

# Transcending Boundaries

*Avian and Human Migration in the Time of Climate Change*



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## INTRODUCTION

I sit writing at my desk watching European Starlings fly about outside my window. I find their iridescent coloration beautiful, and I am intrigued by their various vocalizations. Studying birds at the University of Vermont, in courses including Birding for Change and Ornithology, I have uncovered a strong connection to birds. I was fascinated when I learned about the journey of European Starlings that brought them to the United States, as they were brought by Shakespear fanatics who wanted to populate the New World with birds from England. (All About Birds, 2019). These birds are very prevalent now, and ecologists label them as invasive species. This perspective is logical on the basis of increased competition with native birds for food and nest sites (New York Invasive Species Information, 2019). However, in the book, *The Next Great Migration*, by Sonia Shah, she creates an argument to deconstruct the framework of invasive ecology. She argues the existence of this framework works to other species that originate from different places. This perpetuates a fear of the other and promotes native purity. This translates from ecology to anthropology and is shown through xenophobia and anti-immigration policies (Shah, 2020). I am not an ecologist and do not claim to understand this thought fully. However, this concept feels very personal to me as an Asian American, especially in these times of increased Asian hate crimes and racism. I believe it is worth questioning the framework of this ecological understanding of migration and invasives in order to have an interdisciplinary understanding of migration for both humans and wildlife. This is the context I bring to this research, and my identity informs my pursuit of knowledge.

The theme of transcending boundaries originated with the visual of birds flying unobstructedly through national and state borders during migration. This image contrasts the various barriers humans experience in their migration, as they are halted with social and political

structures. My research aims to transcend the boundaries between natural science and social science with an interdisciplinary exploration of avian and human migration. Climate change knows no boundaries, and its effects must be studied with a multispecies lens in order to create a just and resilient world.

## **WHAT IS MIGRATION?**

The definition of migration is expansive, as this one word is used to describe various forms of movement. Generally, migration is understood as a geographic relocation (IOM, 2020) (McFarland, 2014) (Britannica, 2021). Countless species living on Earth are migratory and will relocate their homes in their lifetime. Humans and birds have a long history of migration as an adaptive response to environmental changes that has shaped the distribution of each species on Earth (Shah, 2020). Broadly, birds and humans migrate because they are seeking something that is not available at their current residence (Bartram, Poros & Monforte, 2014) (Denny, 2016). Birds are especially known for their migration, and 40% of all bird species migrate (Denny, 2016). This number is approximated by using a multitude of different counting techniques including bird banding, manual counting, radio telemetry, satellite tracking and radar technology (Denny, 2016). On the other hand, 3.48% of the human population migrated internationally in 2019 (McAuliffe & Khadria, 2019). While this may seem like a small portion of the population, it does not account for the hundreds of millions of individuals who migrate within their nation's border (McAuliffe & Khadria, 2019). In addition, the prevalence of illegal and undocumented migration makes this number largely underestimated (Bartram, Poros & Monforte, 2014). The different types of migration in birds and humans are differentiated by many factors, some only applying to their respective species. Bird migration is shaped by the constraints of their biological ability and the geographies encountered on their route. Human migration is also

defined by those factors, but is also affected by abstract human made boundaries including international laws, politics and man made borders (Shah, 2020). However, “nature transgresses borders all the time. And with good reason” (Shah, 2020). The migration of both birds and people are unified by their pursuit of a better life (Dingle & Drake, 2007) (IOM, 2020).

## **TYPES OF BIRD MIGRATION**

The different forms of avian migration are largely defined by ecological factors and the scientific study of bird behavior. Depending on how many individuals of the population leave and when, bird migration is defined as complete, partial or irruptive. *Complete migration* encompasses journeys where all individuals within a species leave their breeding range when their nonbreeding season begins. This often corresponds with the change in seasons. These are long distance migrations, and can surpass 15,000 miles in total (Kerlinger, 2009). *Partial migration* is the most common type of migration, and like complete migration, it often correlates with the change in season (Kerlinger, 2009). However, unlike complete migrants, not all members of a species leave their breeding range, and some only travel half of the distance of others (Dingle & Drake, 2007) (Denny, 2016). In this type of movement, there is an overlap of the breeding and nonbreeding grounds (Kerlinger, 2009). When birds do not travel in a predictable manner, their migration is labeled as *irruptive*. The movement of irruptive migrants is not related to a change in seasons, nor is it geographically predictable. Instead, their migration has no pattern or repetition. The distance traveled and the number of members of a species is random. These movements are called irruptions (Kerlinger, 2009).

