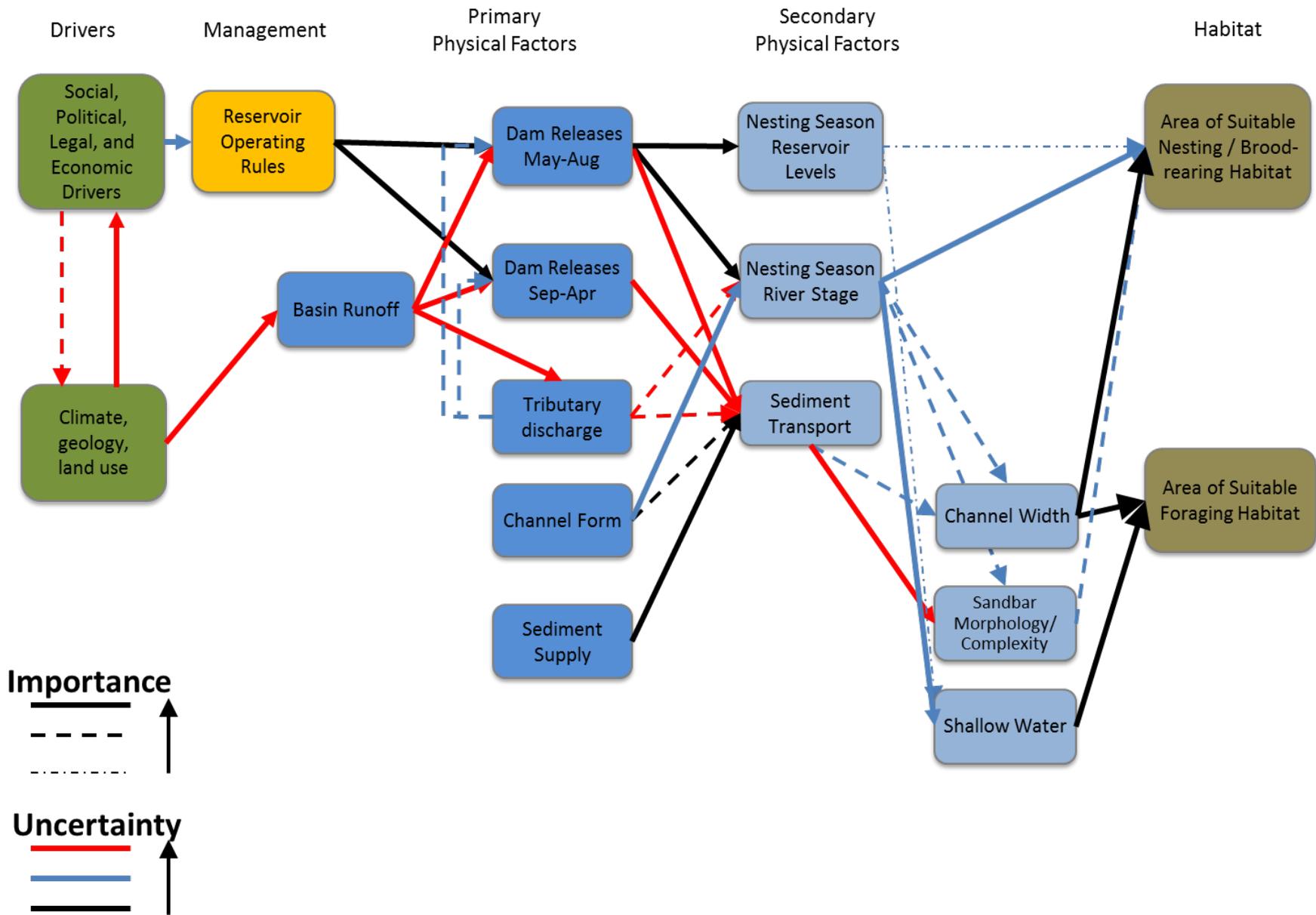
The majority of hypotheses are phrased to indicate whether an increase or decrease in a particular factor will lead to a positive outcome in the habitat or species endpoint. The corresponding null hypothesis for each, while not written out in this document, is that the increase or decrease has no effect on the endpoint. The phrasing facilitates the development of management hypotheses. For example, if a decrease in dam releases during the nesting season is hypothesized to increase the area of nesting habitat, then the corresponding management action(s) to cause that desirable outcome would be one(s) which decrease dam releases during the nesting season.

Conceptual Ecological Models

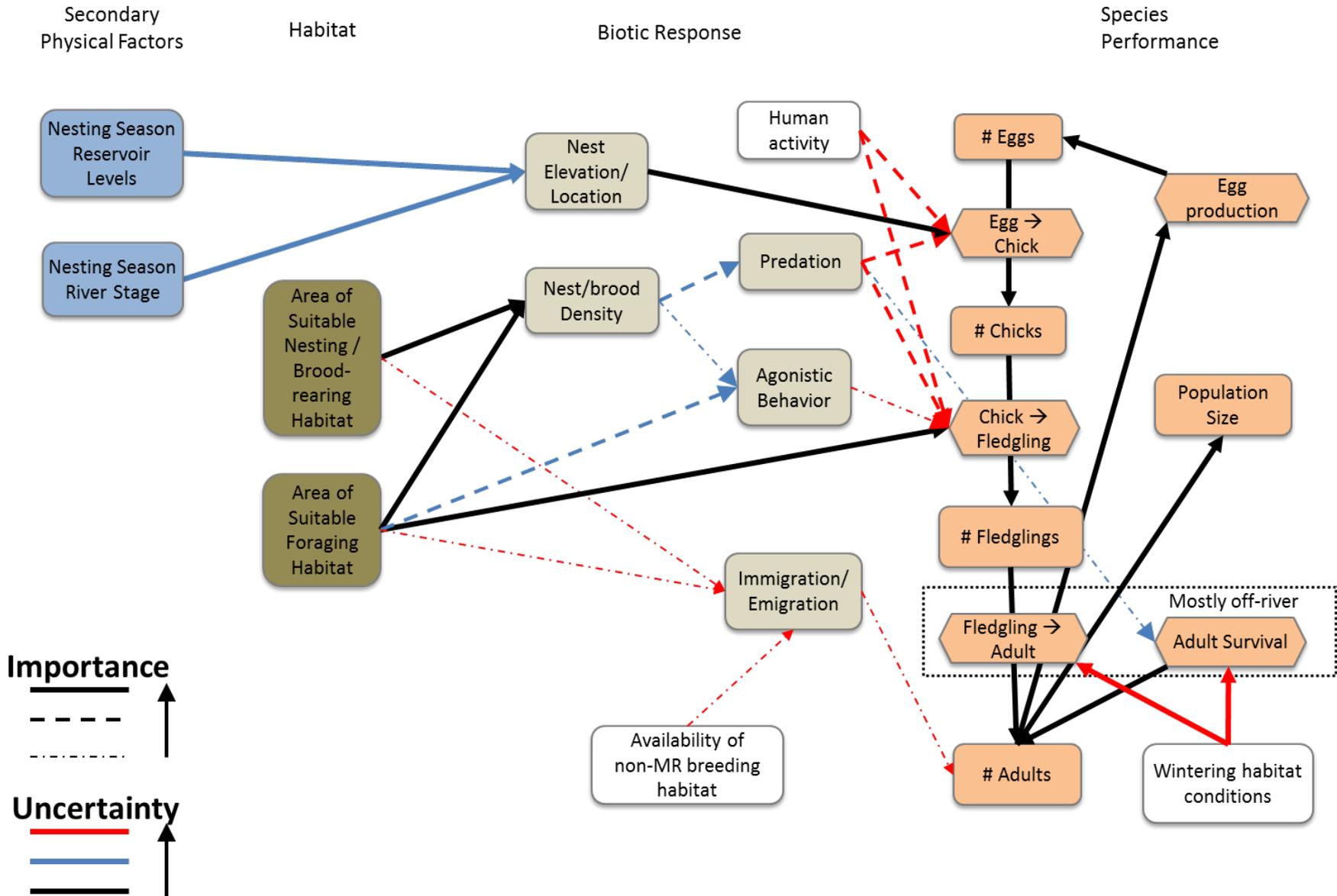
Piping Plover Conceptual Ecological Model: Drivers → Habitat



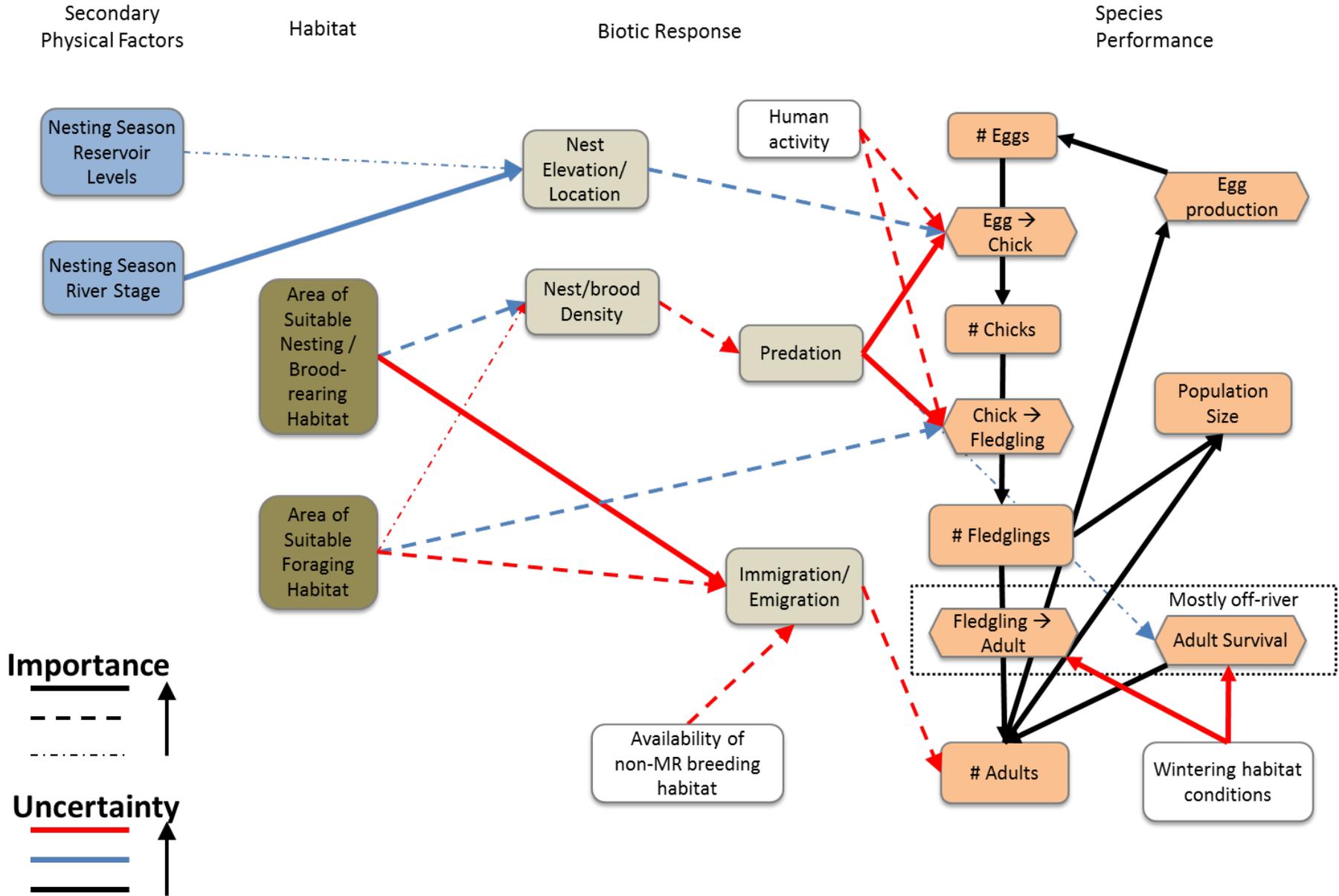
Least Tern Conceptual Ecological Model : Drivers → Habitat



