



REVIEW

Contributions of evolutionary anthropology to understanding climate-induced human migration

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Abstract

Humans are able to thrive in a multitude of ecological and social environments, including varied environments over an individual lifetime. Migration—leaving one place of residence for another—is a central feature of many people's life histories, and environmental change goes hand-in-hand with migration, both in terms of cause and consequence. Climate change has amplified this connection between environment and migration, with the potential to profoundly impact millions of lives. Although climate-induced migration has been at the forefront of other disciplines in the social sciences, evolutionary anthropologists (EAs) have given it little attention. In this paper we draw upon existing literature and contribute our EA perspective to present a framework for analyzing climate-induced migration that utilizes theoretical approaches from a variety of social science disciplines. We focus on three overlapping dimensions—time, space, and severity—relevant to understanding the impact of climate change on human migration. We apply this framework to case studies from North America of people impacted by climate change and extreme weather events, including hurricanes, droughts, rising sea-levels, and wildfires. We also consider how access to both economic and social resources influence decisions regarding migration. Research focused on climate-induced human migration can benefit equally from the addition of EA perspectives and a more interdisciplinary theoretical approach.

1 | INTRODUCTION

Two keys to understanding the human story—climate and migration—are central research themes in evolutionary anthropology, both the subject of decades of study. Prominent theories of human evolution, including of the evolution of bipedalism and increased brain size, have centered explicitly on environmental change and climate variability (reviewed in the introduction to this special issue, Pisor &

Jones, 2020a; Pisor & Jones, 2020b). Migration also plays an integral role in understanding population structure and gene flow (Crawford & Campbell, 2012; Fix, 1999), and genetic research has been coupled with evidence from linguistics and archaeology to retrace the historical migration routes of humans globally (see Renfrew, 2010). For example, a recent study uses computer simulations to model how climate variation over the last 125,000 years impacted the dispersal opportunities of anatomically modern

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humans across continents, finding good correspondence between events such as glaciations and sea-level rise and the fossil and archaeological record of human occupation (Timmerman & Friedrich, 2016).

Within evolutionary anthropology (EA), human behavioral ecologists (HBEs) use evolutionary theory to better understand human behavior in ecological contexts (Winterhalder & Smith, 1992, 2000). Moreover, one of the hallmarks of an HBE approach is the analysis of alternative behavioral strategies, such as the decision to migrate. Although migration studies are not numerous in HBE, migration is often just under the surface of many research questions, such as how normative marital residence patterns connect to social structure and economic equality (see Borgerhoff Mulder et al., 2019; Reynolds et al., 2020), or how temporary labor migration impacts fertility (Shenk et al., 2016). Those HBE studies that have examined migration directly have focused primarily on individual migration behavior in agricultural contexts with a lens on inheritance and marriage opportunities (Clarke & Low, 1992; Strassmann & Clarke, 1998; Towner, 2002; Voland & Dunbar, 1995).

Of course, migration studies also abound in other social science fields including sociology, geography, demography, history, economics, and political science. Many such studies even consider the impact of climate, as exemplified by the recent Routledge Handbook of Environmental Displacement and Migration (McLeman & Gemenne, 2018). Evolutionary anthropologists, however, are conspicuously lacking from this impressive edited volume. It is also to these other social sciences that policymakers have turned most in trying to better understand climate and migration (Pisor & Jones, 2020a; Pisor & Jones, 2020b). Results include policy reports by groups such as the International Organization of Migration that consider the impact of environmental change on migration (McAdam & Limon, 2015; United Nations, 2019). Even a detailed climate task force report from the American Anthropological Association (Fiske et al., 2014) largely ignores EA, despite grappling with concepts such as adaptation, risk management, and resilience in the face of environmental change (Jones et al., 2020).

In this paper, we draw on an EA framework to examine human migration in response to climate change, with a particular focus on migration within North America. In accordance with the theme of this special issue, we place an eye both on what an EA approach can contribute to and learn from the research being produced in other social sciences (Gibson & Lawson, 2015; Gurven, 2020; Jones et al., 2021). We begin with a review of several theoretical approaches used by EAs that are suitable to

modeling human migration behavior at different levels, from individuals to complex societies. In doing so, we highlight the relevant dimensions (e.g., resources, social relations, cultural knowledge) that both EAs and other social scientists agree influence migration decisions. We then review case studies from other social sciences of migration in response to both rapid climate events and gradual climate change. We evaluate these studies in light of EA and discuss how a more interdisciplinary approach may lead to a deeper understanding of observed patterns.

1.1 | Terminology: Mobility and Migration

An important task at the onset of interdisciplinary work is to clarify terminology, not simply to explain the terms used but also to ensure that contributors to the field avoid talking at cross-purposes (Brettell & Hollifield, 2014; Jones et al., 2020; Sear, 2020). Terms such as *mobility* and *migration* are often taken as self-evident, with myriad adjectives, often disciplinary-specific, used as modifiers (e.g., labor migration, marital migration, rural to urban migration, forced migration, chain migration).

Our goal here is not to give definitive cross-disciplinary definitions, but rather to clarify our own use of the terms. At its most basic, the term *mobile* means “capable of moving or being moved” and *mobility* is “the quality or state of being mobile or moveable” (Merriam-Webster, 2021). The word “capable” with “mobile” is significant, as it highlights the fact that not all individuals capable of moving will move, and thus studies of migration must also consider those who choose to stay in their current location (e.g., immobility or philopatry).

In HBE and evolutionary archaeology, mobility studies ask questions about human movement at all spatial scales, from foraging distances (e.g., Bliege Bird & Bird, 2020; Wood et al., 2021), to visiting friends and family in neighboring communities (e.g., Pisor & Jones, 2020a; Pisor & Jones, 2020b), to crossing seas to colonize unoccupied islands (e.g., Giovas & Fitzpatrick, 2014). The behavior typified by this last example is also termed *migration* or *dispersal*, where the movement is associated with switching one's place of habitual residence from one location to another. This definition focuses on the individual, although we note that people very often migrate with others, and that the accumulation of many migrants going from one location to another can be recognized as mass migrations at the population level.

