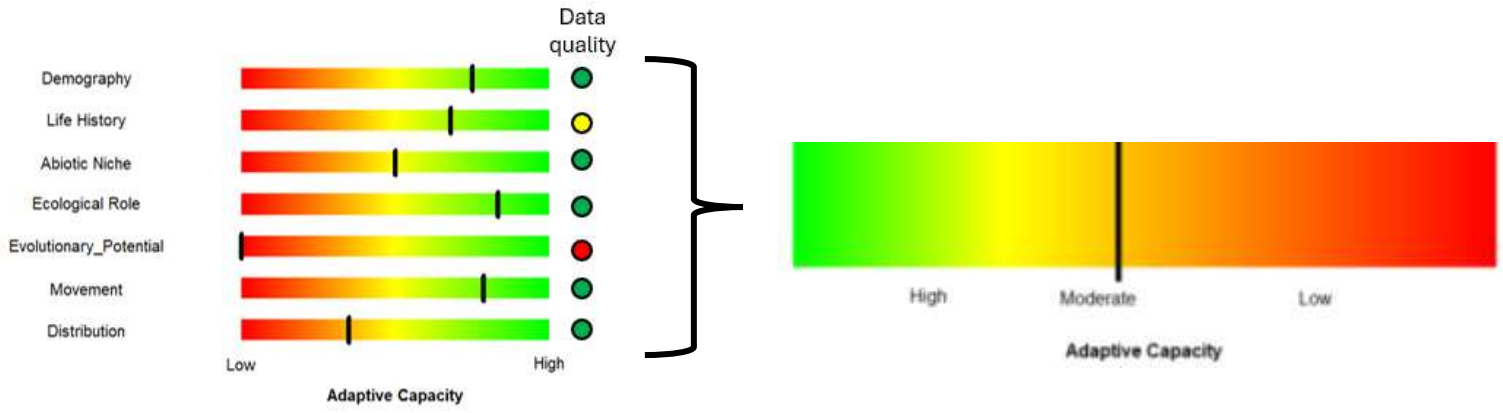
Adaptive Capacity of Black Swift (*Cypseloides niger*)

Adaptive Capacity refers to the intrinsic ability of a species to adapt to predicted changes in its environment. This assessment scores species on 37 species or population attributes documented in the scientific literature or with local research across seven categories: distribution, movement, evolutionary potential, ecological role, abiotic niche, life history, and demography (Appendix A). Natural resource managers and others can then use these assessments to understand a species vulnerability to a variety of environmental stressors and identify and prioritize the most effective management strategies for increasing a species' resilience to those stressors. The methodology to assess adaptive capacity is an extension of NatureServe's climate change vulnerability index that was developed by Nature Serve in partnership with the US Geological Survey.

The assessment is conducted over 37 categories organized within 7 modules. Within each module categories are scored from High adaptive capacity (0 points) to Low adaptive capacity (4 points) and the proportion of points scored for each module is then summed to determine the species' adaptive capacity. Note that the scoring may be counterintuitive as high adaptive capacity values have low point scores while low values have high point scores. To make visualization more intuitive, slider bar figures are inverted.

Summary

Species has a score of Moderately Low Adaptive Capacity indicating that it may not adapt well to climate change and may struggle to adapt to other threats it faces in Montana.



Contents

Assessment Modules

Distribution

Factor	Adaptive Capacity	Score	Comments
Extent of Occurrence	High	0	71,766 km2 from NHP Range Maps
Area of Occupancy	High	0	8,432 km2 from NHP predicted habitat models
Habitat Specialization	Low	4	Species nests under waterfalls
Commensalism with Humans	Moderate	2	Species tolerates human presence near nests, but not disturbance
Geographic Rarity	Moderate-High	1	Species is found in discrete populations in the Pacific northwest, Colorado, California, Mexico and Central America.
7 total points/20 possible points = 0.35			

Low High

Movement

Factor	Adaptive Capacity	Score	Comments
Dispersal Syndrome	Low	4	Swifts show high nest site fidelity, but have been documented to disperse to new sites if previous sites are no longer suitable
Dispersal Distance	Moderate- High	1	species has substantial movement capability, but exhibits a moderate to high degree of site fidelity and has very limited existing or potential habitat within the assessment area
Dispersal Phase	High	0	Species may disperse to new nest sites throughout its life
Site Fidelity	Low	4	Species has high fidelity to nest sites
Migration Frequency	High	0	Annual migration
Migration Demography	Low	4	All individuals migrate in Montana
Migration Timing	High	0	Migration cues are thought to be biotic and abiotic and are likely flexible.
Migration Distance	Low	4	Species overwinters in central and South America
17 total points / 32 possible points = 0.53			