Another way to categorize bird migrations, is to divide them into obligate and facultative (Dingle & Drake, 2007). This distinction has more to do with the motivation for migration. Obligate and facultative migrants lie on opposite sides of a spectrum. Like many perceived

dualities, the distinction between different types of migration is not a harsh binary. Rather, many bird migrants have obligate and facultative parts of the journey (Newton, 2011). While both obligate and facultative migrants are guided by instincts, *obligate migration* is characterized by predictability and regularity, and the movement of birds is seemingly pre-programmed. Their migration has consistent timing, direction and distance that often corresponds with the seasons. Obligate migrants are also usually complete migrants, as most times all members of the species regularly leave their breeding range during non breeding season (Kerlinger, 2009). This type of migration corresponds to a consistent lack of food in the winter in a breeding area, and birds leave proactively before their resources perish to prevent possible starvation. This method of migration is mostly associated with long distance migrants, and they repeat the same scheduled journey each year (Newton, 2011) (Denny, 2016). This is also called annual migration (Dingle & Drake, 2007). In contrast to the repetition and consistency of obligate migration, facultative migration is irregular and inconsistent from year to year.

Rather than following a predictable schedule, *facultative migrants* leave in response to their environmental conditions at any given time (Newton, 2011). Birds may migrate to pursue a food source that fluctuates in availability or is declining, and the timing and distance of their travel varies each year (Denny, 2016). The decision to migrate is not predetermined and occurs as a direct result of a lack of resources. In addition, facultative migration occurs over short distances. Facultative migration encompasses both partial and irruptive migration, but irruption represents the more extreme case of randomness of this type of migration (Newton, 2011). Within obligate and facultative migration, avian travel is further differentiated by the reasons for embarking on the journey. The most cited reason for bird migration is food availability, and this is one of the underlying motivators of seasonal migration (Denny, 2016).

*Seasonal migration*, executed by obligant migrants, is an example of an annual migration, as these repeating journeys are synchronous with the annual cycle of seasonal changes (Dingle & Drake, 2007). Complete and partial migration can fall under seasonal migration (Kerlinger, 2009). In this type of migration, birds travel between breeding grounds and wintering grounds each year to avoid the physiological stresses of an undesirable climate (Dingle & Drake, 2007) (Ehrlich, Dobkin & Wheye, 1998). From living in the United States, we can observe this in *neotropical migrants* that breed in North America while their wintering grounds are in Central and South America. This journey is also described by the label of *latitudinal migration*, as birds move between the northern and southern hemispheres (Gregg, 2019). Alternately, *longitudinal migrants* move east and west (Mayntz, 2019). Due to the length of the neotropical migrant's journey, it is also known as a long-distance migration (Denny, 2016).

Birds leave preemptively before the bitter cold and snow eliminate food sources like insects, flowers and fruits (Denny, 2016). Shorter days also allow less time for birds to search for food (Ehrlich, Dobkin & Wheye, 1998). This demonstrates obligate migration, as the departure is not a direct result of a changing environment (Newton, 2011). Instead, birds are triggered by genetic predisposition and environmental factors like decreased photoperiod, or daylength, and lower temperatures (The Cornell Lab, 2007). An example is the Ruby-throated Hummingbird who breeds in the Eastern portion of the United States and Canada in the spring and summer months and starts flying south in the fall to its wintering grounds in Central and South America (Hummingbird Central, 2021). This migration allows individuals like hummingbirds to follow abundant resources and decrease competition in their wintering grounds (Ehrlich, Dobkin & Wheye, 1998).

In addition to latitudinal and longitudinal migration, there are also *altitudinal migrants*. These birds often live in mountains and travel between higher and lower altitudes regularly with the seasons also making them seasonal migrants. They breed at higher altitudes in warmer months and migrate to lower altitudes in colder months when food supply decreases (Denny, 2016). Just a few hundred feet can provide a significant change in temperature and resources, so these birds are often short-distance migrants (Mayntz, 2019). Seasonal migration can also be considered a *loop migration* when the returning route from the wintering grounds is different from the route taken to get there when departing the breeding grounds. In addition to moving based on the seasons, birds can also irrupt to follow food resources (Denny, 2016).