We prefer the word migration over mobility in this context for several reasons. “Migration” is more narrowly defined and focuses attention on the behavior itself. We also aim, at least initially, to use terms that avoid assumptions about what is driving migration or the ability of people to move freely in their environments. Moreover, while HBEs and evolutionary archaeologists typically think of the term “mobility” as applying to spatial movement, its use in other social sciences very often refers to wealth, status, or occupational mobility. Finally, “mobility” in anthropology is also often used to describe how settled a given population is in space—from highly mobile foragers to more sedentary farmers (although this dichotomy is itself problematic; see Barnard & Wendrich, W. (Eds.), 2008).

2 | MODELING HUMAN MIGRATION

Humans migrate for many possible reasons, for example, to access new resources in an environment, to find mating opportunities, or to avoid danger; in this respect, humans are no different from other animals (see Greenwood, 1980; Pusey & Packer, 1987). Despite the potential benefits, migration also incurs potential costs, both in terms of the time and energy required to move and resettle, as well as possible hazards encountered along the way or in a new location (e.g., rough terrain, hostile conspecifics, different pathogens) (Alberts & Altmann, 1995; Isbell & Van Vuren, 1996). Consequently, the decision to stay is by no means clear-cut, even when local conditions appear suboptimal. Mathematical modeling is one of the tools that HBEs use to better understand such alternative behaviors (see many examples in Winterhalder & Smith, 1992).

Evolutionary models examine how adaptive strategies may play out for individuals in particular contexts, based on the impact behavior has on underlying currencies (Jones et al., 2020). This is often phrased in terms of the costs and benefits of a particular strategy as it impacts a currency, which in evolutionary models is chosen for its potential impact on fitness or reproductive success (Winterhalder & Smith, 1992). This currency could be quite directly related to fitness (e.g., number of live births) or something else thought to correlate with lifetime fitness in a particular context (e.g., acquiring a high-quality residential location to pass on to one's children). Moreover, variance in fitness, notably the risk of hitting a zero in any given generation, may be just as critical as any absolute measure (Jones et al., 2020; Jones & Bliege Bird, 2014).

We next describe three modeling approaches relevant to migration research. Each focuses on a specific

evolutionary or ecological theory, and is also typically applied at different ecological scales, from individuals to large populations in complex systems.

2.1 | Optimality models

To illustrate a simple verbal optimality model at the individual level, a migration decision can be conceptualized as a choice a potential migrant must make between their current location of residence and a new location. Each location is characterized by a set of environmental parameters that could be ecological, economic, or social in nature (e.g., soil quality, job openings, number of relatives nearby). Moreover, the potential migrant has their own individual states (e.g., age, reproductive status, wealth) that may change over time. The potential migrant must pay some direct cost (e.g., time, increased mortality risk) to move from the current to new location, and certain stochastic events (e.g., a drought that wipes out wealth, land being permanently flooded) can be built into simulations based on the model. The adaptive strategy is the one expected to yield higher fitness (the modeled currency).

As a more concrete example, Towner (1999) uses dynamic state variable modeling (Mangel & Clark, 1988) to build such a model of individual migration in a land-based economy, including some probability of inheritance of land in the natal family area, but not in the new area. One prediction from the model is that migration is preferred by individuals who still have enough expected time left to recoup the direct migration costs and enough wealth to pay the costs of migration, but not so much wealth that they have potentially more to lose than gain by relocating. In addition to generating predictions from theory, modeling like this helps researchers clarify assumptions and investigate how changing specific environmental parameters might impact decision making for individuals who themselves vary in states such as age or reproductive status (Mangel & Clark, 1988).

2.2 | Ideal free distribution models

Ideal free distribution (IFD) theory, first developed in ecology (Fretwell & Lucas Jr., 1969), expands on the individual optimality models above to include density-dependent effects of others in a population also choosing between two or more “resource patches” (see detailed review in Cashdan, 1992). If multiple individuals are making settlement choices at the same time, the net benefits of one location over another may depend on the number of individuals already there. This could include



negative density-dependent effects, as a location becomes saturated and competition for resources increases, as well as positive density-dependent effects, particularly initially when individuals benefit by having potential mates or companions nearby. Elaborations of the models also allow individuals to vary in their competitive abilities. Although the models center on adaptive individual behavior, resulting predictions typically focus on the population level.

Like HBEs, archaeologists have been some of the first to integrate evolutionary theory into studies of human space use. For example, Winterhalder et al. (2010) use IFD models along with Bayesian simulations to examine prehistoric Chumash occupation sites on the Northern Channel Islands of California (starting 7000 bp). They successfully reconstruct settlement sequences that match both IFD predictions and archaeological evidence and are able to identify key environmental measures (e.g., length of rocky intertidal zone) that were likely important to the Chumash people in making decisions. Building on this approach, Giovas and Fitzpatrick (2014) model the colonization of Caribbean islands during the Ceramic Age (starting 2500 bp). They also find utility in the IFD approach, for example in predicting the pulsating nature of settlement timing, as well as noting possible explanations for those cases where the model falls short (e.g., due to the presence of other earlier settlers on some islands or particularly challenging ocean currents separating some sites).

2.3 | Critical transition theory

Moving to larger scales, the societies in which humans live and make migration decisions are clearly very complex. What maintains stability in complex systems, and when might complex systems undergo rapid change or even collapse? Critical transitions theory (Scheffer et al., 2001, 2012) identifies underlying mathematical signs of when an event such as a shift from one state to another in a complex system is predicted to occur. These mathematical signatures of change are generic, emerging in complex systems ranging from networks of neurons, to financial institutions, to ecosystems like coral reefs (Scheffer, 2009). Signs that a system is losing its resilience include taking more and more time to return to the previous state after a perturbation. This is called “critical slowing down,” and is seen in increased temporal autocorrelation, as well as greater variance, in states over time. Eventually, a system is pushed across a threshold where it then very rapidly transitions to a new state.

Archaeologists study human occupation sites that often no longer exist. Examples of large, complex societies that have disappeared are many, and understanding

the processes that lead to their disappearance may shed light on the external forcers such as climate change that may push populations over critical thresholds. In an early application of critical transitions theory to human societies, Downey et al. (2016) examine population growth and collapse in the European Neolithic period (starting 9000 bp). They see evidence of critical slowing down in populations well-ahead of population crashes. Scheffer et al. (2021) use a rich archaeological archive of tree ring data to look at construction activity in pre-Hispanic Pueblo societies. They find signs of critical slowing down preceded at least four major transitions in Pueblo occupation periods. Interestingly, however, this did not happen prior to the final population crash and mass outmigration experienced by the Pueblo populations in the late 13th century. We return to this example in the discussion.

