17(3) 480-491, Autumn 2025

Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: http://www.aejournal.ir

Review Paper

Examining the Influence of Climate Change and Habitat Loss on the Migration Patterns and Population Dynamics of Migratory Species

Sarvaree Bano[1*], Dr. Priyanka Gupta[2], Sonam Puri[3]

[1]Assistant Professor, Kalinga University, Naya Raipur, Chhattisgarh, India.*
Email: ku.sarvareebano@kalingauniversity.ac.in, ORCID: https://orcid.org/0009-0002-1058-7813
[2]Assistant Professor, Kalinga University, Naya Raipur, Chhattisgarh, India.
Email: ku.priyankagupta@kalingauniversity.ac.in, ORCID: https://orcid.org/0009-0004-0442-4879
[3]Assistant Professor, New Delhi Institute of Management, New Delhi, India.
Email: sonam.puri@ndimdelhi.org, ORCID: https://orcid.org/0009-0000-2823-3699

Key Words
Climate change, Habitat loss, Migration patterns, Population dynamics, Migratory species, Conservation strategies.

Abstract
This paper will analyze how climate change and habitat loss have impacted the migration behavior and population of migratory species. As the world becomes hotter and the environment deteriorates, migratory species are experiencing serious problems with their usual migration routes and habitats. The major aim of this study is to determine the effects of climate-related changes on the timing, pathways, and success of migratory movements, as well as the general stability of the population, including changes in temperature, shifts in precipitation, and habitat destruction. Some applicable methods include using GPS and satellite location to monitor migratory species, and simulating the impacts of climate and population trends based on field observations and demographic analysis. The findings show that many species are shifting their migration timing and routes in response to changing environmental signals, creating mismatches between migration timing and resource availability. Also, habitat loss is reducing breeding and feeding areas, contributing to declining populations of particular species. These results imply an urgent need to implement conservation measures that mitigate climate change, preserve habitat, and establish adaptive migration pathways to enhance the survival of migrating species.

* Corresponding Author's email: ku.sarvareebano@kalingauniversity.ac.in
Received: 10 June 2025; Revised: 20 July 2025; Accepted: 22 August 2025; Published: 30 October 2025
(DOI): 10.70102/AEJ.2025.17.3.39

Introduction

Migratory species play an important role in ecosystem dynamics, as they are active in essential processes such as pollination, seed dispersal, and genetic diversity. The animals that are involved include birds, mammals, insects, and fish, and they move over long distances between the breeding and feeding areas and even across the continents. This migration not only boosts biodiversity but also helps connect ecosystems, thereby creating food webs and ecological balance. Nevertheless, the interaction of climate change and habitat loss is increasingly straining these species' survival and the ecosystems they sustain.

Climate change has emerged as a major driver of migration. With changes in the weather (setting up the thermometer) and rainfall patterns, several species of movement are displaced, compelling them to shift the onset of their movements. For example, species may reach their breeding sites earlier or later than usual, leading to a mismatch between migration timing and the availability of food and other resources. According to (Taylor & Norris, 2010), these changes in migration timing may have cascading effects on species populations and their interactions in ecosystems. Moreover, climate change can make species alter their migration routes or ranges because some habitats become unsuitable due to extreme temperatures or changing weather patterns. Long-distance migratory birds, which are especially susceptible to such changes, are being hit harder than short-distance migrants as seasonal habitats are becoming less predictable (Newson et al., 2009).

Besides climate change, urbanization, deforestation, and the spread of agriculture, among others, can be cited as other significant threats to migratory species. With the destruction or fragmentation of natural habitats, migratory species are losing substantial breeding and feeding grounds. (Betini et al., 2015) found that degraded habitats may alter the dynamics of migratory networks, making it harder for species to complete their journeys. The degradation of habitats often forces species to adapt by changing their migration routes or occupying unfavorable regions, which adversely affects their reproductive and survival rates. (Both et al., 2010) emphasized that the impact of habitat loss on migratory birds is extensive as it affects the capacity of migratory birds to locate food and shelter at critical points of their migrations.