Not guided by instinct, birds can react directly to a shortage of food by irrupting, an example of facultative migration (Newton, 2011). An *irruption* is an irregular movement of a group of individuals of a bird population beyond its normal breeding or non breeding ranges (Dingle & Drake, 2007). The number of individuals and distance traveled is random and inconsistent with each migration (Kerlinger, 2009). In addition, this migration is not seasonal and is random based on changing resource availability (Denny, 2016). Similar to irruptions, *nomadic migration* is also unpredictable and responds to resource availability. However, nomadic migrants move within the normal geographic range (Mayntz, 2019). As a result, this falls under the category of partial migration, and these are short-distance migrants (Newton, 2011) (Kerlinger, 2009). Populations of birds abandon parts of their breeding or non breeding range together in pursuit of food and water. Once the resources of an area of their range are depleted, they move on (Mayntz, 2019). If plentiful resources are discovered, the population may stay and become residents (P. Allen Smith, 2016). Like bird migration, human migration is differentiated into many different types.



## TYPES OF HUMAN MIGRATION

Less scientific than bird migrations, the different modes of human migration are defined by social institutions and motivations for moving. Human migration is defined by the United Nations (UN) as “The movement of persons away from their place of usual residence, either across an international border or within a State”. This move can be permanent or temporary and caused by a variety of reasons (IOM, 2020). Contrary to the beliefs of some politicians with anti-immigration agendas, humans are meant to migrate. Like birds, humans have evolved to migrate in response to changing environmental conditions, whether they be political or biological, to increase our chances of survival (Shah, 2020). Also like bird migration, human migration is an umbrella term that has many different subtypes. Similar to birds, human migration is differentiated by the distance traveled, duration of relocation, the regularity of the movement and the reasons for migrating (Denny, 2016) (IOM, 2020). In contrast, man made borders and international law are human constructed barriers that affect the definitions of human migration with no effect on birds (IOM, 2020). This makes human migration difficult to define in many cases, as borders are subject to change over time and international institutions have the subjective power to label certain types of migrants based on their reasons for leaving home (Bartram, Poros & Monforte, 2014). In addition, while there are many reasons that drive human migration, not all people are able to migrate. “Whether it’s money, skills, connection, or stamina, migration requires capital” (Shah, 2020). The world’s poor are most vulnerable and motivated to migrate, yet they often lack the resources to relocate. However, to put it simply, “we’ve been moving all along” (Shah, 2020).

To begin defining types of human migration, all forms of migration can be categorized as either temporary and permanent depending on the duration. A *short-term or temporary migration*

refers to a change in residence that lasts from three to 12 months while a *long-term or permanent migration* lasts for one or more years (United Nations, 2021). Like birds, there are short distance and long distance human migrants. Unlike birds, borders are also an important detail that is used to differentiate types of human migration.

A border is a human made concept that guides and restricts people's movements (Bartram, Poros & Monforte, 2014). The UN International Organization for Migration (IOM) defines borders as “politically defined boundaries separating territory or maritime zones between political entities and the areas where political entities exercise border governance measures on their territory or extraterritorially” (IOM, 2020). Whether or not a trip crosses the border of one's country determines if it is internal or international migration (IOM, 2020). An *internal migration* is the movement of people within their own country of residence where they settle at a new home either permanently or temporarily (IOM, 2020). State and local borders may be crossed, but an individual remains within the boundaries of their country. Oppositely, *international migration* describes the movement and resettlement of individuals across international borders into a country where they are not nationals (IOM, 2020). In this type of migration, a person leaves their home country where they are considered a national or citizen and enters a new country where they are seen as a foreigner (Bartram, Poros & Monforte, 2014).

Contrary to one's initial assumption, international migration is not always long-distance, as the crossing of border lines does not mean a great distance to travel. A person may take a few steps and be considered an international migrant if they have crossed from one country to another. Similarly, a long-distance migrant can also describe an internal migration, as some countries are very expansive and traveling within them can cover great distances (Bartram, Poros & Monforte, 2014). Trends show that international migration usually occurs from developing

countries to those with stronger economies. Since 1970, the United States has been the most popular destination for international migrants (IOM, 2019). The border between the United States and Mexico is the most frequently crossed international border in the world (Shah, 2020). While borders are not a physical barrier to migration, they are a social institution meant to prevent unauthorized crossings. Between the United States and Mexico, there are 48 official border crossing points along the 2,000 miles border. These points process the 350 million migrants who cross each year (Shah, 2020). These borders can become the setting of violence and death when crossed illegally (Bartram, Poros & Monforte, 2014).

Human migration is classified as *safe, orderly and regular* when the laws and regulations of both the country of residence and the destination are upheld during the trip. In addition, the rights of people migrating are upheld and their dignity are maintained. This method of migration exists in contrast to *irregular migration* where people's movement occurs outside of the laws and regulations of internal and or international governments (IOM, 2020).