Low AC High AC

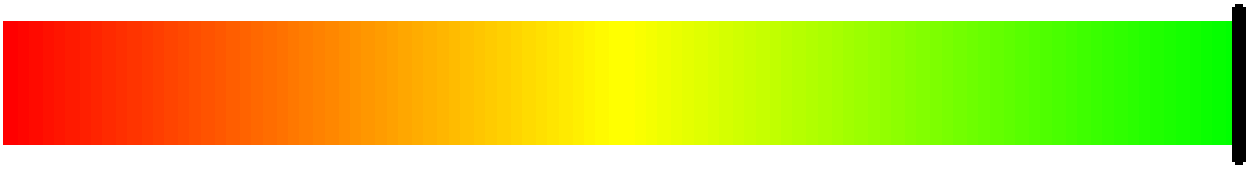
Evolutionary Potential

Factor	Adaptive Capacity	Score	Comments
Genetic Diversity	Unknown	-	Genetic Diversity has not been studied in this species within Montana
Population Size	Moderate-Low	3	Population in Montana is estimated to be between 263 and 743 individuals.
Hybridization Potential	Low	4	Species is not known to hybridize with other species
7 total points / 8 possible points = 0.88			

Low AC High AC

Ecological Role

Factor	Adaptive Capacity	Numeric	Comments
Enemies	High	0	No species likely to be favored by climate change are likely to impact this species
Diet Breadth	High	0	Species' diet is flexible
Diversity of Obligate Species	High	0	No interspecific dependencies
0 points/ 12 possible points = 0			



Low AC High AC

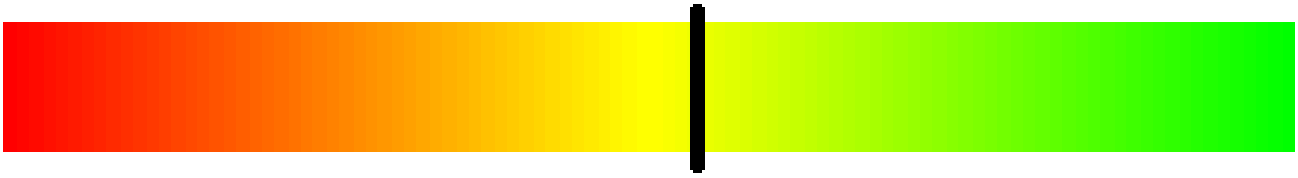
Abiotic Niche

Factor	Adaptive Capacity	Score	Comments
Seasonal Phenology	High	0	Migration and breeding are dependent on biotic and abiotic cues, but species is capable of adjusting timing to accommodate these changes
Climate Niche Breadth	Low	4	Species breeds at waterfall sites with very specific microclimates which may be reduced as a result of climate change.
Physiological Tolerances	Low	4	Nests in cool, wet areas. Change in these conditions would cause nest failure
Behavioral Regulation of Physiology	Low	4	Nest selection is inflexible
Disturbance Tolerance	Moderate	2	Changes in the intensity, frequency, or severity of disturbance events due to climate change are likely to have moderate impacts on the species
14 total points / 20 possible points = 0.70			

Low AC High AC

Life History

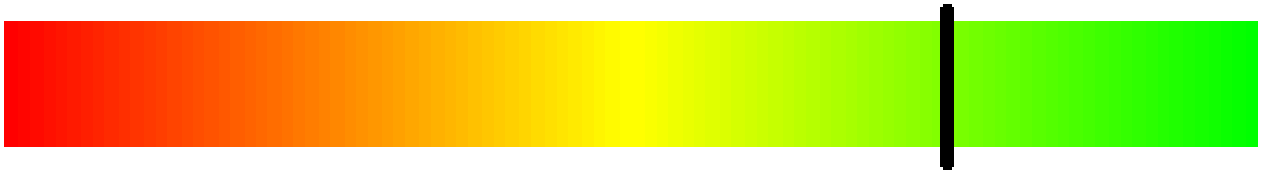
Factor	Adaptive Capacity	Score	Comments
Reproductive Phenology	Moderate	2	Migration and breeding rely on biotic and abiotic factors, but species may adjust timing of breeding to account for changes
Reproductive Mode	Moderate	0	Species is oviparous
Mating System	Moderate- Low	3	Species is monogamous
Fecundity	Moderate	2	Lifetime fecundity is poorly documented. Species lays a single egg per year but is long lived. Likely 3-10 offspring per lifetime.
Parity	High	0	Species is Iteroparous
Sex Ratio	High	0	Sex Ratios are approximately 1:1
Sex Determination	High	0	Chromosomal sex determination
Parental Investment	Low	4	Young are altricial
11 total points / 32 possible points = 0.34			



Low AC High AC

Demography

Factor	Adaptive Capacity	Score	Comments
Life Span	Moderate-Low	3	Species can live between 10-20 years
Generation Time	Moderate-High	1	Generation time is likely between 3-5 years
Age of Sexual Maturity	Moderate	2	Species matures in 3-5 years (~1/3 of lifespan). Assessed as Moderate but could be High.
Age Structure	Moderate	2	Poorly documented but populations may have a relatively balanced age structure
Recruitment	Unknown	-	Unknown
8 total points/ 16 possible points = 0.5			

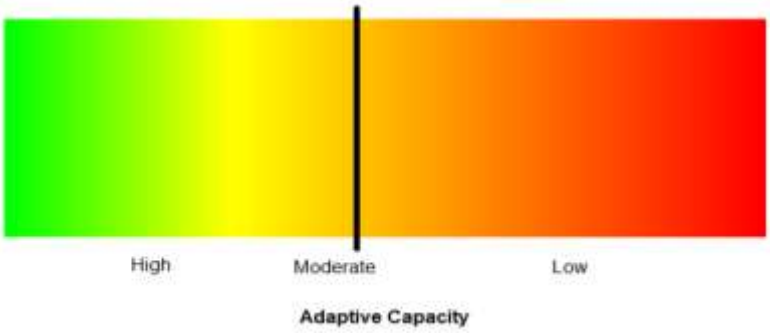


Low AC High AC

Calculation of Adaptive Capacity

The adaptive capacity score of a species is calculated as the sum of each module score.