3 | SALIENT DIMENSIONS OF CURRENT AND MIGRATION LOCATIONS

Our primary focus in the case studies that follow is not on the particular climate change or event itself, but rather how its dynamics impact the other salient dimensions that characterize a current and potential migration location (as detailed in the verbal model above). We focus on three themes that we refer to as “primary dimensions” connected to a specific location: capital resources, kin and social relationships, and cultural knowledge and roots. We also examine two additional secondary dimensions, risk and population dynamics, that operate through their impact on the primary dimensions.

3.1 | Resources

Understanding the resource base, very broadly defined to include means of production of income, food, land, and other goods will be key to knowing how location is tied to livelihood. Moreover, patterns of ownership and inheritance may be key to knowing how “transferrable” a resource is to a new location, or how land-tied people are. There may also be competitive advantages in terms of resource defensibility that residents enjoy simply by virtue of being on a site (see Cashdan, 1992). Where inheritance of parental resources is biased toward some offspring over others, some may stay in their natal locations, even while many of their siblings disperse (Clech et al., 2020; Towner, 2001). Residential locations may or may not be closely linked to the resources people need to survive. This becomes important with climate change because the climate may have a direct impact on either or both. For instance, a fire might destroy one’s home,

but leave one's workplace and other community resources intact. Conversely, rising temperatures might drive food sources out of a region or make certain jobs obsolete without directly threatening one's home. We would expect that people whose resource base and place of residence are tied to the same location will be both more vulnerable to climate change and also more likely to migrate, since both are threatened.

3.2 | Kin and social relationships

Humans are a highly social species and engage in long-term relationships with both kin and non-kin. Work on mobility and behaviors such as maintaining extended social networks through visiting and exchange have long been of interest to evolutionary anthropologists (Wiessner, 1977). Pisor and Jones (2020a, 2020b) examine the hypothesis that long distance relationships may be particularly important in coping with climate variability. They find little evidence for this function among Bolivian farmers, perhaps because climate variability impedes long-distance travel, at least in the short term. Conversely, if someone has relatively high status in their local community, this may be difficult to recreate in a new location where they are less well-known to others (see Shenk et al., 2016 for an analysis of how competition for social status relates to fitness). How much one depends on kin or non-kin to engage in behaviors like food acquisition or childcare may make two locations which seem similar in other respects starkly different in a direct comparison.

3.3 | Culture and local knowledge

The global distribution of humans is itself made possible by our ability to adapt—both culturally and physiologically—to a wide range of environments with vastly different climates. This climate diversity and the cultural adaptations that people employ to survive and reproduce in such environments is clearly represented in this special issue, from the Arctic tundra to the Australian desert (Bliege Bird & Bird, 2020; Kramer & Hackman, 2020; Pisor & Jones, 2020a; Pisor & Jones, 2020b; Ready & Collings, 2020; Scaggs et al., 2021). This set of specialized knowledge and behaviors in the context of a location has been referred to as the cultural niche (Ready & Price, 2021). But although we may observe current cultural adaptations to existing climate, without a deeper time window, we may not understand the cultural evolutionary processes that enabled these adjustments (Jones et al., 2020). Moreover, culturally relevant knowledge (e.g., how to access food, build housing,

and socialize in acceptable ways with others) is not necessarily easily transferred from one location to the next, particularly at longer distances. In terms of migration choices, we would expect the value of a potential migration location would decrease the further it takes someone away from that niche where they are most rooted.

3.4 | Risk and variability

Each of the primary dimensions discussed above might be impacted by stochastic events, related or completely unrelated to climate change. Crops fail due to disease, important relationships might dissolve, and cultural knowledge might disappear with the deaths of elders in a community. In terms of climate, both gradual climate change and specific climate events may vary markedly in scope, predictability, and impact. They are also thus multidimensional with respect to their impact on migration dynamics (Black et al., 2011). The particular environmental measures used to characterize a location may vary across studies (e.g. sea level, precipitation, high/low temperatures), but whatever the measures, we must also incorporate temporal and spatial dynamics of climate events (see Table 1) to better enable comparisons of populations and understand their impact on other dimensions. For instance, a seasonal pattern of high and low temperatures that is predictable may be much more tolerable than one where floods and droughts hit in a more haphazard pattern (Kramer & Hackman, 2020). Very local risks (e.g., an eroding cliff) may be more easily managed than widespread risks (e.g., a rising river). Migration itself may be one of the key strategies that humans use to manage such risk (Pisor & Jones, 2020a; Pisor & Jones, 2020b), a problem if historical mobility patterns have been constrained (Bliege Bird & Bird, 2020).

3.5 | Population dynamics

Another dimension that impacts others is the importance that population dynamics can have on individual decisions. For example, the availability of suitable marriage partners in a location might impact the decision to disperse (Towner, 2002). If population growth increases competition for resources in a location, this could impact settlement patterns. For instance, poorer individuals may be forced to settle in locations that are more exposed to potential damage from climate events. Conversely, very low population densities may eventually lead to a lack of community services (e.g., schools, grocery stores) that decrease the value of the current location, leading to settlement abandonment (McLeman, 2018). Certain types of labor migration or migration to high-risk opportunities, insofar as they attract