The US Mexico border has over 150 checkpoints beyond the official border crossing points to catch migrants who passed the official crossing points and are entering illegally (Shah, 2020). The differentiation between safe, orderly and regular migration from irregular migration is reminiscent of the difference between obligate and facultative migration in birds. In birds, obligate migration follows instinct and seasonal changes which can be seen as following natural law. Like irregular migration, facultative migration in birds is random and unpredictable not following the patterns and laws of nature (Newton, 2011). However, irregular migration in birds does not increase the chance of death during migration as it does for humans. Birds are able to follow abundant resources and thrive when in the same situation, humans can be halted, penalized and sent back to their original home (Bartram, Poros & Monforte, 2014).

An example of irregular migration in humans includes the *smuggling of migrants* which takes place when an individual is obtained via irregular entry into a different country for a financial or other benefit (IOM, 2020). Smuggling can be observed at the border between the United States and Mexico. This is the most frequently crossed international border in the world (Shah, 2020). Groups who are paid to smuggle migrants across are called coyotes. This is a form of illegal migration, and it is investigated by the US Immigration and Customs Enforcement (ICE). ICE estimates the price migrants pay currently to be smuggled from Central American countries into the United States from \$5000 and \$12,000 (Vargas, 2014). Individuals who partake in this irregular migration are labeled illegal or undocumented immigrants in the country they enter. It is estimated that around 11 to 12 million illegal immigrants reside in the United States (Bolter, 2019). However, this journey has deadly risks. Between 1998 and 2018, it is estimated that 22,000 migrants died trying to cross the US Mexico border. A law enforcement official in South Texas said “for every one we find, we’re probably missing five.” The irregularity of these migrant’s journeys makes it difficult to keep track of individuals (Shah, 2020). The migrants who do survive this dangerous journey account for about 3.2% of the US population. However, they contribute to a higher proportion of the workforce at 4.4% (American Progress, 2020). This leads to reasons for human migration, as many people migrate in search for jobs.

*Labor migration* refers to the movement of individuals in search for employment. The movement can cross either internal or international borders (IOM, 2020). Out of nearly 272 million international migrants, two-thirds of them are classified as labor migrants (IOM, 2019). A report released in 2020 estimated that there are 10.4 million undocumented migrants in the US, and out of those individuals, 5 million of these migrants are considered essential workers helping in the covid-19 pandemic. Their jobs include construction, food services, farming and

healthcare providers in addition to many more (American Progress, 2020). The movement of labor migrants can also be considered a circular migration when a person migrates between two or more countries, and their movement is economically motivated as well as cyclical and temporary. A circular flow of migration occurs between a country of origin and a different country of employment repetitively. This repetition is similar to loop migration in birds (Denny, 2016). Remittances are common in working migrants, as individuals send money and resources earned from their job back to their relatives and community in their home country (Bartram, Poros & Monforte, 2014). This connection between migrating individuals is unique to humans as a result of our social and familial bonds.

A common cycle of labor migration occurs when migrants seek agricultural work (Bartram, Poros & Monforte, 2014). These individuals are also known as migrant farmworkers, and they are employed temporarily or seasonally at farms, orchards, plant nurseries and other more (Migrant Clinicians Network, 2017). Migrant farmworkers may have traveled regularly or irregularly, and many come to the US from Central and South America during growing seasons to work on farms. The H2A Guest Worker Program is an example of a government organized way for migrant workers to be legally supported in their temporary jobs (National Center for Farmworker Health, n.d.). However, if an individual overstays the length of their visa, they become an illegal migrant subject to penalization by law (Bartram, Poros & Monforte, 2014). The route between Central and South America and the US is frequented both by labor migrants as well as Neotropical bird migrants. Both birds and humans migrate to increase their chances of survival. However, regardless of their contribution to society, human migrants can be criminalized if their migration is irregular. They are subject to the consequences of international law, which, in the US, can be deadly.