Module	Score
Distribution	0.35
Movement	0.53
Evolutionary Potential	0.88
Ecological Role	0
Abiotic Niche	0.7
Life History	0.34
Demography	0.5
Sum = 3.3	



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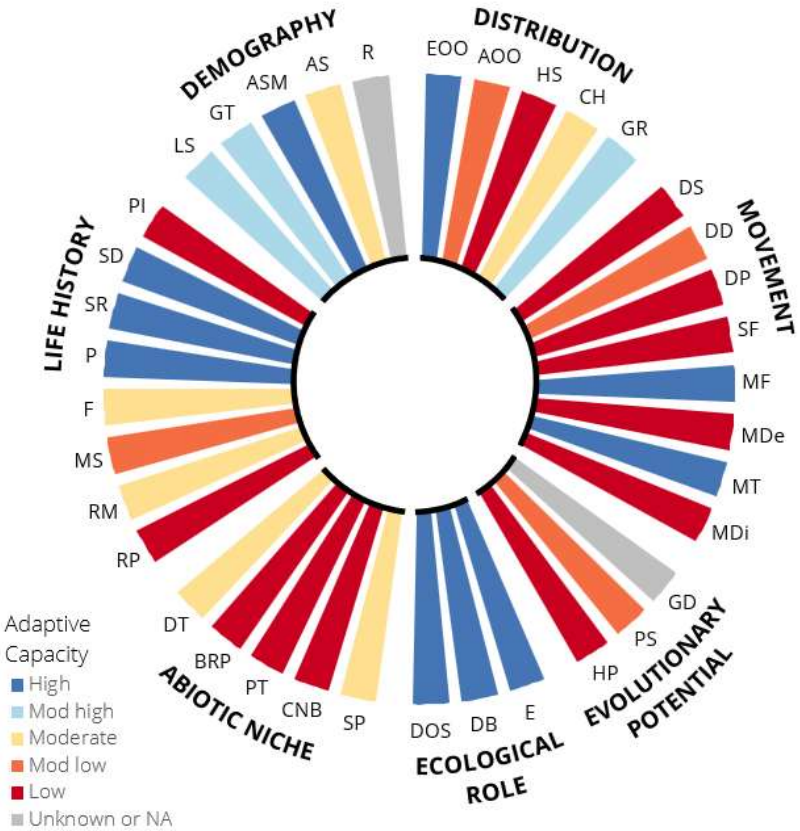

Adaptive capacity scores across the 37 assessment categories grouped by the seven modules. Category codes can be found in methodology to assess adaptive capacity.

Appendix A: Category Definitions and Scoring

Module	Factor	Description	Adaptive Capacity	Definition
Distribution	Extent Of Occurrence	The area contained within the shortest continuous boundary that can be drawn to encompass all known, inferred, or projected sites of present occurrence of a taxon, excluding cases of vagrancy (IUCN 2012). In the case of migratory species, Extent of Occurrence should be based on the minimum of breeding or non-breeding areas, but not both, because the bulk of the population is found in only one of these areas at any given time.	Low	<100km2
			Moderate-Low	100-5000 km2
			Moderate-High	5000-20,000 km2
			High	>20,000 km2
	Area of Occupancy	The area within a species' Extent of Occurrence, excluding cases of vagrancy (IUCN 2012). Area of Occupancy is a scaled metric that represents the area of suitable habitat currently occupied and is a measure of "insurance effect," wherein taxa that occur within many patches or large patches across a landscape are insured against risks from spatially explicit threats. Area of Occupancy reflects the fact that a taxon will not usually occur throughout the area of its Extent of Occurrence, which may contain unsuitable or unoccupied habitats. In some cases, the Area of Occupancy is the smallest area essential at any stage to the survival of existing populations of a species. The size of the Area of Occupancy will be a function of the scale at which it is measured and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats, and available data.	Low	<10 km2
			Moderate-Low	10-500km2
			Moderate-High	500-2,000km2
			High	>2,000km2
	Habitat Specialization	Also referred to as habitat specificity. Habitat Specialization evaluates the use of a relatively restricted subset of habitats, with narrow or well-defined physical or biotic characteristics, for the purposes of foraging, breeding, and other important life-cycle	Low	Highly dependent on a particular habitat
			Moderate	Moderately dependent on a particular, uncommon, habitat; (1) an indicator of, but not an endemic to that habitat (contains 65–85% of occurrences); OR (2) more or less restricted to a habitat that is uncommon within