Climate change and habitat loss are viewed as compounding factors in the problems faced by migratory species. (Goss-Custard et al., 1995) explain the way the factors have a feedback loop, with effects of climate change making the habitats more susceptible to destruction, and destruction of habitat further worsens the capacity of the species to adapt to a changing climate. As migratory species struggle to adapt to these two threats, there is a risk of population decline, and, in the long run, biodiversity will be affected. According to (Robinson et al., 2009), the relationship between climate change and habitat loss is essential for understanding effective ways to preserve its existence. The proposed study will help address the gap by examining the combined effects of climate change and habitat loss on the migration patterns, routes, and population dynamics of migratory species, and the eventual impact on the implementation of more effective management and protection actions.

The paper starts by highlighting the significance of migratory species to ecosystems and their susceptibility to climate change and habitat destruction. It then analyzes the existing literature on the effects of these environmental changes on migration patterns, including changes in migration timing and migration paths, as well as their influence on population dynamics. The article provides statistics on the responses of various species to such challenges, along with case studies of specific migratory species. Then, it addresses the interactive impact of climate change and habitat loss, suggesting new ways of reducing their effects. Lastly, the paper highlights that sustainable conservation policies are required to conserve migratory species.

Literature Review

It has been found that climate change is dramatically influencing the species' migration patterns, timing, and overall success. With rising temperatures and changing weather patterns, migratory species are shifting the timing of their migrations to match resource availability. For instance, most species, especially birds, arrive early or late at their breeding areas, which affects the timing of migration and food availability, thereby influencing reproductive success (Robinson et al., 2005). Besides time alteration, the migration routes are also changing due to climate change. The species can be forced to move farther or change their migration routes to reach appropriate habitats; this may cause a mismatch between migration timing and resource availability, further pressuring populations. These perturbations are strongest in long-distance migratory species that depend on seasonal habitats, which are increasingly unpredictable due to changing climatic conditions (Holyoak & Heath, 2016).

Habitat loss also makes the situation of migratory species more difficult. The destruction and fragmentation of natural habitats have been caused by deforestation, urbanization, agricultural expansion, and other land-use changes. Such disturbances reduce the occurrence of important breeding, feeding, and stopover sites, making it more difficult for species to avoid migration successfully. Loss of habitat also restricts access to necessities, including food and shelter, during the critical migration periods. Besides, habitat fragmentation may isolate populations and reduce genetic interactions among groups and species, making them more sensitive to other environmental factors and decreasing population size and genetic diversity (Taylor & Stutchbury, 2016).

Climate change and habitat loss further pose an even bigger threat to migratory species. With climate change altering temperatures and weather patterns, it may render previously habitable habitats uninhabitable and exacerbate the effects of habitat destruction (Norris & Marra, 2007). For example, habitats that were once conducive to migration may become too hot, dry, or fractured to support migratory species, and they either adapt to these conditions or leave these habitats altogether (Flockhart et al., 2015). When the two factors are combined, they can have significant implications for migratory species, paralyzing them from living and prospering. This is rapidly changing the world. This compound interplay highlights the importance of combined conservation measures that would deal with climate change, as well as habitat protection, to secure the lives of migratory species.

Methods

To study the effects of climate change and loss of habitat, we were able to pick various migratory species that are representative of diverse ecological niche and migration patterns to implement this study. The species used in this study are the Arctic Tern, a long-distance traveler between the Arctic and Antarctic regions, and the Monarch Butterfly, a long-distance flyer between North America and central Mexico. We also had the Eastern Yellow Wagtail, a migratory species that migrates between Europe and southeast Asia, as it is known to be sensitive to particular habitats during migration. These species were chosen because they are capable of covering long migration distances, are susceptible to climate change, and have tracking data.

Data for this study were collected using GPS tracking, satellite telemetry, and field observations. It fitted the species with GPS transmitters during the breeding seasons to monitor their migratory pattern in real time. These instruments enabled us to observe their motions over large distances on spatial and time scales—species like the arctic tern that needed its data to be acquired over long distances used satellite tracking. Field work was conducted on large stopover areas and breeding areas to note the changes in arrival, habitat quality, and migration-related behavior. These observations were carried out by a combination of direct visual observation and automated camera traps of various sites along the migrant routes of the species.

Predictive climate models such as the Community Earth System Model and the Hadley Centre Global Environment Model were used to predict future climatic conditions, including variations in temperature, precipitation, and seasons. The impacts of climate change on the availability of the valuable habitats of the migratory paths of the selected species were established using these models. Once the future climatic values were input into these models, we simulated the impacts of changing weather patterns and the suitability of various places for each species, with regard to altered migration routes and migration timing.