TABLE 1 Climate event dimensions and migration outcomes

| | Description | Low End of Spectrum | High End of Spectrum |
|-------------------------------------|--|--|---|
| Climate event dimension | | | |
| Temporal: Onset rate | Amount of time people have to react/respond to an event | Sudden – event occurs with little to no warning (e.g. begins within hours to days) | Gradual – event occurs over a long period of time (e.g. months to years), often worsening as time goes on |
| Temporal: Duration of event | Time period during which event takes place | Short-Term - event starts and finishes in a matter of hours to weeks | Long-Term - event starts and finishes over months to years |
| Temporal: Permanence of impact | Whether conditions are reversible or recoverable during a person's lifetime | Temporary - impact from event lasts only a short time and residents are able to return after weeks or months | Permanent - impact from event is permanent and residents may never be able to return even after years |
| Spatial: Geographic range of impact | Area and number of people impacted by event | Small - major impact contained in small area and affecting a relatively small number of people (e.g. neighborhood, small group of cities/towns, affecting less than 5000 people) | Large - major impact covering large area and affecting a relatively large number of people (e.g. entire states/provinces or sections of country, affecting usually over 100 000 people) |
| Severity of impact | Degree of damage to area, including resident dwellings, and impact to available services | Low - minor damage to home/ neighborhood, little disruption in services | High - complete or heavy destruction to home/ neighborhood, rendering area and services almost impossible to utilize |
| Migration outcomes | | | |
| Onset of migration | Rate at which migration occurs in response to the event | Gradual - individuals and households leave one by one or in small groups over months to years | Sudden - people have to leave an area with little to no notice (e.g. evacuation) |
| Temporal scale of migration | Time length during which migrants are moving or away from their place of origin | Short-Term (Temporary) - migrants leave their place of origin for a short time and return after weeks or months | Long-Term (Permanent) - migrants leave their place of origin and may never return even after years |
| Spatial scale of migration | Geographic scale on which migrants are moving | Local/Regional - migrants move to nearby villages/towns or within a region of a country | International - migrants cross international borders |

more men than women, may lead to biased adult sex ratios in both the source and destination areas (e.g., Glover & Towner, 2009; Strassmann & Clarke, 1998).

4 | DIMENSIONS OF CLIMATE-INDUCED MIGRATION IN NORTH AMERICAN CASE STUDIES

Here we examine these dimensions through a review of North American case studies (summarized in Table 2).

Our analyses of the case studies are organized around a set of more specific questions, centered on one or more of the dimensions detailed above. The case studies also sample a variety of climate related changes, from short and localized events, to more gradual widespread change (Table 1). The people vary in their cultural ties to an area—from deep to more recent, and except for the Anasazi, the communities are embedded within larger post-industrialized nations, shaped by government policy and economic factors well beyond their local neighborhoods.

TABLE 2 Synopsis of North American case studies: Hurricanes, extreme seasonality, sea-level rise, and wildfires

| Case studies | Location | Who impacted | Year(s) | Severity of impact | Geographic range of impact | Onset rate | Duration of event | Possibility of return to location | Permanence of impact | Environmental impacts | Economic /social context | References |
|---|---|---|----------------------------|--------------------|----------------------------|------------|-------------------|-----------------------------------|----------------------|--|--|--|
| Hurricanes | | | | | | | | | | | | |
| Hurricane Katrina | Coastal Regions of Louisiana, Mississippi, & Alabama | Residents of the coastal regions of Louisiana, Mississippi, & Alabama | 2005 | Low to High | Large | Sudden | Short-term | Yes | Temporary | Flooding, Loss of electricity, Lack of transportation, Unable to access clean water, Destruction of homes, Businesses, & Other public services | Job decline | Fussell et al., 2014; Groen & Polivka, 2010; Landry et al., 2007 |
| Hurricane Maria | Puerto Rico | Puerto Ricans | 2017 | Low to High | Large | Sudden | Short-term | Yes | Temporary | Flooding, Loss of electricity, Lack of transportation, Unable to access clean water, Destruction of homes, Businesses, & Other public services | Economic Crisis in Puerto Rico, Governmental regulations/oversight from U.S. | DeWaard et al., 2020; Lloréns, 2018; Meléndez & Hinojosa, 2017; Mora et al., 2018; Rayer, 2018 |
| Extreme Seasonality | | | | | | | | | | | | |
| Dust Bowl | Oklahoma, Kansas, Texas, Colorado | Tenant Farmers and other residents within the Dust Bowl affected area | 1930s | Low to High | Large | Gradual | Long-term | Yes for local/regional migrants | Temporary/Permanent | Less productive agriculture, Food scarcity, Extreme heat, Extreme drought, Torrential rain (brief periods) | Great Depression | Gutmann et al., 2016; Long & Siu, 2018; McIeman, 2006; McIeman et al., 2008 |
| Drought within Pre-Columbian Southwest Utah | Four Corners Region: Colorado, Arizona, New Mexico, and Utah | Anasazi "pre-Columbian Native Americans" | ~1150-1350 AD | Low to High | Large | Gradual | Long-term | No | Permanent | Less productive agriculture, Food scarcity, Increased violence and disease, Extreme drought | Increased violence due to scarcity of maize | Benson et al., 2007; Benson & Berry, 2009 |
| Rising Sea-levels | | | | | | | | | | | | |
| Chesapeake Bay | Islands with the Chesapeake Bay area including Holland Island | Residents of the Islands within the Chesapeake Bay area | Abandoned from ~1900-1930s | High | Small | Gradual | Long-term | No | Permanent | Flooding, Land loss | Previous out-migration meant lack of community and inability to maintain sustained life | Arenstam Gibbons & Nicholls, 2006; Richter, 2015; Schulte et al., 2015 |
| Isle de Jean Charles | Louisiana | Biloxi-Chitimacha-Choctaw Tribal Nation | Present Day | High | Small | Gradual | Long-term | No | Permanent | Flooding, Land loss | Earlier out-migration decreasing the community and lack of community center | King, 2018; Prache, 2019 |
| Villages of Shishmaref & Newtok | Alaska | Yup'ik & Inupiat Tribes | Present Day | High | Small | Gradual | Long-term | No | Permanent | Flooding, Land loss | Increasing dependency on amenities that are brought in & lack of mobility due to history of colonization | Hamilton et al., 2016; Marino, 2012; Rossi, 2019 |
| Wildfire | | | | | | | | | | | | |
| Fourmile Canyon Fire | Boulder and Larimer County, Colorado | Residents within Boulder and Larimer County | 2010 | Low to High | Small | Sudden | Short-term | Yes | Temporary | Loss of tree/plant life, Fire damage | Reduced prices in the housing market following fire possibly preventing outward migration and/or enticing inward migration | Graham et al., 2012; Nawrotzki et al., 2014 |



4.1 | How does resource availability influence whether individuals return to their original residence after being displaced following a rapid-onset environmental disaster?