In the US, the Immigrations and Customs Enforcement (ICE) was created in 2003 and is most known for its work in upholding US immigration law within and beyond the nation's borders. ICE was created under the assumption that the US needs to be protected against “those who present a danger to our national security, are a threat to public safety, or who otherwise undermine the integrity of our immigration system” (US Immigrations and Customs Enforcement, 2021). However, ICE has a problem with its abusive practices that violate the human rights of migrants. Recently, ICE has been detaining and deporting record numbers of individuals from the US often without the right to a fair hearing in court. There is clear discrimination based on race, ethnicity and national origin (ACLU, 2021). Many human rights violations occur in detention centers. For example, ICE separates children from their parents without keeping records of their familial connections (Shah, 2020). Migrants are detained for prolonged periods of time without access to necessary resources like medical treatment and access to telephones. They are forced to withstand inhuman conditions like freezing temperatures, overcrowding and tragic deaths (American Oversight, 2021). In addition, the majority of detainees do not receive legal representation, making it exponentially more difficult to succeed in immigration proceedings let alone complain about the conditions they are forced to live in (ACLU, 2021). There are countless more atrocities occurring at detention centers, and people are subject to them simply because they migrated irregularly. It is unimaginable to arrest a bird for irregular migration just because they are pursuing resources with the changing seasons. However, if humans migrate the “wrong way”, they are subject to being arrested, detained, imprisoned and deported. These consequences are faced by a person seeking more resources, much like migrating birds (Shah, 2020). There are also other urgent reasons for migration that force an individual to leave their home out of fear.

*Displacement* is a type of human migration that happens when people are forced or obligated to leave their homes and relocate to escape violence, persecution, development of land, environmental destruction and urbanization (Bartram, Poros & Monforte, 2014) (IOM, 2020). Displacement can be an internal migration or international migration. When people are forced to leave their current place of residence but remain in their country of origin, they are considered an Internally Displaced Person (IDP). While the UN recognizes IDP, no legal protection is offered outside of their country of origin (Bartram, Poros & Monforte, 2014). In contrast, when displacement occurs across international borders, people can seek asylum in their destination country and apply for refugee status. This label of refugee carries legal significance and it is recognized internationally that a person's home country will not offer them protection allowing another country to offer asylum (Bartram, Poros & Monforte, 2014).

*Refugees* are individuals who travel outside of the borders of their home country in fear of conflict, violence, or persecution based on their race, religion or other identities that compromises their safety (United Nations, 2021). Their situation requires protection by the UN (United Nations, 2021). This prevents individuals from being penalized for entering or residing in a country against that country's laws when they have traveled from a country where their safety and wellbeing were at risk. The movement of refugees usually corresponds with wars (Bartram, Poros & Monforte, 2014). A form of displacement, the journey of refugees can be seen as irregular migration when laws are not followed (IOM, 2020). However, before gaining refugee status, individuals are seen as Asylum Seekers. Asylum Seekers are individuals who have fled their home country to escape an unsafe situation but are not yet officially refugees. They must make a case to prove their need for refugee status and protection due to the consequences of what would happen if they return to their home country. This status can be

denied, and if this happens and an individual refuses to return to their home country, they become an illegal migrant (Bartram, Poros & Monforte, 2014). Included in reasons for forced migration and refugee status is environmental disaster. This is also classified as environmental migration (IOM, 2020).

*Environmental migration* occurs when people move in response to a sudden or increasing change in the environment of their home that negatively affects their life. The move can be temporary or permanent as well as internal or international depending on the severity and location of the environmental change (IOM, 2020). Examples of an environmental change that could drive a person to migrate include floods, droughts and tropical storms which can destroy a person's home and or livelihood (IOM, 2014). The immediate migration resulting from a devastating natural disaster or environmental change can also be deemed displacement, as the move is obligated. It is difficult to estimate the number of environmental migrations, as human migration is multicausal, and a person's relocation can be motivated by a combination of political, cultural and personal factors in addition to responding to environmental change (Laczko & Singleton, 2016). In addition, environmental changes can cause food and resource scarcity which cause increased competition in communities and individuals that can drive people to migrate (Podesta, 2019). This is very similar to what drives bird migration, as both need to relocate in order to have enough resources. The International Organization for Migration approximates that the current millions of environmental migrants will increase to 200 million by 2050 (Brown, 2008). This is largely a result of the environmental disruption caused by climate change. These natural disasters in addition to more slow onset environmental changes, like drought or sea-level rise, will increase as a result of climate change and in turn increase climate migration (Podesta, 2019).



## **THE CLIMATE CHANGE-MIGRATION NEXUS**

Climate change affects all living beings on Earth, but it does not affect them equally. Climate change is caused by the increased emissions of greenhouse gases which accumulate in the atmosphere resulting in increased global temperatures (Gloalwarmingindex.org, 2020). An increase in warming has radiating effects that increase the frequency of climate induced events like flooding and storms in addition to climate processes like sea-level rise and desertification (Brown, 2008). The effects of climate change are felt unevenly based on geography, as certain regions are predicted to experience more warming or cooling in addition to increases or decreases in annual precipitation (Green & Pearce-Higgins, 2014). These changes in precipitation and weather patterns are affecting humans and birds alike, and this is displayed in the climate change-migration nexus, as humans and birds migrate as a survival response to extreme weather events and environmental degradation. Humans and birds are both vulnerable to the destruction brought by climate change, but their migration responses are different. Some birds are able to migrate in direct response to changing environmental conditions, and these are the ones we must learn from. The populations of birds who do not adjust their migration patterns are declining (Knudsen, Lindén, Both, etc., 2011). Their lack of migration foreshadows the fate of humanity if barriers to migration are not lowered to avoid the devastating effects of climate change. The perpetuation of climate change needs to be addressed concurrently with the facilitation of human migration to both address suffering in addition to its cause.