Piping Plover Conceptual Ecological Model : Habitat → Species Performance



Least Tern Conceptual Ecological Model : Habitat → Species Performance



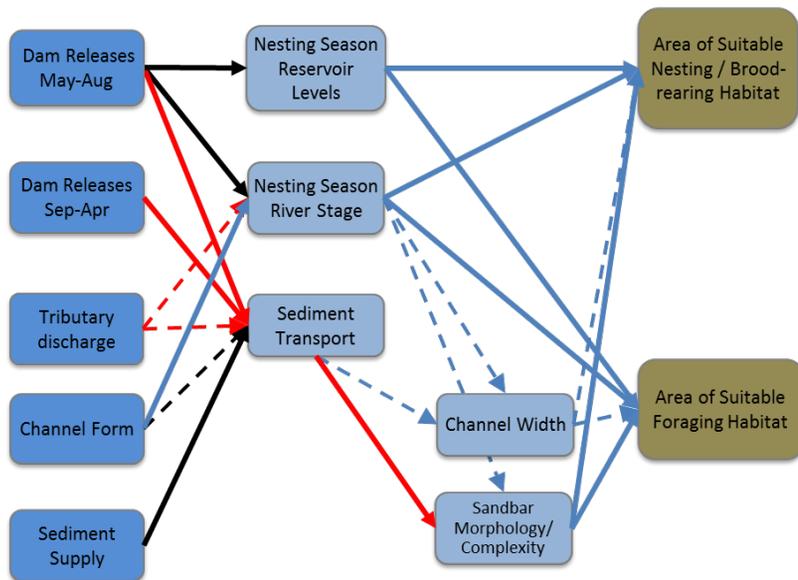
Habitat Hypotheses

Overview: Habitat

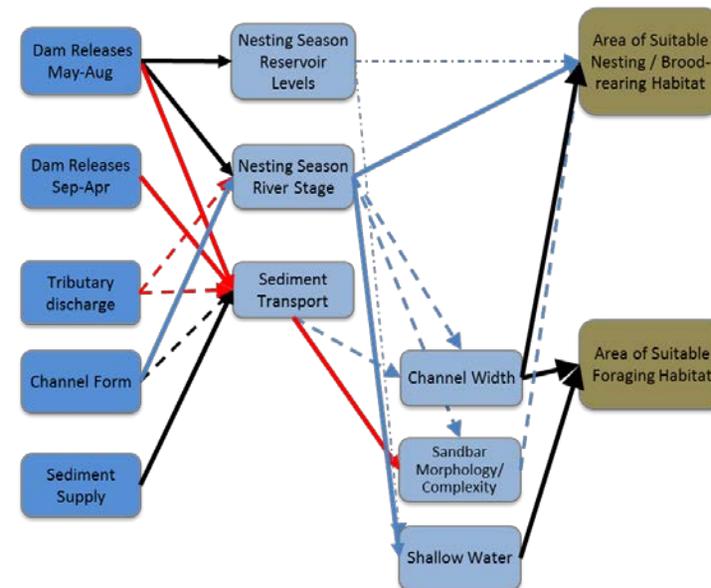
Habitat hypotheses describe the effects of hydrological and geomorphological factors on habitat availability. For simplicity we consider tern and plover habitat together; however, this does not compel us to consider their habitat requirements to be identical. Evidence for or against hypotheses can be assessed at the species level.

- H1 Increases in dam releases (if greater than inflows) during the nesting season (May-August) increase the area of suitable nesting/brood rearing and plover foraging habitat on a reservoir.
- H2 Decreases in dam releases during the nesting season (May-August) increase the area of suitable nesting/brood-rearing habitat and plover foraging habitat on the river.
- H3 Decreased dam releases year-round increase area of nesting/brood rearing habitat and foraging habitat by reducing loss of habitat to erosion.
- H4 Increased dam releases at any time of year can increase area of nesting/brood rearing habitat foraging habitat, if flows are of sufficient magnitude and duration, by increasing deposition, assuming sediment is available.
- H5 Increased width and complexity of channel form increases the area of nesting/brood-rearing habitat and foraging habitat.
- H6 Increased sediment supply increases the amount of nesting/brood-rearing habitat and foraging habitat, given that flows are occasionally high enough to deposit sediment at elevations normally above the water surface.

Plover

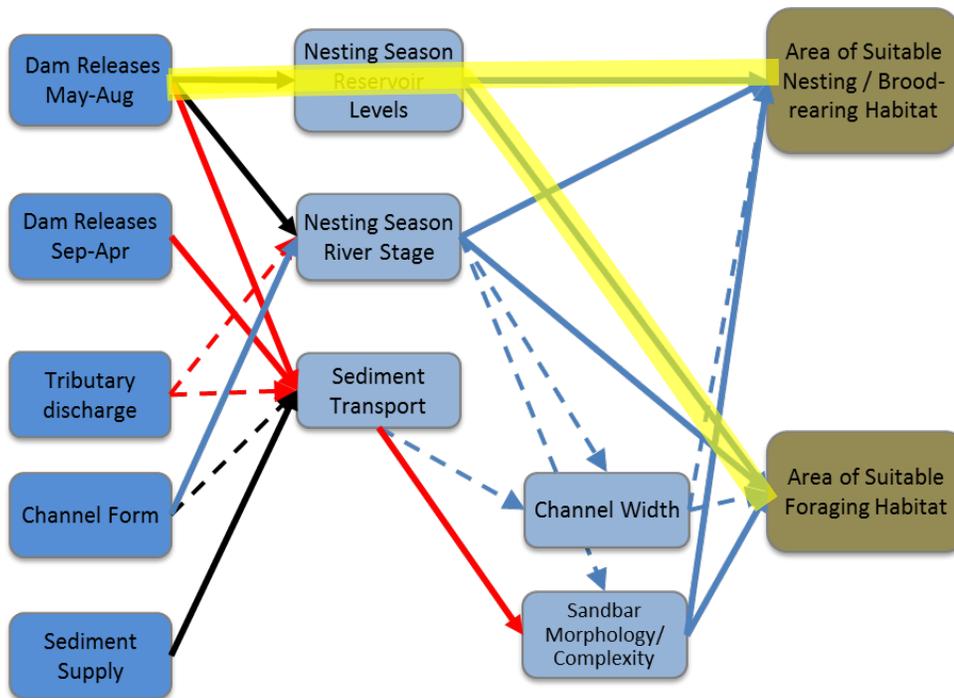


Tern

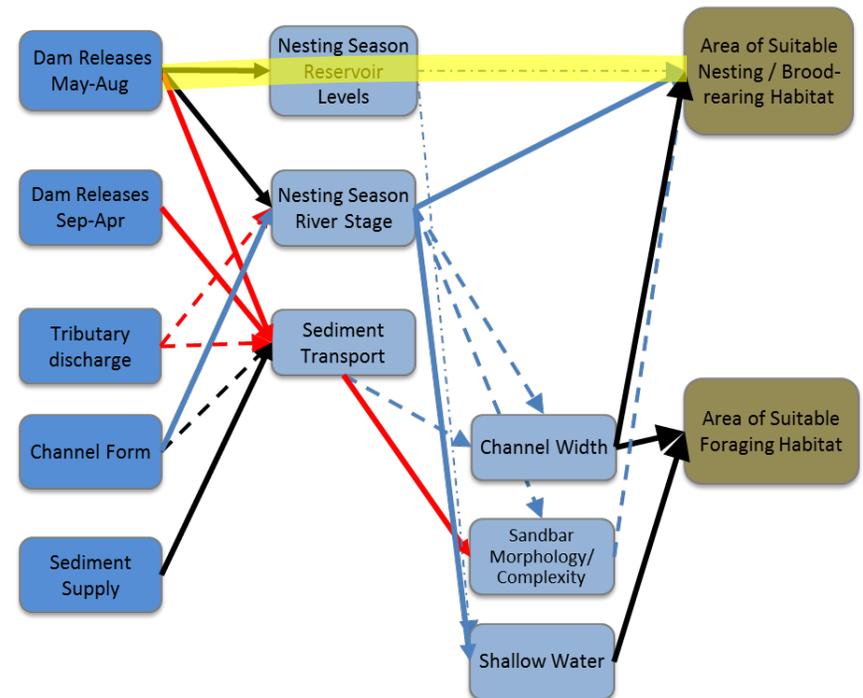


ID	Hypothesis/pathway	Intermediate hypotheses/mechanisms	Importance	Uncertainty	Notes
H1	Increases in dam releases (if greater than inflows) during the nesting season (May-August) increase the area of suitable nesting/brood rearing and plover foraging habitat on a reservoir.	Increased dam releases decrease nesting season reservoir levels, if releases exceed inflows (depending upon upstream reservoir operations and tributary discharge). Decreased reservoir level during the nesting season increases the area of suitable nesting/brood-rearing habitat and foraging habitat on reservoirs.	high (plovers), low (terns)	low/medium	
			high	low	
			high (plovers), low (terns)	medium	