Module	Factor	Description	Adaptive Capacity	Definition
		processes, including the reliance on particular habitats through which a species can move.		the species' range but is not one of the dominant types within that range.
			High	Having a clear preference for a particular habitat (contains >85% of occurrences), but the habitat is among the dominant types within the species' range; OR somewhat flexible in habitat utilization; OR described as a habitat generalist and/or occurrence has been documented on widely varied habitat types
	Commensalism with Humans	Degree of tolerance of human interactions and infrastructure.	Low	Intolerant of human influences and/or human-dominated landscapes
			Moderate	Moderately tolerant of human influences, utilization of semi-natural landscapes (e.g., agricultural fields, suburban parks)
			High	Highly tolerant of human influences, wide utilization of human dominated landscapes
	Geographic Rarity	Sensu Rabinowitz (1981); takes into consideration that some species may be broadly distributed in their spatial extent but simultaneously exhibit patchiness in their occurrence, or low local abundance.	Low	Geographically restricted with isolated populations
			Moderate-Low	Geographically restricted with highly connected populations (e.g., endemic species)
			Moderate-High	Broadly distributed with sparse or isolated populations
			High	Broadly distributed with highly connected populations (i.e., common)
Movement	Dispersal Syndrome (Mobile Species)	The degree of flexibility in either the timing or mechanism of dispersal. For mobile organisms, dispersal can either be obligate (dispersal events are fixed within a specific life stage) or facultative (individuals can "choose" if and when to disperse). For sessile organisms, dispersal syndrome refers to the morphological characteristics of seeds or propagules that are correlated with particular dispersal agents	Low	Obligate (fixed timing, or dependence on a specific cue)
			High	Facultative (flexible timing, or no cue dependence)
	Dispersal Dis	The distance an individual or propagule can move from an existing population's location, or a population's average location.	Low	Species is characterized by severely restricted dispersal or movement capability (

Module	Factor	Description	Adaptive Capacity	Definition
			Moderate-Low	Species is characterized by highly restricted dispersal or movement capability; species rarely disperses through unsuitable habitat more than about 10–100 m per dispersal event; OR dispersal beyond a very limited distance (or outside a small, isolated patch of suitable habitat) periodically or irregularly occurs, but is dependent on highly fortuitous or rare events; OR species has substantial movement capability but exhibits a very high degree of site fidelity
			Moderate-High	Species is characterized by limited (or moderate), but not highly or severely restricted, dispersal or movement capability; a large percentage (at least 50%) of propagules or individuals disperse approximately 100–1000 m per dispersal event (rarely farther); OR species has substantial movement capability, but exhibits a moderate to high degree of site fidelity and has very limited existing or potential habitat within the assessment area
			High	Species is characterized by good to excellent dispersal or movement capability; species has propagules or dispersing individuals that commonly move more than 1 km from natal or source areas; OR species tends to occupy all or most areas of suitable habitat, or readily or predictably moves more than 1 km to colonize newly available habitat
	Dispersal Phase	The phase or life-stage in which individuals or propagules disperse.	Low	Short period or discrete phase (e.g., life stage)
			High	Long period or throughout life
	Site Fidelity	Natal site fidelity (the propensity to be a “stayer” within the population) allows for locally adapted life history traits that increase reproductive success and fitness. Alternatively, “straying”	Low	High site fidelity (higher proportion of “stayers”)
			Moderate	Moderate site fidelity (roughly equal proportion of “stayers” and “strayers”)

Module	Factor	Description	Adaptive Capacity	Definition
		during dispersal events promotes the colonization of new habitats, increases opportunities for genetic mixing among populations, and can buffer populations from variation in habitat quality.	High	Low site fidelity (higher proportion of “strayers”)
	Migration Frequency	The frequency in which individuals of a population migrate within their lifetime.	NA	Species is not migratory
			Low	Once during lifetime
			High	Throughout lifetime (annually or seasonally)
	Migration Demography	The proportion of individuals in a population that migrate during a migratory event.	NA	Species is not migratory
			Low	Complete (most or all individuals within a population migrate)
			Moderate	Partial (some individuals reside on breeding/natal grounds year-round, while others migrate)
			High	Differential (individuals migrate different distances or to different locations)
	Migration Timing	The timing of migration and dependence on environmental cues.	NA	Species is not migratory
			Low	Obligate (fixed timing or reliance on environmental cue or resource)
			High	Facultative (flexible timing and independent of environmental cue or resource)
	Migration Distance	The total, geographic distance spanned during a migratory event. Long-distance migrants have shown steeper population declines than their resident and short-distance migratory counterparts. Ecological conditions at stopover sites, along with weather conditions, affect the survival, schedules, and reproductive success of migrants. Long-distance migrants are therefore at increased risk of exposure to spatially heterogeneous threats.	NA	Species is not migratory
			Low	Long-distance migration (e.g., crosses geopolitical, large-landscape, or ecotypic boundaries)
			Moderate	Variation in distances or destinations within a population/species (differential migration)
			High	Local migration
Evolutionary Potential	Genetic Diversity	The diversity of genotypes (or genetic variability) within a species. Genetic diversity can be subdivided into adaptive vs neutral genetic diversity. Neutral genetic diversity confers no direct effect on fitness, or the adaptive potential of a population, but it can	Low	Low, within-population genetic variability; OR genetic variation reported as “very low” compared to findings using similar techniques on related taxa (i.e., lack of genetic variation has been identified as a conservation