Rapid-onset environmental disasters occur within a short period of time and can often cause massive amounts of destruction in a short duration, such as the aftermath seen from hurricanes (Table 2). In August of 2005, the coastal regions of Louisiana, Mississippi, and Alabama were hit by Hurricane Katrina, which displaced roughly 1.5 million people ages 16 and older (Groen & Polivka, 2010). Many residents were evacuated before the hurricane hit or shortly afterwards, due to the immediate flooding dangers and extensive damage that ultimately occurred within the region (Groen & Polivka, 2010). Of these evacuees, individuals were less likely to return to their previous residence if they were under the age of 30, had a college education, were married, or had children (Groen & Polivka, 2010; Landry et al., 2007).

Within these specific circumstances, residents' migratory decisions were partially impacted by their access to resources (e.g. property, financial, social) in their original location. Residents who owned their pre-Katrina residence were more likely to return to their previous residence after being displaced as opposed to remaining in the displaced area or permanently migrating elsewhere (Hunter, 2005). An individual's ability to take pre-disaster measures to mitigate damage prior to a disaster and/or afford post-disaster resources to rebuild may also influence migratory decisions, as an inability to prevent or repair damage to personal property should preclude displaced individuals from returning to their original residence (Hunter, 2005; Morrow-Jones & Morrow-Jones, 1991).

Social resources can also impact migratory decisions. Research suggests an inverse relationship between a displaced individual returning to their original residence and damage sustained to residential areas along with public and private services (Groen & Polivka, 2010). Extensive damage to these social resources will likely drive residents to remain in the location they were displaced to or to permanently migrate elsewhere in search of a new social environment. Socioeconomic status (SES) contributes to the acquisition and/or maintenance of all of the aforementioned resources, explaining why individuals with lower SES may have been unable to return to their previous residence after the hurricane. Being unable to protect or restore their previous habitat, so-to-speak, these individuals instead sought out new habitats that similarly met their needs. Migratory decisions involving families become more complicated, as the needs and

wants of multiple individuals must be simultaneously considered (Groen & Polivka, 2010; Landry et al., 2007).

Most people who were evacuated from New Orleans and surrounding areas were displaced to nearby cities (Fussell et al., 2014). Residents who participated in permanent migration were also displaced to areas close in proximity to their previous residences but remained in the displaced location or migrated elsewhere (Fussell et al., 2014; Meléndez & Hinojosa, 2017). Migrating to habitats with more familiar structures would enable these individuals to work similar jobs and maintain the majority of their social network (Groen & Polivka, 2010). Social networks may be maintained through several different avenues, such as visiting friends and family who still live within the original area of residence over the holidays or other special occasions (Beauchemin & Bocquier, 2004; Smith, 2014). Resource quality and/or access can change drastically following a rapid-onset environmental disaster, and the degree of this change in an individual's residence and community affects whether they choose to return to their original location, remain where they had been displaced, or to permanently migrate elsewhere.

4.2 | How does economic resource scarcity impact migration decisions in the midst of a slow-onset environmental disaster?

In contrast to the rapid-onset nature of some environmental disasters (e.g. hurricanes), slow-onset environmental disasters occur gradually and can last for extended periods of time, as seen within extreme seasonality through fluctuations between high precipitation and drought (Table 2). There is evidence that increasing temperatures associated with anthropogenic climate change can interact with periods of decreased precipitation and low soil moisture to cause droughts (Diffenbaugh et al., 2015). During the mid to late 1930s, the states of Colorado, Kansas, Oklahoma, and Texas were hit by severe drought and wind erosion, giving rise to what is known as the Dust Bowl (Long & Siu, 2018). The Dust Bowl was marked by widespread crop failures and economic difficulties, which was only amplified by the Great Depression (Table 2; Gutmann et al., 2016). Most Dust Bowl migrants made the decision to migrate on a local/regional level, staying within the affected area, while a smaller number migrated further away (Long & Siu, 2018). Within Oklahoma, approximately 200 000 people migrated within the Southern Great Plains while 100 000 people migrated further away to California (McLeman et al., 2008).

In addition to resource availability, access to information about opportunities contributed to migration decisions during the Dust Bowl (Long & Siu, 2018; McLeman, 2006). People who owned a radio were less likely to migrate, possibly due to having a higher SES or more information regarding the impact of the Great Depression in other areas within the United States (Long & Siu, 2018). Long-distance dispersal in particular may be associated with higher risk-taking strategies, leading to greater variation among dispersers (e.g., see Glover & Towner, 2009 for long-distance dispersal of silver prospectors to Colorado).

If basic resource needs such as food, water, and safety were no longer available in an individual's current habitat, fulfilling those needs would overshadow sociocultural factors that may have deterred migration under different circumstances (Gutmann et al., 2016; Long & Siu, 2018). However, homeownership was also a possible deterrent to migration, indicating that resources related to property may still hold some level of influence over migratory decisions (Long & Siu, 2018). Government-funded programs put into place to help residents during the economic and environmental crises also influenced migration decisions. Individuals who obtained work were able to earn the income needed to help weather the environmental and economic hardships without having to relocate (McLeman et al., 2008).

In spite of the striking differences between Hurricane Katrina and the Dust Bowl, there are several commonalities worth emphasizing. First, for those individuals who chose to permanently migrate in response to the environmental disaster—be it rapid- or slow-onset—they tended to migrate locally or regionally, remaining somewhat near their original location (Fussell et al., 2014; Long & Siu, 2018). Individuals may preferentially seek out habitats similar to their original location, and many social and cultural ties are better maintained over shorter distances, as are many types of employment or subsistence (Fussell et al., 2014; Groen & Polivka, 2010; Meléndez & Hinojosa, 2017). Home ownership deterred migration under both of these scenarios as well (Hunter, 2005; Long & Siu, 2018; Morrow-Jones & Morrow-Jones, 1991), perhaps because the market-value of the home in the threatened area would not be easily transferred to a home of comparable size or quality in a new location.

4.3 | How does a loss of social relationships impact migratory decisions in the context of irreversible environmental disasters?

In some situations, individuals are faced with slow-onset environmental disasters, such as sea-level rise, that often

have an irreversible impact (Table 2). During the early 20th century, several islands within the Chesapeake Bay area that had been populated since the 1850s were quickly abandoned, partly because of coastal erosion and rising sea levels that led to the complete submergence of islands that had once been flourishing communities (Richter, 2015; Schulte et al., 2015). Within Holland Island specifically, the population began to decline, partially because land loss from increased levels of erosion decreased the amount of habitat available to residents (Arenstam Gibbons & Nicholls, 2006; Richter, 2015).