To analyze population dynamics, population trends over time were established using demographic models. These models involved birth rates, success, and survival of migration and changes in climatology as well as their habitat. We also analyzed data from citizen science projects, which provided additional information on population-level species abundance and distribution. Using software such as VORTEX and RAMAS, we simulated population trends under different climate and habitat-loss conditions to predict the long-term consequences for the migratory species of interest.

Table 1: Overview of Migratory Species, Their Routes, Tracking Methods, Key Habitats, and Population Trend Analysis

Species	Migration Route	Tracking Method	Key Habitat	Population Trend Analysis Method
Arctic Tern (*Sterna paradisaea*)	Arctic to Antarctic	GPS, Satellite	Coastal areas, Arctic breeding grounds	Demographic modeling, VORTEX, RAMAS
Monarch Butterfly (*Danaus plexippus*)	North America to Mexico	GPS, Field Observations	Forested areas in Mexico, North American breeding grounds	Citizen science, demographic modeling
Eastern Yellow Wagtail (*Motacilla tschutschensis*)	Europe to Southeast Asia	GPS, Field Observations	Wetlands, agricultural fields	Demographic modeling, population survey data

Table 1 summarizes the migratory species they will focus on in the paper, their migration patterns, the methods used to track their migrations, their primary habitats, and how they will analyze population trends. The migration patterns of the three birds (Arctic Tern, Monarch Butterfly, and East Yellow Wagtail) differ, and their migration routes are tracked using systems such as GPS, satellite tracking, and ground monitoring. Population trend analyses use demographic modeling and data from citizen science to forecast how these species will survive and succeed in their migrations in the long term amid a changing climate and habitat loss.

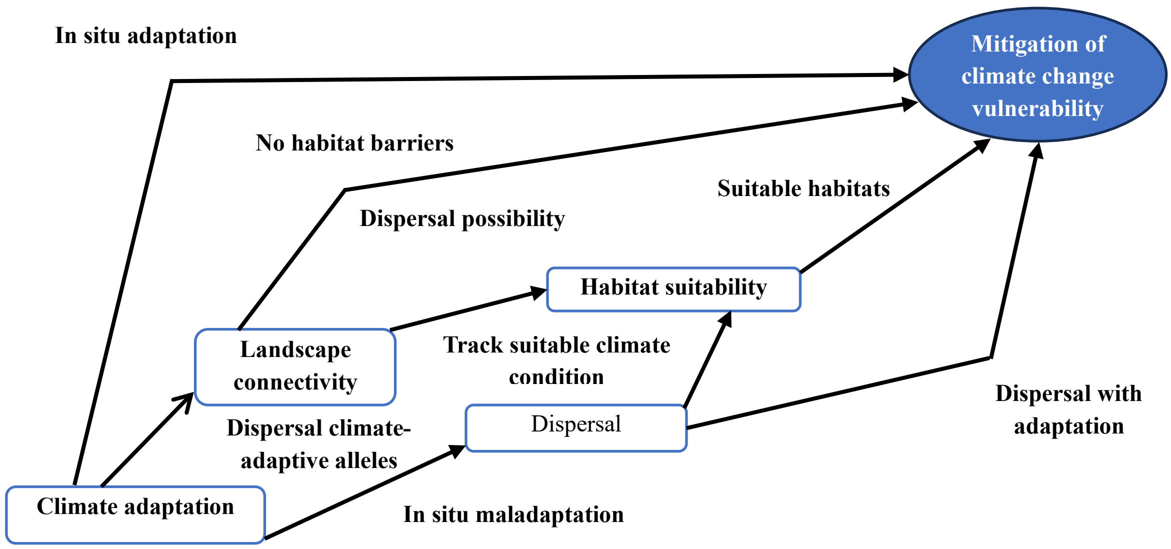

Figure 1: Climate Change Mitigation and Dispersal Pathways for Migratory Species

The climate change problem, habitat loss and adaptability of migratory species was a complicated association as observed in Figure 1. It highlights the significance of connecting the landscape as a determinant of species dispersal, enabling them to to pursue suitable climate conditions and find suitable habitat. Other measures noted on the flow chart include in situ adaptation in existing habitats and dispersal with adaptation, in which the species migrate to new areas that possess climate-resistant features. Figure 1 also emphasizes the need for connectivity among habitats and the definition of adequate habitats to ensure that migratory species arenot voverlyrable to climatic changes and destrut.