Plover

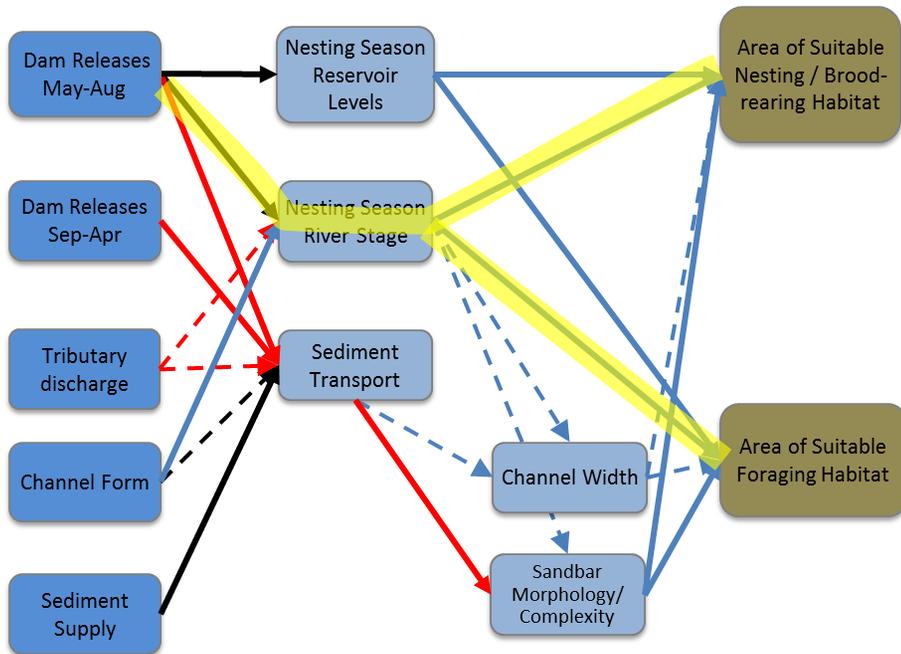


Tern

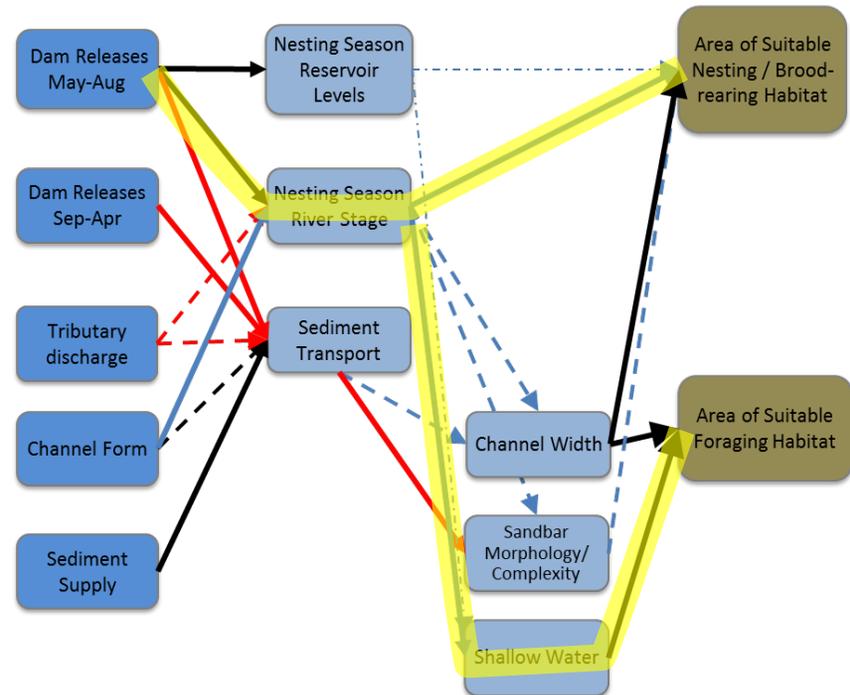


ID	Hypothesis/pathway	Intermediate hypotheses	Import.	Uncert.	Notes
H2	Decreases in dam releases during the nesting season (May-August) increase the area of suitable nesting/brood-rearing habitat and foraging habitat on the river.	<p>Reduced dam releases decrease the nesting season river stage</p> <p>Decreased river stage during the nesting season increases the area of suitable nesting/brood-rearing habitat and foraging habitat in the river.</p>	high	low	
		Decreased river stage can reduce area of suitable nesting/brood-rearing habitat and foraging habitat by connecting sandbars to the floodplain, depending upon channel morphology.	high	low	
			medium	medium	Connected habitat may still be used, but increases predation risk.

Plover



Tern



ID	Hypothesis/pathway	Intermediate hypotheses	Import.	Uncert.	Notes
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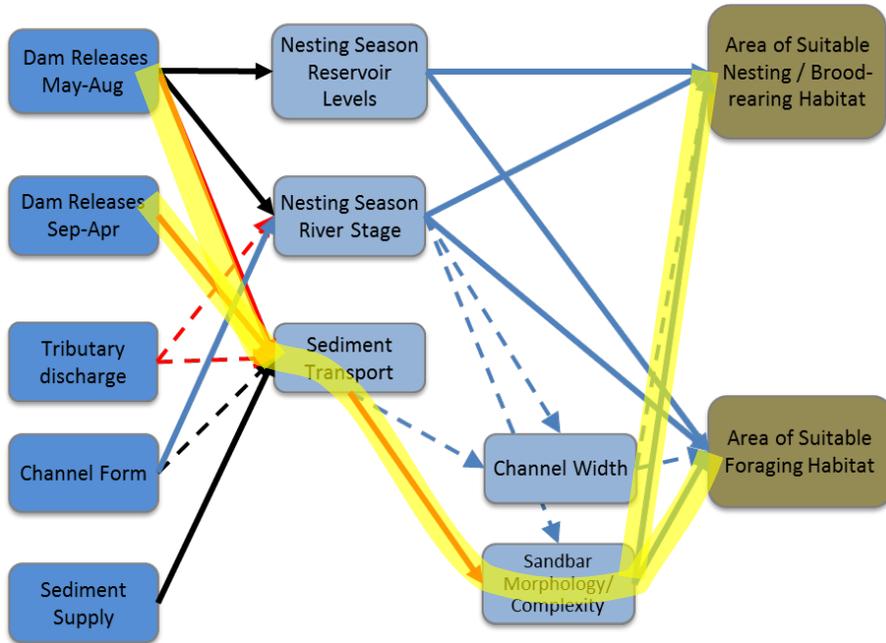
H3 Decreased dam releases year-round increase area of nesting/brood rearing habitat and foraging habitat by reducing loss of habitat to erosion.

Decreased dam releases when flows are generally low decrease the amount of sediment transported.
 Decreased sediment transport at lower elevations (lower flows) tends to reduce erosion, resulting in higher sandbar area and complexity than observed at moderate flows.
 Increases in sandbar complexity increase nesting/brood-rearing habitat and foraging habitat by increasing edge-area ratios.

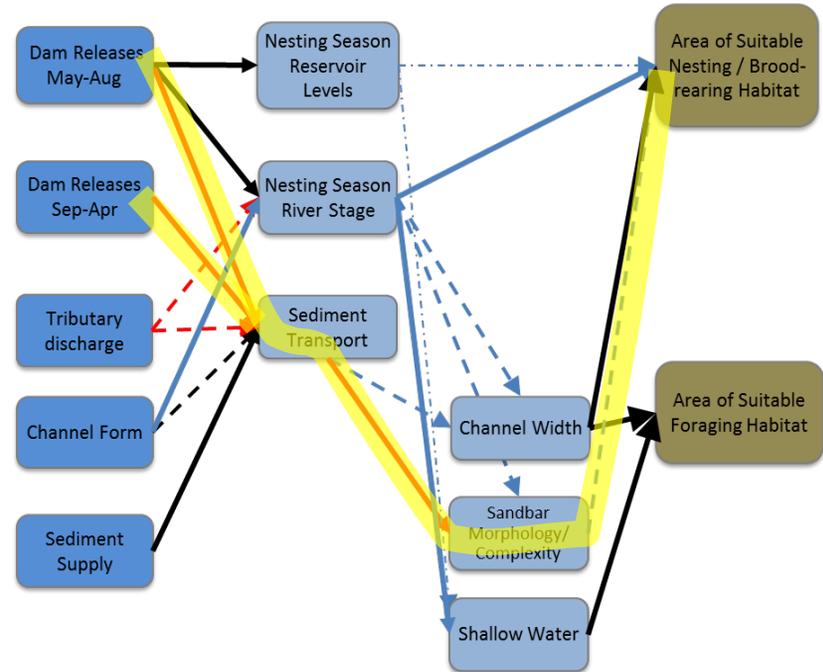
high	high
high	high
high	high
high	medium

Repeated changes in flow (e.g. hydropeaking) also significant source of erosion.
 Long-term erosion results in greater distance between dam and sandbars as sediment is shifted.

Plover



Tern



ID Hypothesis/pathway

Intermediate hypotheses

Import. Uncert. Notes

H4 Increased dam releases at any time of year can increase area of nesting/brood rearing habitat and foraging habitat, if flows are of sufficient magnitude and duration, by increasing deposition, assuming sediment is available.

Increased dam releases increase the rate of sediment transport and the elevation at which it occurs.

Sediment transport at sufficiently high elevations deposits sand on emergent sandbars, increasing area and, in some cases, complexity.

Increases in sandbar complexity increase nesting/brood-rearing habitat and foraging habitat by increasing edge-area ratios.

high high

high high

high high

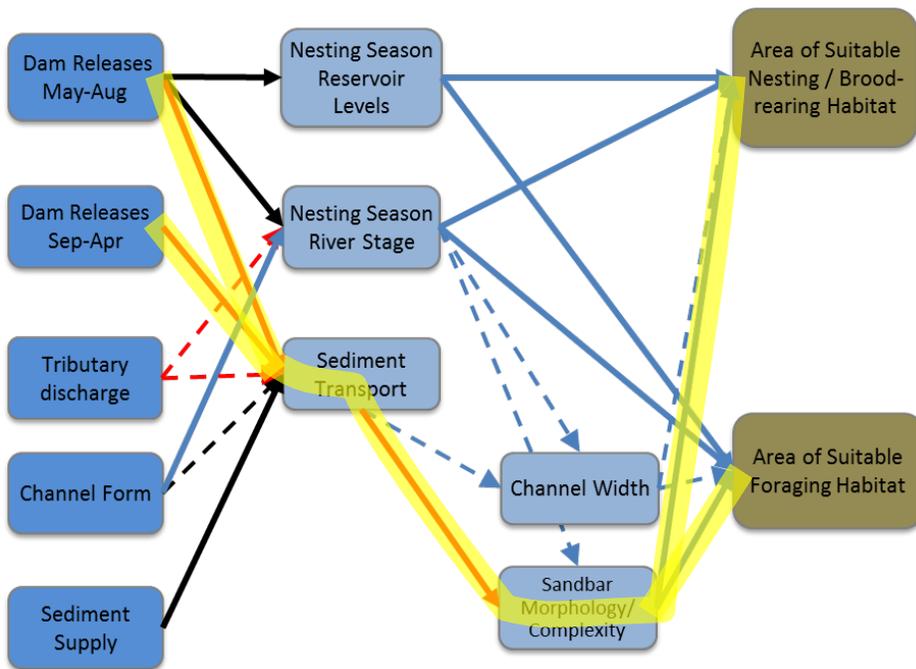
high high

Sufficiently high flows during nesting season have short term effects of reducing nesting habitat while flows are high, but increasing habitat area after flows decrease.