Module	Factor	Description	Adaptive Capacity	Definition
		inform processes such as genetic drift, gene flow, dispersal, and migration (i.e., functional connectivity). Adaptive genetic diversity is the genetic variation under natural selection; it informs a population's evolutionary adaptive potential and is assessed in quantitative genetic experiments.		issue for the species; OR evidence that total population was reduced to ≤250 mature individuals, one occurrence, and/or that occupied area was reduced by >70% at some point in the past 500 years
			Moderate	Moderate, within-population genetic variability; OR genetic variation reported as "low" compared to findings using similar techniques on related taxa; OR evidence that total population was reduced to 251–1000 mature individuals, to less than ten occurrences, and/or that occupied area was reduced by 30–70% at some point in the past 500 years
			High	High, within-population genetic variability; OR genetic variation reported as "average" or "high" compared to findings using similar techniques on related taxa; OR No evidence that total population was reduced to ≤1000 mature individuals and/or that occupied area was reduced by >30% at some point in the past 500 years
	Population Size	The number of individuals in a population or metapopulation that co-occur in a particular geographic area and are capable of interbreeding, including those who contribute offspring to the next generation (i.e., all reproducing individuals in that population) and non-reproducing individuals (adapted from IUCN Red List thresholds, IUCN Standards and Petitions Subcommittee 2019); Population size should be evaluated with consideration of genetic diversity and gene flow, wherein a population contains individuals that are more genetically related than individuals of other populations from which they are physically and/or genetically isolated.	Low	<250 mature individuals (low local abundance), or estimated population decline by ≥25% within 3 years or one generation, whichever is longer
			Moderate-Low	<2500 mature individuals, or estimated population decline by ≥20% within 5 years or two generations, whichever is longer
			Moderate-High	<10,000 mature individuals, or estimated population decline by ≥10% within 10 years or three generations, whichever is longer
			High	>10,000 mature individuals (high local abundance), with high probability of long-term persistence
	Hybridizati		Low	Hybridization does not occur OR hybridization occurs but offspring are not viable, or have lower fitness

Module	Factor	Description	Adaptive Capacity	Definition
		Existence of closely related species, subspecies, or allopatric populations for interbreeding, with much consideration of fitness consequences such as outbreeding depression.	Moderate	Hybridization probably occurs (fitness consequences unknown)
			High	Hybridization occurs; offspring are viable (minimal to no fitness consequences)
Ecological Role	Enemies	Consideration of biotic interactions is essential to accurately predicting species' responses to climate change as some species may be favored while others become disadvantaged. Climate change can disrupt food webs by altering the distribution or abundance of species that act as key resources, competitors, or predators in the system, or by shifting phenology and synchronies of interacting organisms (e.g., host-pathogen dynamics), ultimately causing important changes in the nature of relationships among species. Climate change can also be a driver of species introductions and range shifts, resulting in new and novel interactions.	Low	Strongly affected by a native or non-native species that is likely to be favored by climate change; OR climate change is likely to substantially increase the prevalence of the natural enemy (or enemies); OR significant disruptions to trophic or nontrophic interactions, with consequences for species' fitness or access to critical resources (e.g., through altered predator-prey interactions, competition, or disease dynamics)
			Moderate	Moderately affected by a native or non-native species that is likely to be favored by climate change; OR climate change is likely to only marginally increase the prevalence of the natural enemy (or enemies); OR disruptions to trophic or nontrophic interactions likely to have minimal consequences for species' fitness or access to critical resources (e.g., through altered predator-prey interactions, competition, or disease dynamics)
			High	Little or no response to a native or non-native species that is likely to be favored by climate change; OR climate change is likely to reduce or have no impact on the prevalence of the natural enemy (or enemies); OR no significant disruptions to trophic or non-trophic interactions, with no significant consequences for species' fitness or access to critical resources (e.g., through altered predator-prey interactions, competition, or disease dynamics)

Module	Factor	Description	Adaptive Capacity	Definition
	Diet Breadth	Also referred to as diet versatility or flexibility; ability to utilize a range of food resources, or to be flexible in prey preference. This factor is not relevant to plants and other primary producers.	Low	Completely or almost completely (>90%) dependent on one food item (species) during any part of the year; equivalent alternatives to this single-species food resource are not readily available
			Moderate	Completely or almost completely (>90%) dependent during any part of the year on either (1) a few species from a restricted taxonomic group, or (2) a narrow guild the members of which are thought to respond similarly to climate change
			High	Diet flexible; during any season species readily switches among multiple food resources according to availability; OR not strongly dependent on one or a few species; OR omnivorous, with diet including numerous species of both plants and animals
	Diversity of Obligate Species	Also referred to as interspecific dependencies; the number of obligate species interactions, including mutualists, pollinators, dispersers, etc., that a focal species relies on to complete some aspect of its life cycle not pertaining to food resources.	Low	Obligated to one or few species
			Moderate	Obligated to a restricted network (or pool) of species, indicating some functional redundancy in those species to which it is obligated
			High	Diffuse interactions (no obligations)
Abiotic Niche	Seasonal Phenology	The timing of periodic life cycle events, not directly related to reproduction or movement, that are influenced by seasonal and interannual variations in climate. Seasonal events can include budburst, leaf abscission, timing of developmental cycles, hibernation, etc.	Low	Dependence on environmental cue; species is incapable of adjusting the timing or duration of life-cycle events (i.e., detectable change in cue, but no detectable change in the phenological variable measured); OR timing indirectly dependent and linked to non-environmental cue (e.g., photoperiod), which may result in fitness consequences due to misalignment between life-cycle events and climate
			Moderate	Moderate dependence on environmental cue; species is capable of adjusting the timing or duration of life-cycle events (i.e., detectable change in cue and species