The amount of future climate change is reliant on anthropogenic action. If we maintain our reliance on fossil fuels, warming will increase and further disrupt and degrade the environment and nature cycles (Green & Pearce-Higgins, 2014). Our emissions have been increasing since the industrial revolution, and the average global temperature has already risen

by over 1\* Celsius since 1880. Two thirds of this global warming happened in the last 50 years. (NASA, n.d.) (Kool, 2020). Marginalized people and ecosystems suffer the consequences of climate change, yet the humans behind the fossil fuel industry are the main culprit of global emissions and least affected. In 2018, 89% of global carbon dioxide emissions came from the fossil fuel industry (Client Earth, 2019). Migration is a necessary action for the resilience of both humans and birds in order to survive the widespread and life threatening consequences of climate change (Shah, 2020).

## **BIRD MIGRATION AND CLIMATE CHANGE**

One of the most well documented responses to climate change is the change in bird migration. Changes in global average temperature as a result of climate change are altering the seasonal and environmental cues birds rely on to initiate their migration (Knudsen, Lindén, Both, etc., 2011). This effect is most evident in seasonal migrants who migrate between breeding and wintering grounds following the abundance of food resources and avoiding cold temperatures (Dingle & Drake, 2007) (Denny, 2016). Birds time their annual migration to correlate with spring vegetation blooms and the emergence of abundant insects, and climate change is altering this temporal relationship. These spring events are occurring early and earlier as a result of climate change (Harvey, 2019). Globally, spring events, like the blooming of plants, have advanced an average of 28 days per decade from the years 1951 to 2001. Bird migration is observed to follow this advancement, and the arrival of the first individual bird migrant in the spring has become approximately 2 days earlier per decade since the 1960s. The arrival of the average migrating bird has advanced by 1-1.5 days per decade (Green & Pearce-Higgins, 2014). However, climate change does not affect all bird species evenly.

While many birds are advancing the timing of their seasonal migration departure, not all birds are. Birds who do not change the timing of their migration are negatively affected by the environmental alterations from climate change. Facultative bird migrants are able to change their migration departure in direct response to environmental changes. This most often includes short-distance migrants, and they are able to advance their departure if their seasonal food source is decreasing sooner than normal (Green & Pearce-Higgins, 2014). On the other hand, obligate migrants have preset departure times and cannot respond to changes in their immediate environment.

Obligate migrants are genetically hard wired to depart at certain times of the year regardless of changing environmental cues (The Cornell Lab, 2007) (Newton, 2011). This is especially true to long-distance migrants (Green & Pearce-Higgins, 2014). Many obligate migrants have physiological responses to photoperiod (The Cornell Lab, 2007). A shortened photoperiod indicates the onset of autumn and initiates a bird's migration to their wintering grounds before colder temperatures decrease available food resources. Oppositely, a longer photo-period indicates the coming spring, and birds leave their wintering grounds to arrive in their breeding grounds at peak resource availability (Carey, 2009) (Knudsen, Lindén, Both, etc., 2011). Under normal climate circumstances, this allows birds to have a constant abundance of food resources corresponding to the timing of energetically expensive activities like migration and breeding. However, while climate change is altering the timing of resource availability, photoperiod is not changing (Carey, 2009). This disrupts the spatial and temporal relationship of migration and food availability causing a phenological mismatch that will negatively affect survival (Green & Pearce-Higgins, 2014) (Knudsen, Lindén, Both, etc., 2011). In addition to the

advancement of bird migration and phenological mismatch of birds and resources, climate change is making sedentary birds migrate and migratory birds sedentary (Carey, 2009).