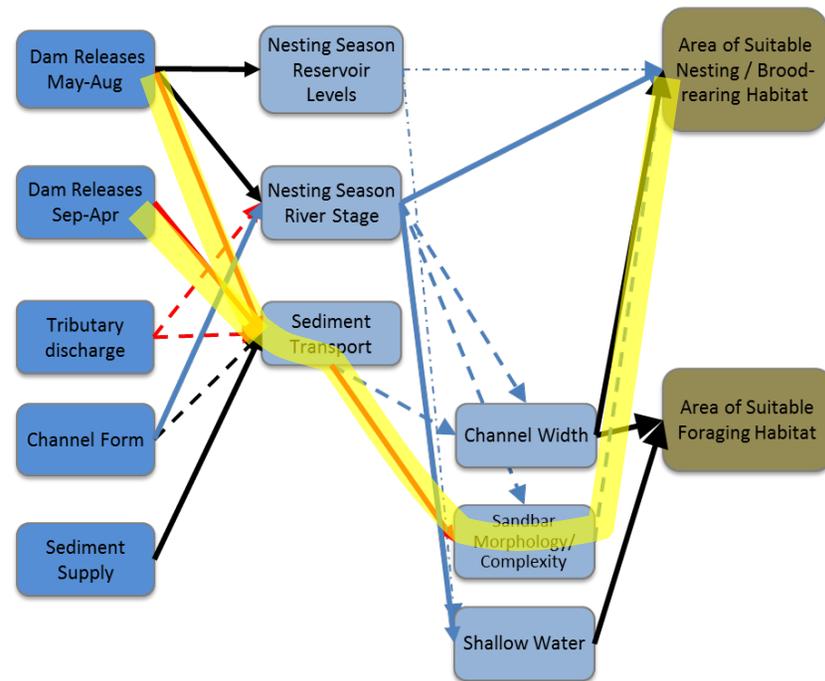
Sediment availability will decrease over time, and distance from dam to sandbars will increase.

More significant for plovers.

Plover

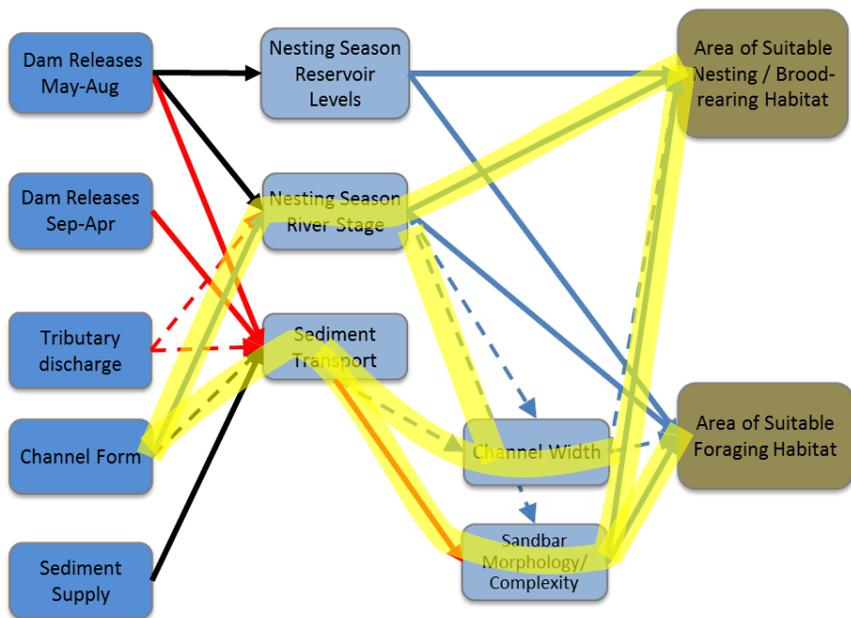


Tern

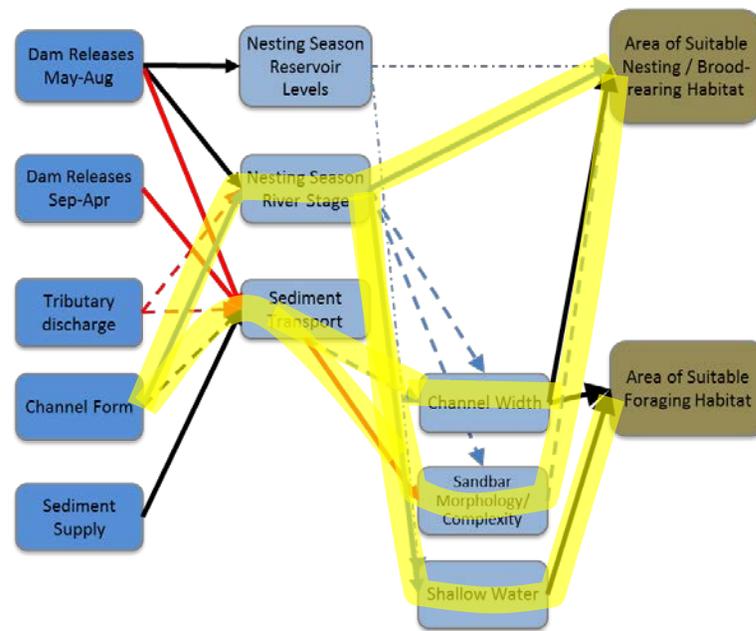


ID	Hypothesis/pathway	Intermediate hypotheses	Import.	Uncert.	Notes
H5	Increased width and complexity of channel form increases the area of nesting/brood-rearing habitat and foraging habitat.				
		Increased channel width reduces nesting season river stage (for a given flow).	high	medium	
		Reduced nesting season river stage increases the area of suitable nesting/brood-rearing habitat and foraging habitat during the nesting season.	high	medium	Effects of river stage on shallow water foraging habitat depends upon channel morphology.
		Increased channel width and complexity reduces the rate of sediment transport, reducing erosion and increasing deposition by decreasing water velocity.	medium	low	Depending upon location in channel; more complex channels have greater variability of sediment transport
		Reduced erosion and increased deposition of sediment, results in higher sandbar area and complexity than observed at moderate flows.	high	high	
	Increases in sandbar area and complexity increase nesting/brood-rearing habitat and foraging habitat directly and by increasing edge-area ratios.	high	medium		
	Increases in channel width increases the attractiveness of nesting/brood-rearing habitat	medium (plovers), high (terns)	medium (plovers), high (terns)		

Plover

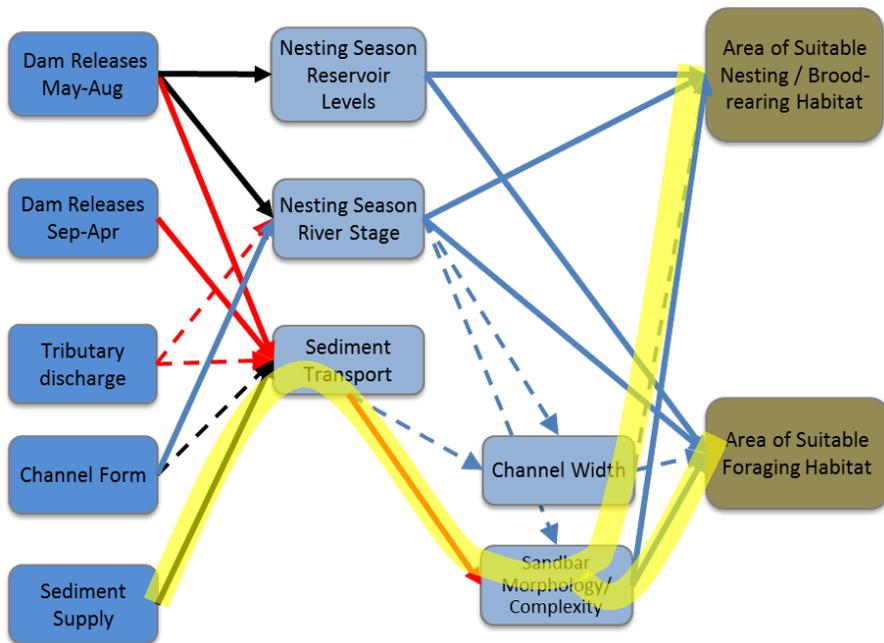


Tern

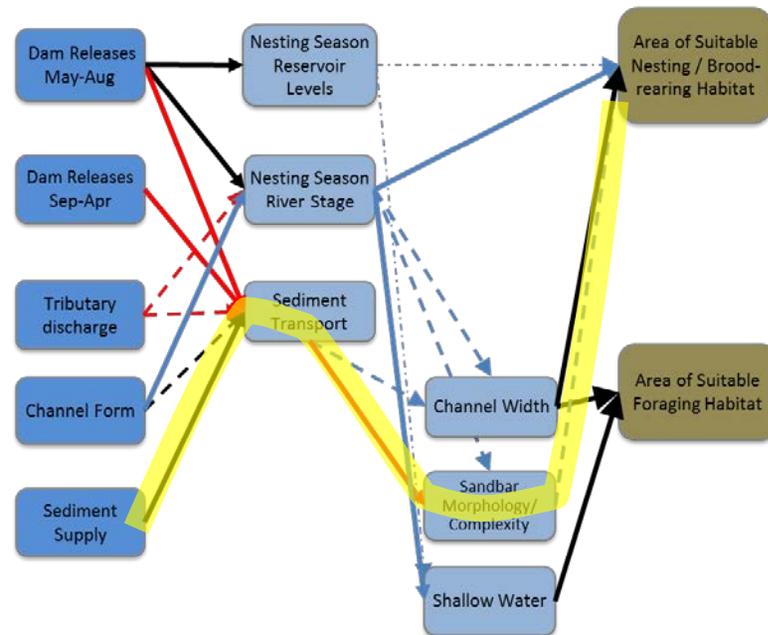


ID	Hypothesis/pathway	Intermediate hypotheses	Import.	Uncert.	Notes
H6	Increased sediment supply increases the amount of nesting/brood-rearing habitat and foraging habitat, given that flows are occasionally high enough to deposit sediment at elevations normally above the water surface.	<p>Increasing the sediment supply increases the amount of sediment transported in the river that can be deposited.</p> <p>Sediment deposition increases sandbar area and complexity, given that flows are occasionally high enough to deposit sediment.</p> <p>Increases in sandbar area and complexity increase nesting/brood-rearing habitat area and foraging habitat area directly and by increasing edge-area ratios.</p>	high	medium	