The initial migratory decision of many residents, particularly wealthier individuals, was simply to move to another area on the island, relatively close to their previous residence (Arenstam Gibbons & Nicholls, 2006; Richter, 2015). As land loss continued, in spite of their desire to maintain their way of life and existing social and cultural ties, it became more difficult for individuals to remain on the island and people began to move further away (Arenstam Gibbons & Nicholls, 2006; Richter, 2015). As these small, close-knit communities dispersed, remaining residents were left without the social and cultural attachments that had initially influenced their decision to remain on the island, which hastened their decision to ultimately migrate off Holland Island (Casagrande et al., 2015; Richter, 2015).

4.4 | How do cultural attachments impact migratory decisions in the context of irreversible environmental disasters?

In some communities facing the irreversible effects of sea-level rise, cultural attachments can strongly override the apparent necessity of migrating elsewhere. This is exemplified with the Isle de Jean Charles in Louisiana, which has been the home of the Biloxi-Chitimacha-Choctaw tribe for many generations. Due to rising sea-levels, coastal erosion, and a reduced ability to adapt to and cope with the changing environment, the island will soon be uninhabitable (Brooks, 2003; King, 2018; Prache, 2019; Rossi, 2019). Many within the tribal community have already migrated elsewhere, but about 70 of the 600 members remain on the island (Prache, 2019), primarily due to their deep social and cultural attachments to the island (King, 2018; Rossi, 2019).

Many residents' decisions not to migrate are influenced by their uncertainty in whether or not they will be able to continue their cultural traditions and way of life, as well as their unwillingness to leave behind the homes that belonged to generations before them (Prache, 2019). While the State of Louisiana was awarded money to help resettle the community—with

an emphasis on maintaining social and cultural structures and preventing the loss of cultural traditions—pushback from residents and additional needs for funding have prevented this plan from being implemented (King, 2018; Prache, 2019; Rossi, 2019). In situations such as this, when assistance to a community comes from outside the community, the assisting group needs a strong understanding of the social and cultural components of the community they are working with. An insufficient understanding of sociocultural features of an at-risk community can make interventions ineffective or, worse, insensitive and counterproductive (Gibson & Lawson, 2015).

4.5 | How does the information and experience regarding risk posed by environmental disasters impact migratory decision-making?

Some environmental disasters—such as wildfires—occur relatively often, although their predictability and intensity can vary greatly between years and locations. Wildfires often begin suddenly and move quickly, potentially impacting large areas depending on the duration and rate of spread of the fire itself (Table 2). How residents perceive their level of risk in relation to these wildfires can influence their decision of whether or not to migrate. Understanding how individuals manage their risk in relation to migratory decisions can be illustrated using the Fourmile Canyon fire in Colorado that occurred in September of 2010 (Graham et al., 2012; Nawrotzki et al., 2014). A survey done by Nawrotzki et al. (2014) indicated that 4% of respondents intended to migrate away from their current residence due to the fire or the potential risk associated with future wildfires. Part of an individual's assessment of habitat quality includes how likely and extreme future risks are, so if an individual's perception of risk in their current habitat becomes too high, they may manage their risk by seeking out a new, lower risk residence site (Nawrotzki et al., 2014).

An individual's management of the level of risk they face was shaped by their own experiences with the wildfire, as well as characteristics of the wildfire itself, such as intensity (Nawrotzki et al., 2014). The survey results also suggested that the experiences of others may contribute to decisions regarding migration, as residents who intended to migrate were more likely to personally know someone who experienced damage from the wildfire (Nawrotzki et al., 2014). The level of precarity and predictability of an environmental disaster—assessed by personal experience and the experiences of others—can influence migratory decisions in

relation to risk management. The more unlikely or less damaging an environmental disaster is, the lower the perceived risk to the individual, favoring risk-management without migration.

Given the data from the Fourmile Canyon fire, we would expect that an individual who experienced damage from an environmental disaster recently (especially if there were multiple recent occurrences of the disaster) or knew someone who had been impacted by that disaster recently would have a greater likelihood of migrating to find better quality (i.e. lower risk) habitat because they view their current habitat as being under high risk. An individual who had never experienced a disaster before and/or sustained little to no damage from the current disaster would be more likely to remain in their current habitat because they still view that habitat as under low risk.

The ability to manage risk may also vary with additional factors relating to social support, mental health, and economics (Jones et al., 2013). Furthermore, people may recognize their level of risk but not let it influence their decision whether or not to migrate (Jones et al., 2013). Nevertheless, the level of impact an area experienced from a disaster is still broadly expected to influence people's risk management and their future plans to mitigate experiencing that disaster again (Jones et al., 2013).

4.6 | How does a lack of resources and cultural ability to manage risk adaptively prevent migration in the face of irreversible disasters?

Some communities lack the necessary access to the resources and support they need to manage climate risk. Along the coastal region of Alaska, people in the villages of Shishmaref and Newtok are facing negative impacts from climate change, including rising sea-levels, coastal erosion, and increased flooding (Hamilton et al., 2016). Some of the difficulties faced by these communities are the direct result of historic colonization, when European settlers forced the population now located in Shishmaref to switch from a highly mobile to more settled social organization (Marino, 2012). While immediate resettlement is needed, neither community has been relocated due to economic, environmental, and sociocultural factors. These include lack of funding, difficulty finding a new location, and resistance to migration (Hamilton et al., 2016; Marino, 2012).

The community of Newtok requested assistance to migrate to another location, but they have not been funded

(King, 2018; Prache, 2019; Rossi, 2019). Additionally, community leaders have been entirely excluded from the decision-making process, effectively taking away their voice within migratory decisions and increasing the marginalization of the community (Marino, 2012). The Stafford Act of 1988 also perpetuates marginalization, as it promotes “rebuilding in place” instead of resettling communities, making it the government’s priority to keep people in their original communities—which may be at risk—instead of helping them migrate (Marino, 2012). Despite their desire and need to relocate, ongoing antagonisms of colonialism interact with present day inequalities to leave these communities incapable of responding to an ongoing climate crisis (Marino, 2012).

4.7 | How do economic conditions influence location choice and migration before and after environmental disasters?