Module	Factor	Description	Adaptive Capacity	Definition
				shows some associated change in the phenological variable measured, but change may be less than that of other species in similar habitats or taxonomic groups)
			High	No dependence on environmental cue; OR dependence on environmental cue, but species is capable of adjusting the timing or duration of life-cycle events (i.e. detectable change in cue and species shows an associated change in the phenological variable measured which is average compared to other species in similar habitats or taxonomic groups; OR timing indirectly dependent and linked to non-environmental cue (e.g. photoperiod) that is not expected to result in fitness consequences due to misalignment between life-cycle events and climate (or misalignment is minimal)
	Climatic Niche Breadth	A measure of niche specialization and reflective of the range of abiotic conditions to which a species is adapted, and their degree of flexibility in responding to changing conditions potentially outside of that range.	Low	Species is completely or almost completely (>90% of occurrences or range) restricted to a particular climatic (or oceanic/hydrological) condition that may be lost or reduced in the assessment area as a result of climate change
			Moderate-Low	Species is moderately (50–90% of occurrences or range) restricted to a particular climatic (or oceanic/hydrological) condition that may be lost or reduced in the assessment area as a result of climate change
			Moderate-High	Species is somewhat (10–50% of occurrences or range) restricted to a particular climatic (or oceanic/hydrological) condition that may be lost or reduced in the assessment area as a result of climate change

Module	Factor	Description	Adaptive Capacity	Definition
			High	Species distribution is not greatly affected by climatic (or oceanic/ hydrological) conditions in the assessment area; OR species occupies habitats that are thought to be not vulnerable to projected climate change; OR species shows a preference for environments at the warmer end of the spectrum (or the leading edge of changing conditions)
	Physiological Tolerances	Reflects the degree to which a species (or population) is restricted to a narrow range of abiotic conditions (e.g., temperature, hydrology, or snow conditions). Evaluation often begins with the identification of the differences in sublethal and lethal effects of climate change on the organism. Individuals exposed to climate stressors may reach a state that is beyond their capacity to maintain homeostasis and, consequently, may display changes in behaviors or performances, such as growth rates and reproduction, to defend themselves against stressors. This requires an understanding of thermal limits (or reaction norms), or degree of tolerance of physiological stressors and whether or not the range of conditions causes lethal or sublethal effects. To assess tolerances to future changes, consider how responsive the species has been to previous, or historical, variability.	Low	Range of novel conditions are known to cause lethal effects (intolerable); OR variation in historical conditions for the limiting abiotic factor is highly restricted
			Moderate	Range of novel conditions unlikely to cause lethal effects (moderately tolerable), although sublethal effects have been observed; OR variation in historical conditions for the limiting abiotic factor is moderate
			High	Range of novel conditions are not likely to cause sub-lethal or lethal effects (tolerable); OR variation in historical conditions for the limiting abiotic factor is broad and/or extreme events have occurred with no subsequent declines in abundance or extent of occurrence
	Behavioral Regulation of Physiology	The ability of individuals to change their behavior in effort to reduce exposure to climate stressors, such as the use of microhabitat features that moderate temperature and extreme conditions (e.g., rock crevices, tree hollows, burrows), or activity periods that limit their exposure to extreme temperatures.	Low	Minimal or no behavioral flexibility and reduction in exposure; species lacks cognitive capacity to enact a behavior, or behavior is canalized and not responsive to environmental influences, or species is restricted in expression of behavior by access to essential resources or other physiological limitations; OR behavior chronically restricts foraging or other essential activities and therefore reduces survivability or fitness
			Moderate	Moderate behavioral flexibility and reduction in exposure; behavior is infrequent, or is occasionally