Plover



Tern

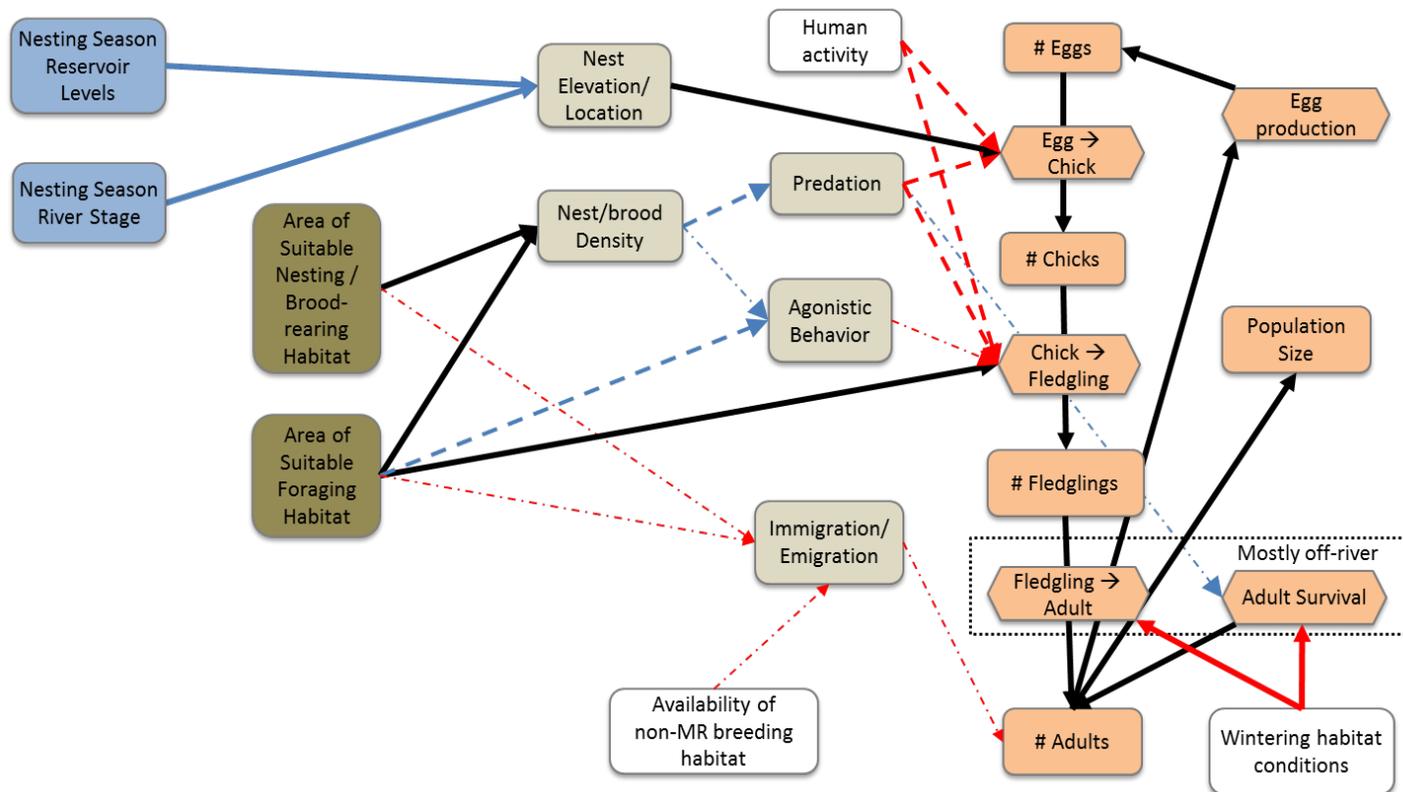


Piping Plover Hypotheses

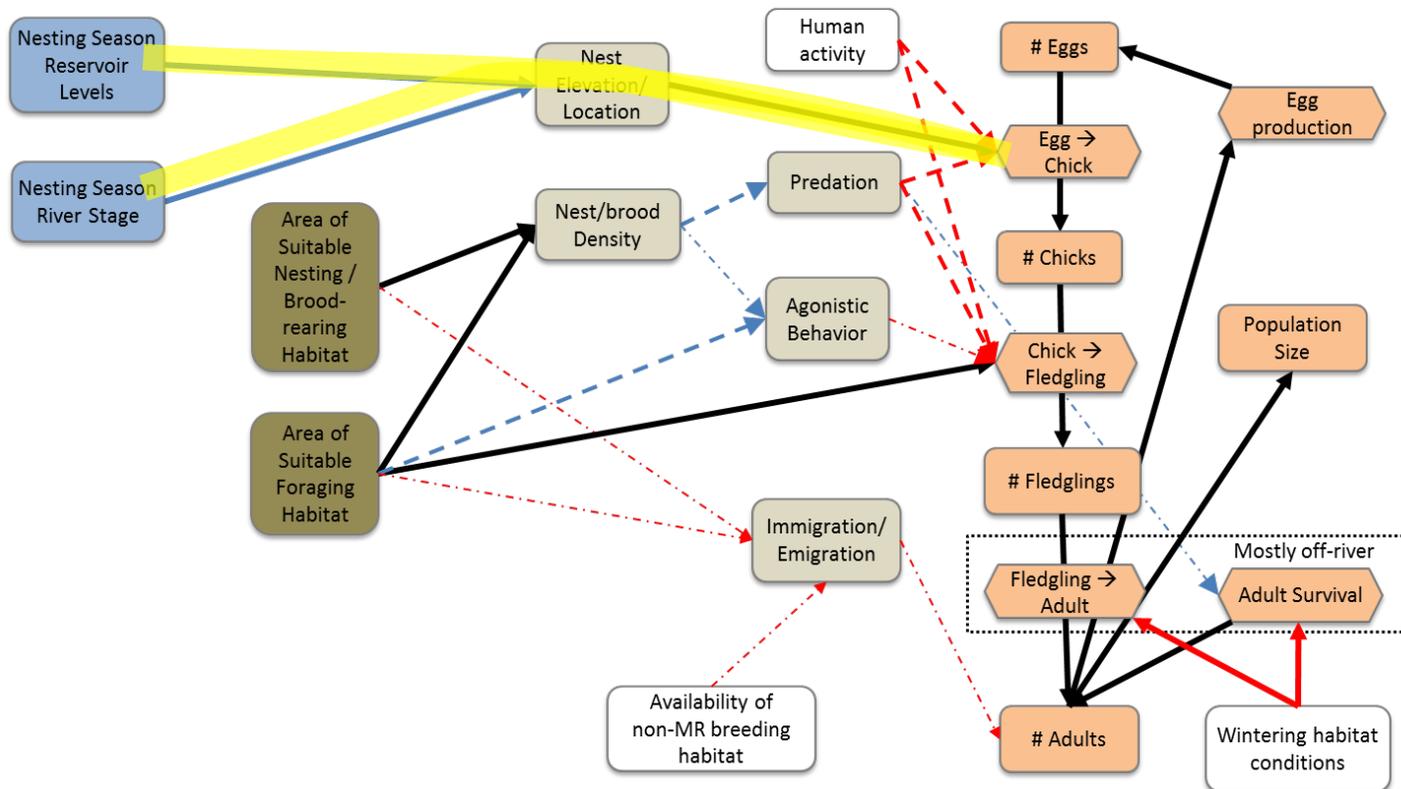
Overview: Plovers

Plover hypotheses describe the effects of water levels and habitat availability on rates of survival between life stages.

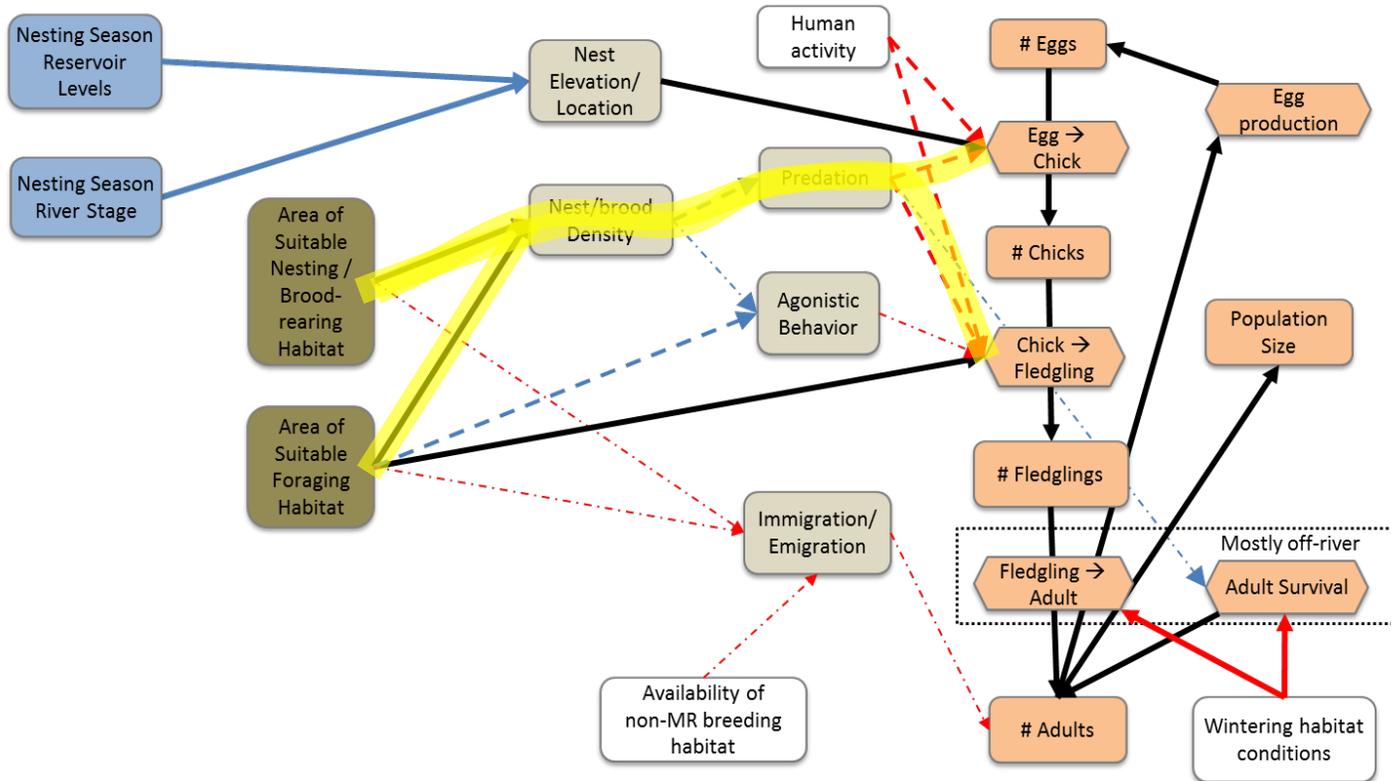
- P1 Steady or decreasing reservoir levels/river stage during the nesting season increases survival from eggs to chick by reducing inundation risk.
- P2 Increases in area of suitable nesting/brood-rearing and foraging habitat increases survival of eggs to chicks and chicks to fledglings by reducing predation.
- P3 Increases in area of foraging habitat increases survival of chicks to fledglings by increasing food availability.
- P4 Increases in area of nesting/brooding and foraging habitat increases the number of adults through immigration.
- P5 Human activity (including pets/livestock) reduces survival of eggs to chick and chick to fledglings.
- P6 More favorable conditions in wintering habitat improves survival from juvenile to adult and overwinter adult survival.