Climate change in combination with other human impacts, like deforestation and large-scale agriculture, creates a multiplier effect that can drive sedentary birds to migrate short distances in search of a new home (Crick, 2004) (Carey, 2009). In addition, climate change is also creating milder winters that are predicted to decrease the number of departing migrants (Knudsen, Lindén, Both, etc., 2011). Birds that respond to immediate environmental cues have the ability to remain in their breeding grounds if resources are still adequate. If there is no decrease in food supply, a facultative migrant has no need to migrate (Newton, 2011). Climate change is increasing the global average temperature, and as a result, some regions will experience milder winters (Knudsen, Lindén, Both, etc., 2011).. A milder winter comes with decreased snow cover which allows for better foraging conditions (Green & Pearce-Higgins, 2014). As a result, less birds choose to migrate or the distance of migration decreases. In addition, human activities like feeding birds in the winter has changed the need for migration (Carey, 2009). There is also evidence of birds wintering closer to their breeding grounds and no longer traveling to the farthest parts of their wintering grounds. However, when some birds choose to migrate, there will be an increased competition for resources when they return that will lead to a decrease in population (Knudsen, Lindén, Both, etc., 2011). Climate change is a multispecies issue, and like birds, human migration is greatly impacted.

## **HUMAN MIGRATION AND CLIMATE CHANGE**

The Intergovernmental Panel on Climate Change (IPCC) indicated in 1990 that one of the largest impacts of climate change could be human migration. The IPCC predicted the displacement of millions of people in response to climate induced coastal flooding and erosion in

addition to disruptions of agricultural livelihoods (Brown, 2008). One study predicts the displacement of over 400 communities in the United States by the end of the 21st century (IOM, 2019). *Climate migration* is a type of environmental migration where an environmental change that forces people to relocate is caused by climate change. Climate change is a complex environmental process that interacts with socio-political and cultural contexts to create unequal consequences in different places. As a result, it is difficult to predict its effects on migration. However, some geographic locations are predicted to be disproportionately affected by consequences of climate change, as coastal communities are indisputably more affected by sea-level rise. In addition, climate change causes environmental disruption that interacts with pre-existing economic, social and political tensions that create a multiplier effect that can collectively drive migration (Piguet, Pécoud & De Guchteneire, 2011). The world's poor are most vulnerable to climate change, and while most affected, individuals living in poorer countries often have the least amount of resources to migrate in response to environmental change regardless of the effect on their livelihood (UN Sustainable Development Goals, 2019) (Piguet, Pécoud & De Guchteneire, 2011). Climate change can both directly and indirectly cause people to migrate, and people's movement can be reactive or proactive to environmental changes (UN Sustainable Development Goals, 2019).

A direct cause for migration is a sudden onset weather event, like flooding and forest fires, where a person is displaced by a natural hazard and forced to leave their home (Podesta, 2019). Events like these can destroy a person's home or community obligating them to reactively move from their current place of residence because it no longer exists or is inhabitable (IOM, 2019). Sudden environmental disasters more frequently cause short-term migration or temporary displacement, as people are able to return eventually once the damage is resolved (Piguet,

Pécoud & De Guchteneire, 2011). In 2018, 17.2 million displacements occurred in association with natural disasters in 148 countries (United Nations, 2019). Climate change is predicted to increase the frequency of extreme weather events which in turn will create more climate migration, as people escape environmental hazards (IOM, 2019).

In addition, climate change is also causing slow onset events, like desertification, sea-level rise, rain pattern changes and land degradation. These changes unfold over a longer period of time, and an individual is not forced to relocate immediately. However, migration is prompted when the environment becomes unlivable or a person's livelihood can no longer support them. People can also move proactively before their situation becomes unlivable (United Nations Climate Change, 2021). Slow-onset weather events are more likely to cause a permanent relocation, as they irreversibly affect the environment (Piguet, Pécoud & De Guchteneire, 2011). People are incentivized to move away from a stressed and risk filled environment and towards safety and new opportunities (IOM, 2019). However, the wealth of the areas affected by environmental change affects whether or not people migrate internally or internationally. Poorer places usually take part in short-term internal migration, as they lack the resources to relocate internationally or permanently (Piguet, Pécoud & De Guchteneire, 2011). Sea-level rise is an effect of climate change that also has disproportionate impacts on human migration.