Module	Factor	Description	Adaptive Capacity	Definition
				limited due to restricted access to resources; OR behavior temporarily restricts foraging or reproductive activities, but is not detrimental to survivability or fitness
			High	High behavioral flexibility and reduction in exposure; behavior is not restricted by access to essential resources and does not substantially limit activities necessary for survival or reproduction
	Disturbance Tolerances	Ecological disturbances are events or forces of abiotic or biotic origin that cause mortality to organisms and changes in their spatial patterning. This plays a significant role in shaping the structure and function of ecosystems. The ecological impact of a disturbance is dependent on its intensity, frequency, severity, and spatial extent. Disturbances can include minor events like localized droughts, floods, small wildland fires, and disease outbreaks in plant and animal populations. They may also include major events like hurricanes and broad-scale wind events or forest fires. Though disturbances tend to negatively affect species, some species are disturbancedependent (or disturbance-adapted) and others can capitalize on opportunities from disturbance events to move into, and gain footholds in, ecosystems that once excluded them.	Low	Changes in the intensity, frequency, or severity of disturbance events due to climate change are likely to have significantly negative impacts on the species; OR changes in the disturbance regime will be beyond the species tolerance limits and likely to cause lethal effects; OR historical range of variation in patterns of disturbance is highly restricted
			Moderate	Changes in the intensity, frequency, or severity of disturbance events due to climate change are likely to have moderate impacts on the species; OR changes in the disturbance regime are marginal and not known to be detrimental to the species fitness or survival; OR variation in historical patterns of disturbance is moderate
			High	Changes in the intensity, frequency, or severity of disturbance events due to climate change are unlikely to have impacts on the species; OR changes in the disturbance regime will be within the species tolerance limits and unlikely to affect species fitness; OR historical patterns of disturbance are highly variable
Life History	Reproducti	The timing of reproductive events within a species life cycle that are influenced by seasonal and interannual variations in climate.	Low	Dependence on environmental cue; species is incapable of adjusting the timing or duration of

Module	Factor	Description	Adaptive Capacity	Definition
				reproductive events (i.e., detectable change in cue, but no detectable change in the phenological variable measured); OR timing indirectly dependent and linked to non-environmental cue (e.g., resource availability), which may result in fitness consequences due to misalignment between reproductive events and climate
			Moderate	Moderate dependence on environmental cue; species is capable of adjusting the timing or duration of reproductive events (i.e., detectable change in cue and species shows some associated change in the phenological variable measured, but change may be less than that of other species in similar habitats or taxonomic groups)
			High	No dependence on environmental cue; OR dependence on environmental cue, but species is capable of adjusting the timing or duration of reproductive events (i.e., detectable change in cue and species shows an associated change in the phenological variable measured, which is average compared to other species in similar habitats or taxonomic groups); OR timing indirectly dependent and linked to non-environmental cue (e.g., resource availability) that is not expected to result in fitness consequences due to misalignment between reproductive events and climate (or misalignment is minimal)
	Reproductive Mode	In sexually reproducing organisms, there are multiple modes of reproduction, differentiated based on the relationship between zygote and parents. These include non-viviparous modes:	Low	Ovuliparity or broadcast spawning
			Moderate	Oviparity or direct development or colonial (as in Hymenopterans)

Module	Factor	Description	Adaptive Capacity	Definition
		ovuliparity, in which fertilization is external and eggs are released into the environment to be fertilized, and oviparity, in which fertilization is internal and the male inserts the sperm into the female intermittently or is picked up from the environment, and the female lays eggs. These modes are distinguished from viviparity, which covers all modes resulting in live birth. Asexual reproductive modes are captured in factor H3 (Mating System).	High	Viviparity or ovoviviparity (eggs are retained within the mother's body until they are ready to hatch)
	Mating System (Animals)	Group structures within populations related to reproductive behaviors; in animals, this ranges from two-partner (monogamous) systems to promiscuous, multi-partner systems; similarly, in plants, reproductive systems reflect varying degrees of outcrossing, which can range from asexual or cloning systems to cross-fertilization among multiple individuals; these systems contribute to the gene frequency and genetic variability within a population. Although self-fertilization has its advantages and is widespread among hermaphroditic species, it has many consequences for the genetic diversity and evolutionary dynamics of populations. Self-fertilization can increase genetic drift and reduces the efficacy of natural selection.	Low	Asexual (e.g., parthenogenesis)
			Moderate-Low	Monogamy or mixed modes of reproduction (e.g., facultative parthenogenesis in which organisms can produce offspring either sexually or asexually); OR hermaphroditism
			Moderate-High	Polygamy (when females have multiple mating partners, it is known as polyandry; when males have multiple mating partners, it is known as polygyny)
			High	Promiscuity (indiscriminate mating)
	Fecundity	The total number of offspring, seed sets, or asexual propagules produced, on average, by reproductive individuals of the species (or population) in a lifetime (i.e., lifetime average).	Low	One or two offspring or propagules
			Moderate	Few offspring or propagules (3–10)
			High	Many offspring or propagules (>10)
	Parity (Animals)	The number of times an organism reproduces within its lifetime (i.e., reproductive rate). In animals, species are either semelparous and have a single reproductive event per lifetime, or iteroparous with multiple reproductive cycles. In plants, species are either monocarpic (single flowering cycle), plietesial (grow for a number of years then flower gregariously or synchronously once), or polycarpic (multiple flowering cycles).	Low	Semelparous; single reproductive event per lifetime
			High	Iteroparous; multiple reproductive cycles per lifetime