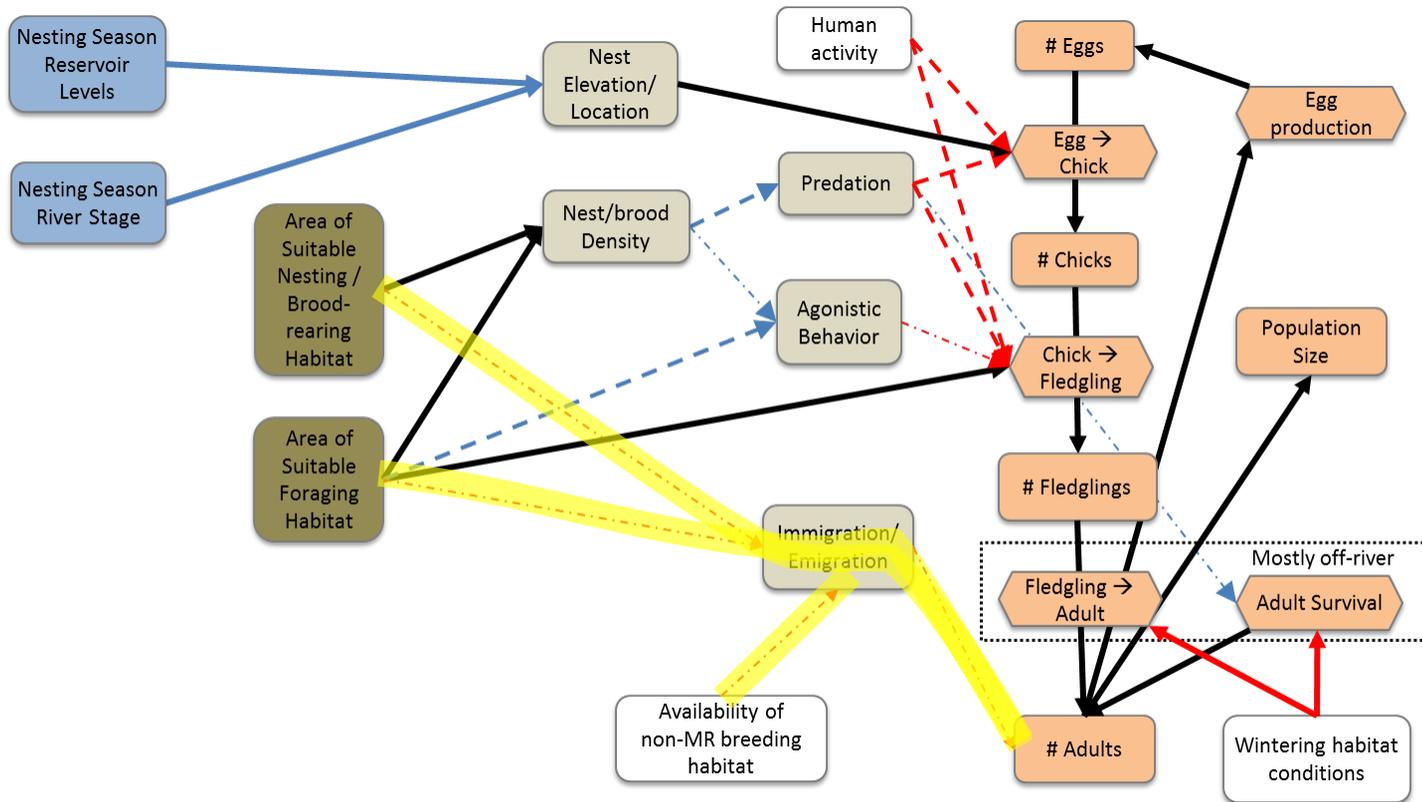
	Plover biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
P1	Steady or decreasing reservoir levels/river stage during the nesting season increases survival from eggs to chick by reducing inundation risk.		high	low/medium	
		Higher water levels early in the nesting season increases elevation of nest sites, as plovers tend to select nesting sites near the water level.	high	medium	
		Steady or decreasing water levels during the nesting season, such that the water level stays below the elevation of nests, increases egg to chick survival.	high	low	



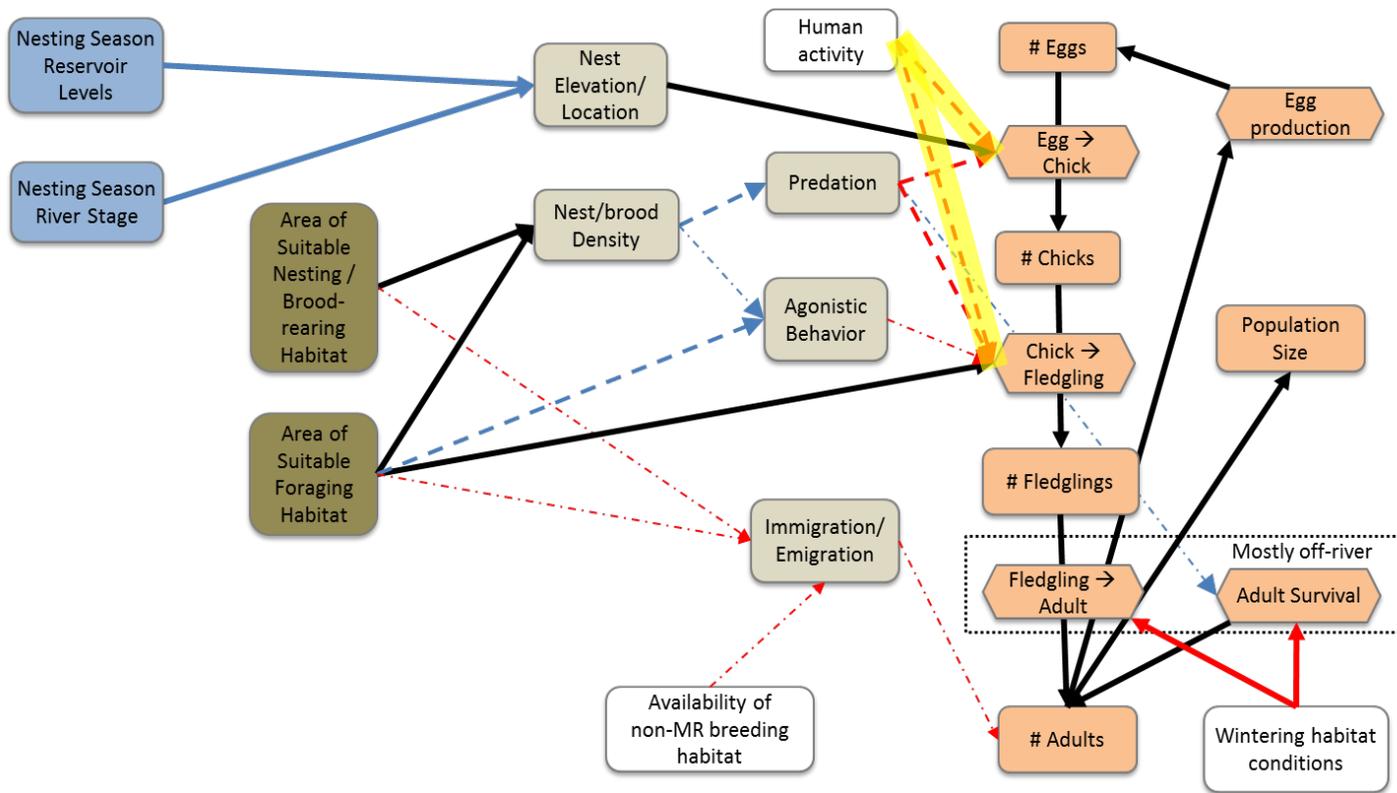
Plover biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
P2 Increases in area of suitable nesting/brood-rearing and foraging habitat increases survival of eggs to chicks and chicks to fledglings by reducing predation.		medium	medium	Assuming that effects of habitat area on predation mortality are similar for eggs and chicks
	For a given population size, increases in nesting/brood-rearing habitat area decreases local nest/brood density	high	low	If birds do not use all available habitat, local nest density may not decrease with increases in habitat (clumped distribution)
	Lower nest/brood densities attracts fewer predators and/or make nests and chicks harder to find, reducing predation.	medium	medium	
	Decreases in predation increase survival of eggs to chicks and chicks to fledglings.	medium	high	



	Plover biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
P4	Increases in area of nesting/brooding and foraging habitat relative to the condition and availability of habitat at other breeding areas increases the number of adults through immigration.		low	high	Dispersal between regions thought to be very low for plovers
		Increases in nesting/brooding and foraging habitat area increases net immigration.	low	high	Partly determined by habitat availability and population sizes in other breeding areas
		Increased net immigration increases the number of adults.	low	high	



	Plover biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
P5	Human activity (including pets/livestock) reduces survival of eggs to chick and chick to fledglings.		medium	high	location dependent



Plover biotic hypotheses/pathways

Intermediate hypotheses/mechanisms

Import.

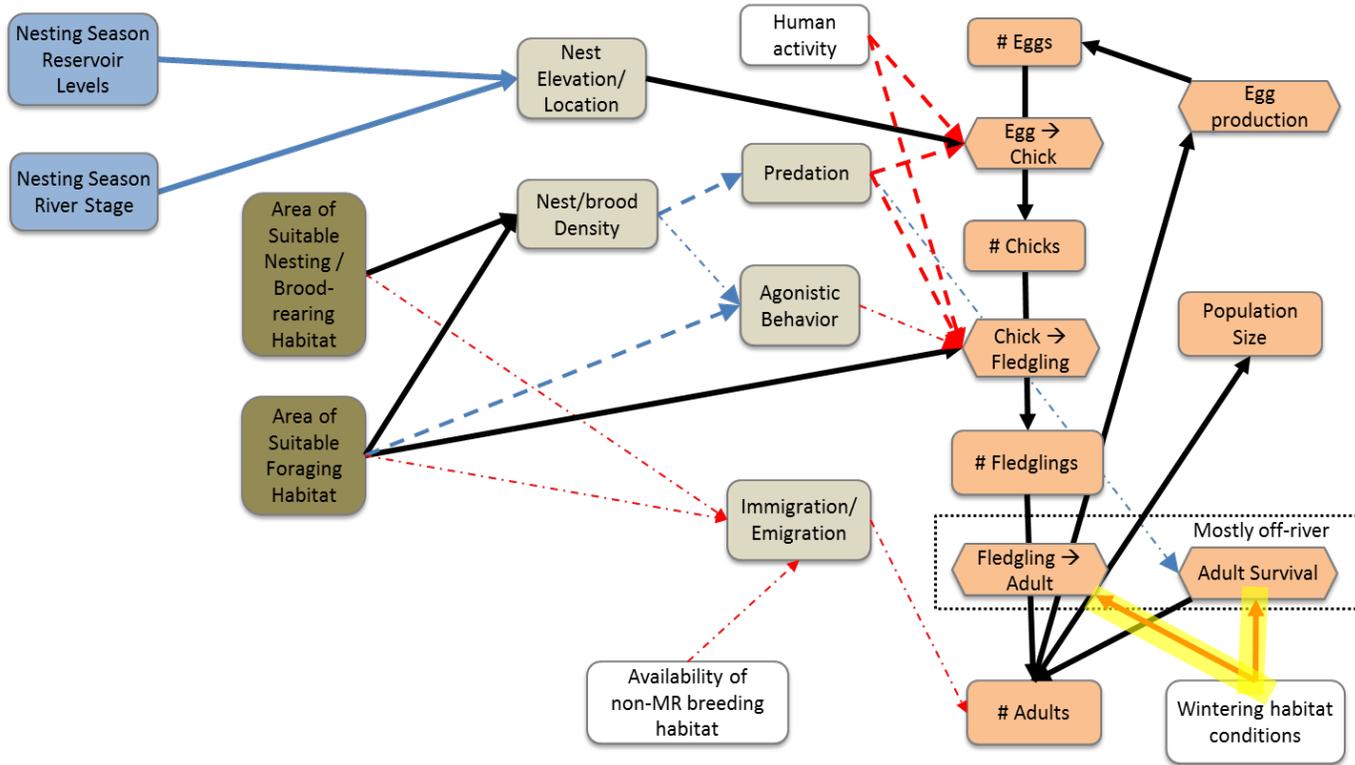
Uncert.