Sea-level rise is a slow onset environmental change perpetuated by climate change that disproportionately affects coastal communities and small island states (Piguet, Pécoud & De Guchteneire, 2011). The increasing global temperatures warms bodies of water causing glacial ice to melt which results in rising sea-levels (Piguet, Pécoud & De Guchteneire, 2011). Sea-level rise illustrates the most direct connection between climate change and migration, as its progression can be measured linearly over time and the populations living at vulnerable

elevations can be calculated. In addition, in the absence of new infrastructure, like dykes to hold back rising water levels from affecting communities, migration is the only solution to sea-level rise (Piguet, Pécoud & De Guchteneire, 2011). Sea-level rise is predicted to completely cover some low elevation coastal communities. A low elevation coastline is defined as an altitude less than 10 meters, and this describes 2.2% of dry land on Earth. However, this land contains 5% of the human population. Out of these 602 million people, 438 live in Asia and 246 million are located in the world's poorest countries (Piguet, Pécoud & De Guchteneire, 2011). This emphasizes the disproportionate impact of climate change on the world's poor. The Isle de Jean Charles in Louisiana is already rapidly disappearing, as only 320 acres remain out of the original 22,000 acres of land. This community's population is largely indigenous and is the first in the United States to have a federally funded relocation because of sea-level rise (Isle de Jean Charles Resettlement Program, 2019) (IOM, 2019). In addition to sea-level rise erasing and relocating coastal communities, it will also flood farmland which will affect people's livelihoods and food security (Brown, 2008).

Environmental alterations from climate change are both threatening people with environmentally dependent livelihoods in addition to increasing food and water insecurity. These are long term drivers of human migration (Piguet, Pécoud & De Guchteneire, 2011). However, the world's poor are most affected, and climate change exacerbates existing vulnerabilities often leaving people without the resources to relocate (IOM, 2014). Changes in precipitation patterns caused by climate change disproportionately affect people with agricultural, pastoral and fishing livelihoods (IOM, 2019). There is the potential to both flood an area as well as create drought. The increasing global temperature is predicted to increase the amount of land in constant drought from 2% to 10% by the end of the century. In addition, the 1% of land suffering from extreme

drought will increase to 30% (Sachs, 2007). Decreased rainfall will have an exceptionally detrimental effect on sub-Saharan Africa which is dependent on rainfall. Agricultural production here is predicted to drop drastically (Brown, 2008). In addition to decreased rainfall, agriculture will be greatly affected by the disappearance of glaciers, as many agricultural systems are fed by glacial melt. Drought will worsen existing food crises in poor and vulnerable people (Sachs, 2007). The lack of fresh water from rainfall and glacial melt and snowmelt will also decrease access to drinking water and increase water insecurity (Piguet, Pécoud & De Guchteneire, 2011). In addition to drought, excess rainfall and flooding are also affecting food and water resources.

In some places, the change in precipitation patterns will cause rain to fall in deluges, which wash away top-soil leading to flooding. Flooding can also be caused by melting glaciers and this risk increases during wet seasons. Melting glacial ice will also increase the risk of glacial lakes flooding in countries including Nepal, Peru and Bhutan (Brown, 2008). This flooding can destroy crops and ruin agricultural fields which impacts both food security and threatens agricultural livelihoods (Piguet, Pécoud & De Guchteneire, 2011). Water run off and increasing temperatures will also impact water quality causing more algal blooms and coral bleaching. This alteration of aquatic ecosystems will negatively affect fish populations. In combination with overfishing, climate change is threatening the livelihoods of fishing communities (IOM, 2019). With environmental and subsistence livelihoods threatened by climate change, there is a trend of rural to urban migration in developing countries. However, unplanned urbanization has the potential to increase the amount of people living in slums with limited clean water, education and sanitation services (Brown, 2008). Human migration in response to climate change needs to be planned and funded in order to ensure the world's most vulnerable are able to survive the effects of climate change.



## REMAINING QUESTIONS

My intentions beginning this research were to uncover the similarities in bird and human migration in order to demonstrate the connection of humans and the natural world. I was hoping bird migration could serve as a model for humans to follow as a mechanism to increase resilience in the climate crisis. Through my research, I learned a great deal about the different types of avian and human migration and the human made categories that define them. The common denominator of risk was also exposed in the journeys of both birds and humans, and climate change is a very real threat to both species. However, the similarities seemed to end there. Instead, differences and complexities revealed themselves, as humans face social, economic and political barriers that simply do not apply to birds. While my research was comprehensive, it was only the beginning. I am left with many unanswered questions:

1. How can we address anthropocentric climate change while humans are still reliant on the fossil fuel industry?
2. Will birds survive climate change?
3. Will humans survive climate change?
4. How can we aid communities of people who are disproportionately affected by climate change?
5. How can we aid species of migratory birds who are threatened by phenological mismatch caused by climate change?
6. What institutional changes need to occur to decrease the death rate of human migrants?
7. What human actions need to be changed to decrease the death rate of migratory birds?
8. What institutional changes need to occur in order for humans to use migration to escape the effects of climate change?

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