Module	Factor	Description	Adaptive Capacity	Definition
	Sex Ratio	Spending equal amounts of resources to produce offspring of either sex is an evolutionarily stable strategy. For species where the cost of successfully raising one offspring is roughly the same regardless of its sex, this translates to an approximately equal sex ratio and is common in sexually reproducing species according to Fisher's principle, wherein parents will invest their resources equally between each sex of offspring because each sex supplies exactly half the genes of all future generations. However, many parthenogenic species and some colonial insect species can either permanently or periodically deviate from the 1:1 strategy and often exhibit female-biased sex ratios. Reptile species that exhibit environmental sex determination also tend towards skewed sex ratios.	Low	Skewed (female- or male-biased; common in small populations of certain taxa) with known or expected consequences to local mate availability, male-to-male aggression, male-to-female harassment, or other disruptions to pair-bond formation or reproductive output
			Moderate	Capable of facultative adjustments to mating systems to account for skewed adult sex ratios (as is the case in some species with female-biased populations); OR species is capable of hermaphroditism
			High	Balanced (1:1); OR temporary deviations from 1:1 sex ratio have no known or expected consequences on mate availability, intraspecific interactions, pair-bond formation, or reproductive output
	Sex Determination	In many species, sex determination is genetic, wherein males and females have different alleles (or genes) that specify their sexual morphology. In animals, this is often accompanied by chromosomal differences or haplodiploidy. With haplodiploidy, females arise from a fertilized egg (diploid) whereas males result from an unfertilized egg (haploid). In other cases, sex is determined by environmental variables (such as temperature) and populations may therefore be susceptible to skewed sex ratios (e.g., if ambient temperature increases). For species that reproduce via parthenogenesis, the sex of offspring is determined by the same method sex is determined in the species itself: for organisms where sex is determined by chromosomes, like the XX female and XY male chromosomes in some insects, fish and reptiles, females will only produce XX female offspring. For organisms where females have ZW sex chromosomes (such as in snakes and birds), all offspring produced will either be ZZ (male) or much more rarely if viable, WW (female).	Low	Temperature- or environment-dependent
			Moderate	Haplodiploidy; OR temperature-induced sex reversal as in some reptiles with chromosomal sex determination; OR parthenogenesis (including facultative parthenogenesis); OR asexually reproducing hermaphrodites
			High	Chromosomal

Module	Factor	Description	Adaptive Capacity	Definition
	Parental Investment	Any parental expenditure (time, energy, etc.) that benefits the offspring at a cost to parents' ability to invest in other components of their own fitness is considered a form of reproductive success (note, this factor is not applicable to plants and other primary producers). Parental Investment represents one of many life-history optimization tradeoffs reflective of the cost of reproduction. Individuals are limited in the degree to which they can devote time and resources to producing and raising their young, and such expenditure may be detrimental to their own future condition, survival, and reproductive output. However, such expenditure is typically beneficial to the offspring, enhancing their condition, survival, and future reproductive success. Parental Investment relates to parental energetic costs (as opposed to offspring survivorship, which is captured in factor H2 (Reproductive Mode).	Low	Altricial (young are hatched or born in an undeveloped state and require care and feeding by the parent[s])
			Moderate	Semi-precocial (dependent on parents for food) or semi-altricial; OR Altruistic care of young by non-reproducing individuals within the population (e.g., sterile worker bees)
			High	Precocial (young are relatively mature and mobile from the moment of birth or hatching and capable of feeding themselves)
Demography	Life Span	Also referred to as longevity; the period between birth and death for the individual, or the average length of life or life expectancy for a population.	Low	≥25 years
			Moderate-Low	10–25 years
			Moderate-High	1–10 years
			High	≤1 year
	Generation Time	Also referred to as generation interval; average time between two consecutive generations in the lineages of a population. Generation Time can be measured as the mother–daughter distance (the average age of mothers at birth of their daughters). Species with longer generation times typically have slower life histories and lower reproductive output.	Low	≥25 years
			Moderate-Low	10–25 years
			Moderate-High	1–10 years
			High	≤1 year
	Age of Sexual Maturity	Also referred to as age at recruitment or age of first reproduction; time to reproductive maturation, relative to overall lifespan. Age of Sexual Maturity is another life history optimization tradeoff; early reproduction lowers the chance of dying without offspring and increases the number of lifetime reproductive attempts	Low	Delayed (late relative to lifespan)
			Moderate	Intermediate (about halfway through lifetime)
			High	Rapid (early relative to lifespan)

Module	Factor	Description	Adaptive Capacity	Definition
		(thereby increasing fitness), but breeding investment in early life can reduce survival probability and accelerate senescence later in life. Therefore, Age of Sexual Maturity, when evaluated in the context of fecundity, parity, and parental investment, is an indicator of reproductive fitness.		
	Age Structure	A summary of the number of individuals of each age (or age class) in a population. Age Structure is useful in understanding and predicting population growth: if most individuals in a population are below the age of first reproduction, then the population is likely to grow, but if most individuals are beyond reproductive age, then the population would be expected to shrink. This factor is likely not applicable to annual plants or most insects.	Low	More old (higher proportion of population is beyond reproductive age)
			Moderate	Balanced (age classes are roughly equal)
			High	More young (higher proportion of population is below first age of reproduction)
	Recruitment	Proportion of juveniles surviving to adulthood (maturity) in a population. Recruitment can be an important factor in predicting future population growth potential; high recruitment may increase a species' current and future abundance within a system, whereas low recruitment can lead to reduced current and future abundance.	Low	Small proportion or None
			Moderate	Approximately half; OR variability in recruitment, such as for r-selected species that exhibit asynchronous and highly variable recruitment and mortality from year to year and across life stages
			High	Large proportion or all juveniles