Sometimes, negative events or circumstances can have compounding effects on other facets of an individual’s life. Depending on how these unfavorable situations interact, the tendency and ability of individuals to seek out better environments will vary. In September of 2017, Hurricane Maria hit Puerto Rico, leaving its residents with a lack of resources and a reduced ability to adapt to and cope with the severe damage, further exacerbated by an ongoing economic crisis (Brooks, 2003; Mora et al., 2018). However, prior to Hurricane Maria, there had already been an increase in migration out of Puerto Rico brought on by the economic crisis, *La Crisis Boricua*, with roughly 600 000 people migrating from Puerto Rico to the mainland United States during the eleven years that predated the hurricane (Mora et al., 2018). Consequently, Puerto Rico’s population size was declining by 0.5% to 1.9% per year in the decade before Hurricane Maria, resulting in a total population decline from 3.8 to 3.2 million people (Cohn et al., 2014; Flores & Krogstad, 2019).

The hurricane by itself may not have been enough to impact residents’ migratory decisions, but combined with the ten years of economic downturn and growing social and economic disparities, it may have acted as the tipping point for some Puerto Ricans to migrate (Lloréns, 2018). Research supports this hypothesis, since migration out of Puerto Rico remained high after Hurricane Maria (DeWaard et al., 2020), particularly in areas that had decreased access to adequate water and housing. From 2% to 4% of Puerto Rico’s population is estimated to have left Puerto Rico following Hurricane Maria (DeWaard et al., 2020; Meléndez & Hinojosa, 2017). Analysis of Facebook data estimated a 17% increase in Puerto Ricans

living in the mainland United States after the hurricane (Alexander et al., 2019), with approximately 30 to 50 thousand Puerto Rican migrants settling in Florida alone (Rayer, 2018). For individuals experiencing negative impacts to resource availability following the hurricane, they may have chosen to follow the migratory decisions of others in their community, reuniting in new locations to maintain social and cultural attachments (Schmidt, 2016; Winters et al., 2001).

4.8 | How do population density and growth influence habitat selection and mobility of individuals before and after environmental disasters?

In situations where favorable environmental conditions lead to population “booms,” a switch to unfavorable conditions can increase pressures on populations that are now at high density and using more resources. Extreme seasonality (intermittent periods of warm, wet weather and severe droughts) occurred within the Four Corners Region of Colorado, New Mexico, Arizona, and Utah during the mid-12th and late-13th centuries, directly impacting the mobility of the Anasazi, a population of pre-Columbian Native Americans who resided there (Benson et al., 2007; Benson & Berry, 2009). The periods of warm, wet weather led to the region experiencing population growth and increased agricultural production, specifically of maize. Archaeological data suggested that this increase in population density within the area led to higher rates of disease, mortality, and violence (Benson et al., 2007; Benson & Berry, 2009). As the area’s climate shifted from a wet period to a dry period, ever increasing stretches of drought may have led the Anasazi to use their reserves of maize, forcing them to compete for increasingly scarce resources (Benson et al., 2007; Benson & Berry, 2009).

Similar to previous examples, these factors may have combined to reach a threshold that pushed some of the Anasazi to migrate out of the region (Benson et al., 2007; Cameron, 1995). The first period of drought (1130–1177 A.D.) led to the partial abandonment of the area while the second period of drought (1273–1297 A.D.) led to a total abandonment of the region (Benson et al., 2007; Benson & Berry, 2009). Although individuals grouped together during periods of warm, wet weather when agricultural yield was high, the advantages of sharing habitat and resources with others decreased as environmental conditions shifted. Understanding drivers of migration in the Anasazi can allow us to more clearly assess the factors related to climate change and shifting population dynamics faced by previous societies, and how these

same responses may appear on a global scale today (Rick & Sandweiss, 2020).

5 | DISCUSSION

Humans are experts at adapting to diverse environmental conditions, but our current climate crisis is unique in both scope and extremes of rapid change. When local conditions make it difficult to meet basic needs for food, safety, and shelter (for oneself and for one's progeny), let alone prosper, people may decide to migrate to new locations. What might an evolutionary perspective contribute to understanding this behavior? EAs have a tendency to focus on individual decision-makers in small-scale societies. Large-scale “modern” or “modernizing” societies have often received less attention, but are studied extensively by other social scientists (Mattison & Sear, 2016). In this paper, we have presented the EA theoretical approach and several modeling examples alongside case studies from other social sciences of climate-related migration in North America.

Approaches like dynamic state-variable modeling (Mangel & Clark, 1988) can help researchers explore how variation in particular states (e.g., wealth, age) might impact an individual's decision to migrate or to stay in the midst of a change in the environment. Patch choice models such as those using the Ideal Free Distribution are able to look at how individual behavior may shape community settlement patterns (Cashdan, 1992). Such models are also able to build in competition between individuals, including asymmetries in competitive ability. At a larger landscape scale, critical transitions theory can provide a whole-system perspective on state in complex systems, including highlighting how certain dynamics, like increasing wealth inequality, might destabilize such systems, particularly in combination with external shocks such as climate disasters (Scheffer, 2009).

In fact, one theme that emerges across case studies and dimensions of climate change is the huge impact of wealth inequality on migration. The wealthiest and most connected individuals in a community may be able to ride out deteriorating conditions for the longest or pay for food, shelter, and other materials they need to stay (Hunter, 2005; Morrow-Jones & Morrow-Jones, 1991). Others may be tied to an area due to “anchoring factors” such as their reliance upon their land for food or financial investments in their home (Penning-Rowsell et al., 2013). It is the economically and socially vulnerable that tend to experience the most severe effects from climate events, often because of preexisting inequalities in their place of residence (Tan et al., 2016). These inequalities may include reduced access to resources such as

disaster compensation (Lelandais, 2016), reduced availability of social services such as education (Mezdour et al., 2016), and limited ability to participate in relevant policy-making (Tan et al., 2016).

For sudden evacuations in response to events like hurricanes, it appears that socioeconomic inequalities play a bigger role in who gets to return home, rather than who gets to leave (Hunter, 2005; Landry et al., 2007; Morrow-Jones & Morrow-Jones, 1991). However, with more gradual departures associated with slow-onset events like sea-level rise, socioeconomic inequalities often dictate who has the means to leave (Hamilton et al., 2016; King, 2018; Marino, 2012). That said, even in the face of irreversible changes such as sea-level rise, there are still those who resist leaving their homes and communities.