Notes

P6 More favorable conditions in wintering habitat improves survival from juvenile to adult and overwinter adult survival

high

high

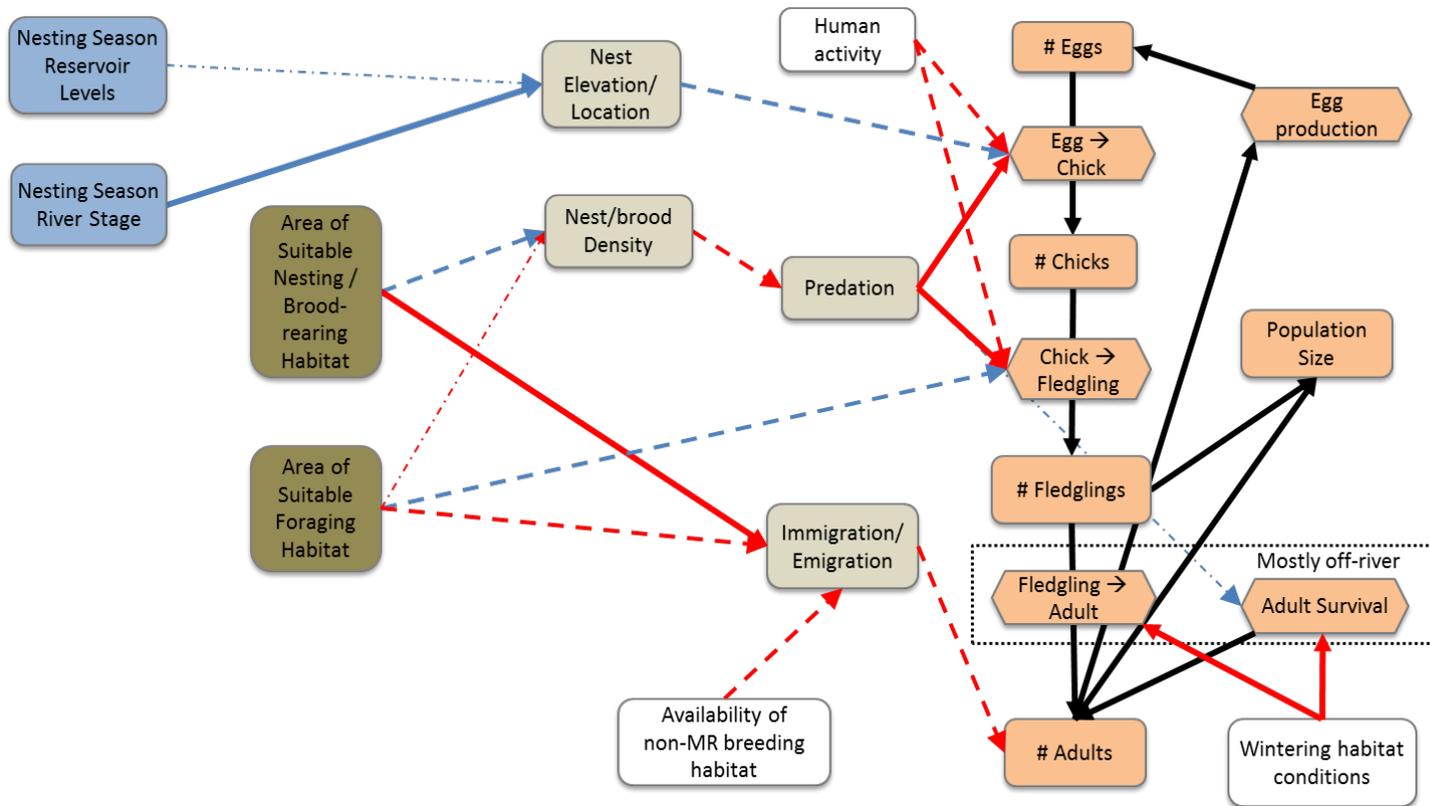


Least Tern Hypotheses

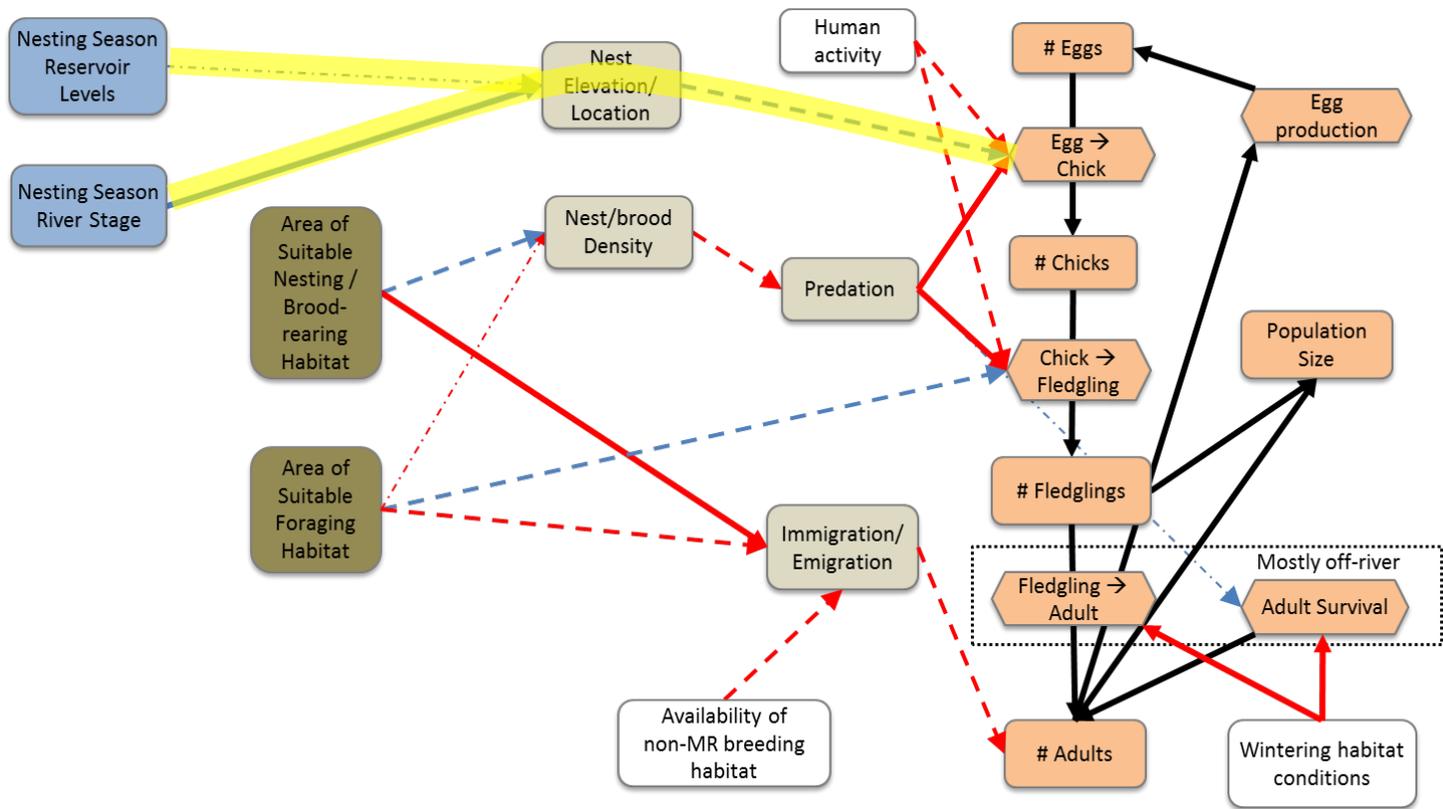
Overview: Terns

Tern hypotheses describe the effects of water levels and habitat availability on rates of survival between life stages.

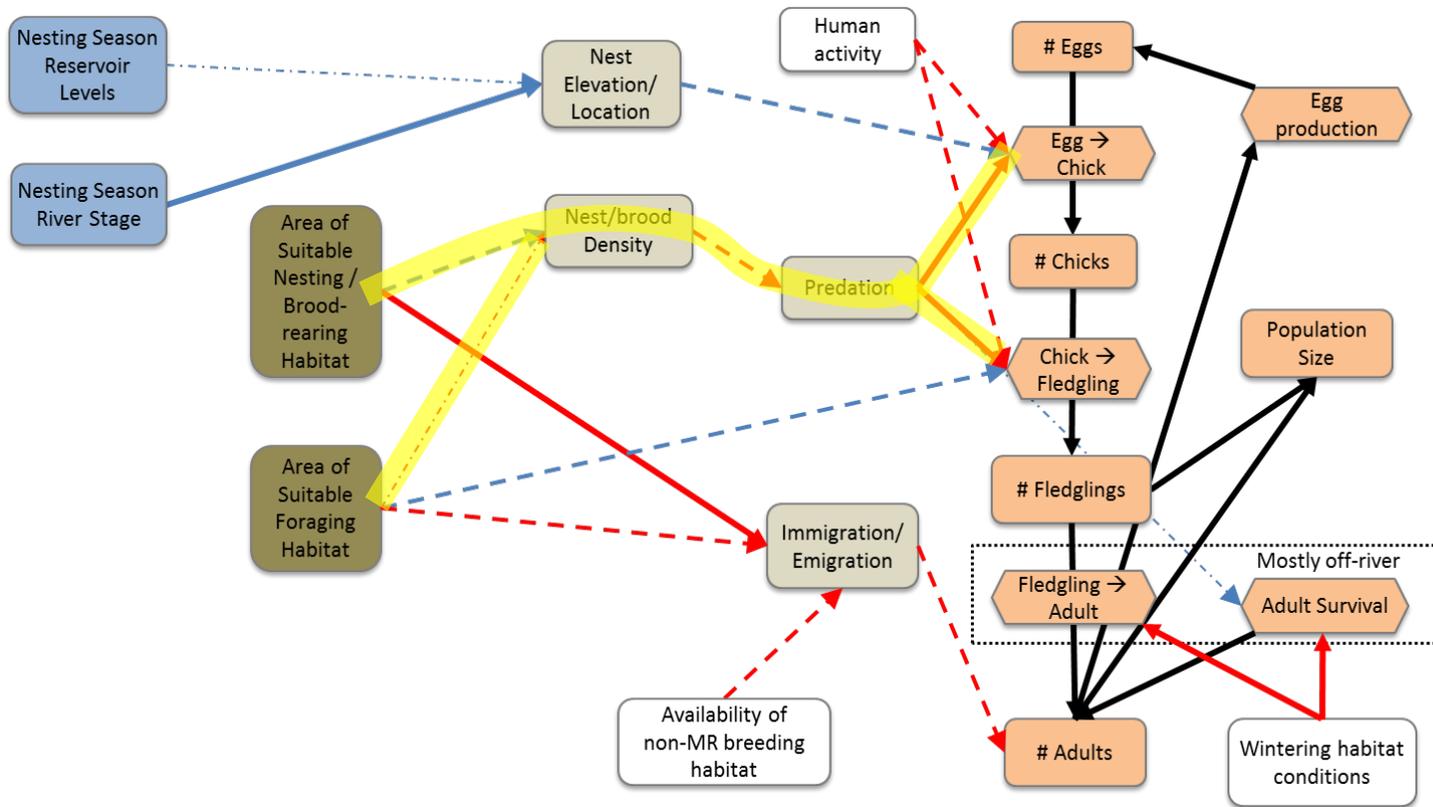
- T1 Steady or decreasing reservoir levels/river stage during the nesting season increases survival from eggs to chick by reducing inundation risk.
- T2 Increases in area of suitable nesting/brood-rearing and foraging habitat increases survival of eggs to chicks and chicks to fledglings by reducing predation.
- T3 Increases in area of suitable foraging habitat increases the survival of chicks to fledglings.
- T4 Increases in area of nesting/brooding habitat increases the number of adults through immigration.
- T5 Human activity (including pets/livestock) reduces survival of eggs to chick and chick to fledglings.
- T6 More favorable conditions at wintering habitat and migratory stopover sites improves survival from juvenile to adult and overwinter adult survival.