In some instances, individuals or households may not even have the resources necessary to migrate and be forced to remain under their current circumstances (Cattaneo et al., 2019; Schmidt, 2016; Towner, 1999). In addition, people are understandably reluctant to abandon a place that has social or cultural importance to them. Many of the communities experiencing forced immobility have already been marginalized and disadvantaged as a result of the reverberating impacts of colonization and ongoing discrimination. For instance, the indigenous communities in Alaska faced with sea-level rise have not gotten a say in decisions regarding their villages' own renovation and relocation, and, for some, colonization by Europeans has both disrupted their previous way of life and placed them in a situation that now renders them immobile in the face of climate change (Marino, 2012).

At the scale of populations and communities, application of models such as the ideal free distribution model typically focus on ecological resources in patches (Cashdan, 1992). Where humans are concerned, patches may be much more complex and include components such as social and cultural resources. A naïve application of a patch choice model to the Isle de Jean Charles community might predict that there is no longer enough habitat of sufficient quality for people to remain on the island. However, incorporating the social and cultural factors that are equally a part of this community paints a different picture—despite worsening environmental conditions, the island holds such great cultural significance for the remaining residents, they are unwilling to abandon it.

Another common thread that emerges from the case studies is the idea of thresholds and their influence on migratory decisions. In some instances, such as sea-level rise, the gradual loss of available habitat on an island or coastal community progressively forces more and more residents to relocate elsewhere. For other, more

temporary environmental disasters, there is often evidence that multiple sources of stressors can interact to push individuals past their threshold for migration. In the instance of Hurricane Maria in Puerto Rico, the damage caused by the hurricane exacerbated the ongoing effects of the decade-long economic crisis (Lloréns, 2018; Mora et al., 2018). Individuals who were already experiencing economic hardship may have been more likely to migrate if they also experienced negative impacts from Hurricane Maria (DeWaard et al., 2020).

For more permanent climatic events, migration decision models incorporating population-level resources (e.g. social networks, employment) that individuals value could be used to explore frequency-dependent dynamics and to identify critical thresholds where such resources have been degraded or lost to the point that migration to a new residential location is preferred to staying. Temporally, critical transitions theory (Scheffer et al., 2009, 2012) shows how both fast and slow dynamics may arise in response to forcings such as climate change. Initially, a population may make slower, in-place adjustments to perturbations, while at the same time approaching an edge where the crossing of a critical threshold suddenly leads to mass outmigration over a short time. For example, the residents on Holland Island that attempted to remain on the island were often the wealthy who could afford to move to another, safer location on the island. However, as sea-levels continued to rise, life on the island became less and less sustainable, and community resources that had been previously available to residents began dwindling, causing the island to be quickly abandoned (Arenstam Gibbons & Nicholls, 2006; Richter, 2015).

Models investigating stable states indicate that different locations within a particular area can sometimes be in different parts of an oscillating cycle between stable states (Ludwig et al., 1997). In the case of the Dust Bowl, although the whole region was experiencing similar environmental and economic conditions, different individuals experienced this shift in conditions at different rates and with different outcomes. Home ownership, as one example, was a deterrent to migration and could have led some families to choose to remain in their place of residence while others without their own land or house chose to migrate elsewhere (Long & Siu, 2018). Tenant farmers were more heavily impacted by the increasing levels of extreme seasonality due to their reliance on agricultural productivity for their way of life.

This could also potentially be expanded to occupation, for instance, farmers and non-farmers belong to differing occupation systems, meaning they will be impacted by different sets of factors during environmental shifts and respond to these changes in unique ways

(Scheffer et al., 2009, 2012). Residents with different occupations may have been more influenced by the economic downturns associated with the Great Depression, which could have placed limitations on their ability to purchase necessary goods and services (Long & Siu, 2018). Even non-farmers were likely to experience the negative environmental effects of the Dust Bowl through food shortages resulting from crop failure, although in a more indirect manner than farmers did. Depending on other contextual factors (e.g. property ownership, family composition), individuals experiencing similar environmental shifts may have made very different decisions when choosing how to respond to the crisis (Gutmann et al., 2016; Long & Siu, 2018).

6 | CONCLUSION

From a policy perspective, migration studies in recent years have tended to focus on the “problem” of international migration, or on the relationship between internal and international migration. Migration, however, is not simply a problem that needs to be fixed, but a defining behavior of humans, associated with both costs and benefits—played out temporally and spatially. The costs and benefits are derived across many dimensions, including but not limited to how people are impacted by resource access, kin and social relationships, cultural knowledge and ties, risk and variation, and population dynamics.

And contrary to some perceptions, evidence suggests that much of the migration response to climate change occurs at regional and local scales (e.g. Gray, 2009; Massey et al., 2010; Penning-Rowsell et al., 2013; but see Halliday, 2006). We believe that evolutionary anthropologists have a unique perspective to contribute on internal migration in particular. The heterogeneity and adaptive nature of migration behavior that emerges at smaller scales may be missed with too heavy an international focus (Ellis, 2012), whereas a focus on how people make behavioral choices within a local context (household, community, habitat) is the level most amenable to evolutionary analysis (Winterhalder & Smith, 1992).

Human vulnerability to climate events is nothing novel, as evidence of human migration in the face of climate-induced crises can be traced in the historical and archaeological records through millennia (McLeman, 2011). Some could argue that this adaptability bodes well for humans now facing the environmental crises brought about by anthropogenic climate change. However, the unprecedented rate of climate change and its associated impacts today has brought about an equally intense increase in the number of people negatively affected by these impacts. A

critical question thus remains as to whether the cultural knowledge and behavioral strategies like migration that humans have utilized over generations to respond to environmental variation will be enough to cope with the current climate crisis. EAs have much to contribute to better understanding such climate-induced migration and should be part of the conversation.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

ETHICS STATEMENT

This is a review paper of published literature. It does not include any research by the authors on human or animal subjects.

AUTHOR CONTRIBUTIONS

Alannah R. Templon: Conceptualization; writing-original draft; writing-review & editing. **Danielle Kirsch:** Conceptualization; writing-original draft; writing-review & editing. **Mary C. Towner:** Conceptualization; writing-original draft; writing-review & editing.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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