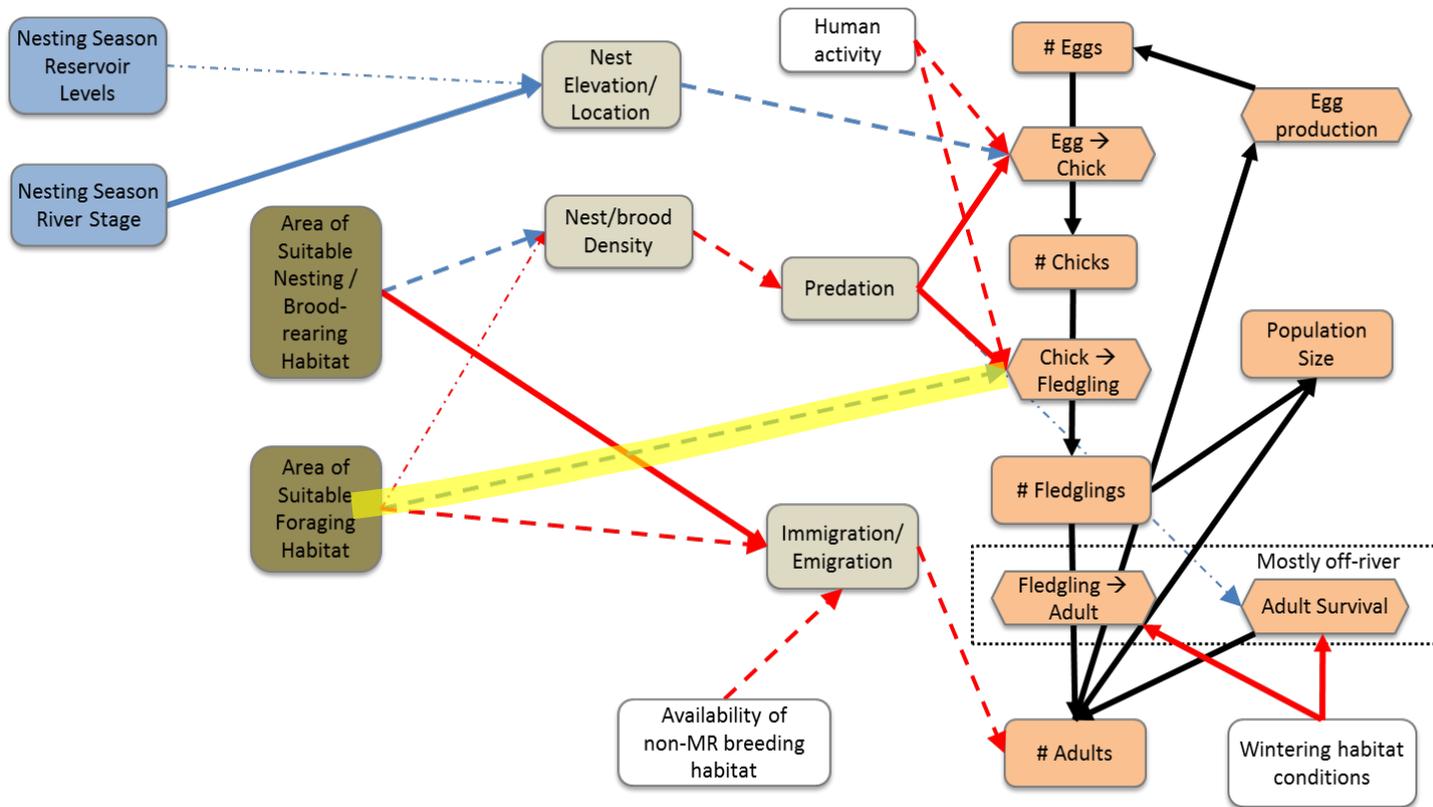
	Tern biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
T1	Steady or decreasing reservoir levels/river stage during the nesting season increases survival from eggs to chick by reducing inundation risk.	Higher water levels early in the nesting season increases elevation of nest sites, as terns must nest above the current water level. Steady or decreasing water levels during the nesting season, such that the water level stays below the elevation of nests, increases egg to chick survival.	medium high (river) low (reservoir) medium	medium medium	



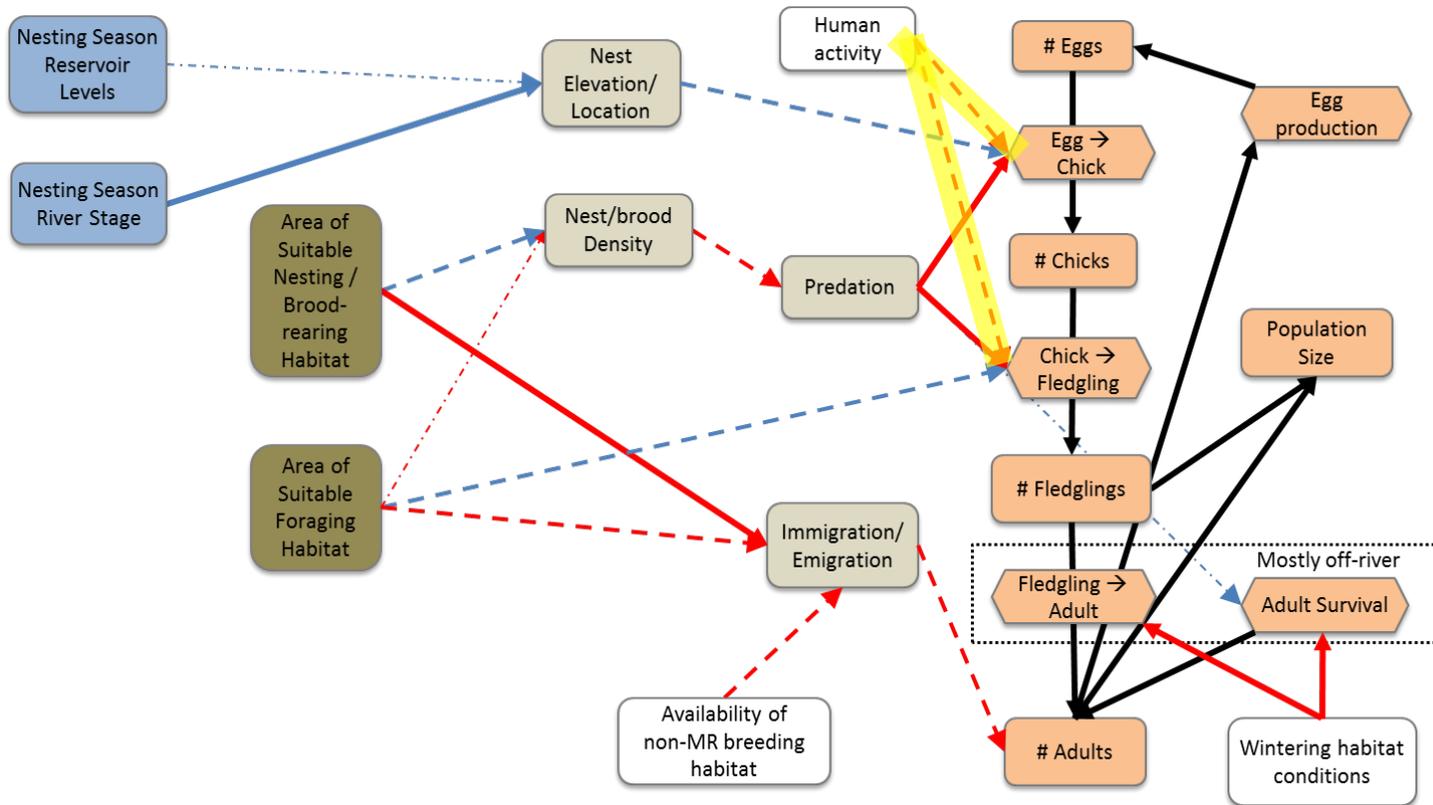
	Tern biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
T2	Increases in area of suitable nesting/brood-rearing habitat increases survival of eggs to chicks and chicks to fledglings by reducing predation.		medium	high	Assuming that effects of habitat area on predation mortality are similar for eggs and chicks
		For a given population size, increases in nesting/brood-rearing habitat area decrease local nest/brood density	medium	medium	If birds do not use all available habitat, local nest density may not decrease with increases in habitat (clumped distribution)
		Lower nest/brood densities attracts fewer predators and/or make nests and chicks harder to find, reducing predation.	medium	high	
		Decreases in predation increase survival of eggs to chicks and chicks to fledglings.	high	high	



	Tern biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
T3	Increases in area of suitable foraging habitat increases the survival of chicks to fledglings.		medium	medium	Includes effects of reduced adult foraging time resulting in increased vigilance at nest.



	Tern biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
T5	Human activity (including pets/livestock) reduces survival of eggs to chick and chick to fledglings.		medium	high	location dependent



	Tern biotic hypotheses/pathways	Intermediate hypotheses/mechanisms	Import.	Uncert.	Notes
T6	More favorable conditions at wintering habitat and migratory stopover sites improves survival from juvenile to adult and overwinter adult survival.		high	high	Especially high uncertainty as location and quality of overwinter habitat is unknown.