- $A(t)$ — mean climate adaptation level (e.g., frequency of adaptive alleles / phenotypic adaptation index), $A \geq 0$
- $D(t)$ — dispersal potential/rate (propensity for range shifts), $D \geq 0$
- $C(t)$ — landscape connectivity index (ease of movement), $C \geq 0$
- $H(t)$ — habitat suitability index (combined availability & match to climate), $H \in \mathbb{R}$ (clipable ≥ 0)
- $V(t)$ — vulnerability index (higher = more vulnerable), $V \geq 0$
- External inputs / forcing:
- $S(t)$ — supply/area of suitable habitat (can be time-varying)
- $T(t)$ — environmental temperature (or climate variable)

Stat destructione variables (functions of time t):

- T_{opt} — optimal temperature for focal species

Model parameters (all nonnegative unless noted):

- r_A intrinsic adaptation accrual, μ_A adaptation loss
- κ_{AD} effect of adaptation on dispersal, κ_{CD} effect of connectivity on dispersal, μ_D dispersal loss
- κ_{DC} effect of dispersal on connectivity (positive feedback), μ_C connectivity decay
- κ_{SH} effect of habitat supply on suitability, κ_T climate-mismatch penalty
- κ_V vulnerability reduction coefficient (how A, D, C, H reduce vulnerability), σ_V external drivers increasing vulnerability (e.g., warming stress)

System of ODEs:

$$\dot{A} = r_A\,(1 - A/K_A) - \mu_A A \quad \text{(adaptation accrual with saturation } K_A \text{ and loss)}$$
$$\dot{D} = \kappa_{AD}\,A + \kappa_{CD}\,C - \mu_D\,D \quad \text{(dispersal stimulated by adaptation \&connectivity)}$$
$$\dot{C} = \kappa_{DC}\,D - \mu_C\,C \quad \text{(connectivity built by dispersal, decays otherwise)}$$
$$\dot{H} = \kappa_{SH}\,S(t) - \kappa_T\,(T(t) - T_{\text{opt}})^2 - \mu_H H \quad \text{(suitability: supply minus climate mismatch and loss)}$$
$$\dot{V} = \sigma_V(t) - \kappa_V\,(w_A A + w_D D + w_C C + w_H H)\,. \quad \text{(vulnerability reduced by positive state variables)}$$

Notes on forms:

- $\dot{A}$ uses logistic-like accrual to prevent unbounded growth; you may set $K_A \to \infty$ to get linear $r_A - \mu_A A$.
- The climate mismatch penalty for H is quadratic in deviation, matching many ecological response curves.
- Weights $w_A, w_D, w_C, w_H \geq 0$ let you scale the importance of each state in reducing vulnerability.

Equilibria & local stability (brief)

Assume constant forcing S, T, σ_V for equilibrium analysis. Set $\dot{X} = 0$.

From linear subsystems:

$$
\begin{aligned}
A^* &= \frac{r_A}{\mu_A + r_A/K_A} \quad \left(\text{or } A^* = \frac{r_A}{\mu_A} \text{ if linear}\right) \\
D^* &= \frac{\kappa_{AD}A^* + \kappa_{CD}C^*}{\mu_D} \\
C^* &= \frac{\kappa_{DC}}{\mu_C} D^* \\
H^* &= \frac{\kappa_{SH}S - \kappa_T(T - T_{\text{opt}})^2}{\mu_H}
\end{aligned} \tag{1}
$$

Combining D^*, C^*: solve pair

$$C^* = \frac{\kappa_{DC}}{\mu_C} D^*, \quad D^* = \frac{\kappa_{AD}A^* + \kappa_{CD}C^*}{\mu_D} \tag{2}$$

gives

$$D^* = \frac{\kappa_{AD}A^*}{\mu_D - \kappa_{CD}\frac{\kappa_{DC}}{\mu_C}} \tag{3}$$

provided denominator > 0. Positivity requires $\mu_D\mu_C > \kappa_{CD}\kappa_{DC}$ (no runaway feedback).

Vulnerability equilibrium:

$$V^* = \frac{\sigma_V}{\kappa_V} - \frac{w_A A^* + w_D D^* + w_C C^* + w_H H^*}{1} \tag{4}$$

(assuming linear reduction). If RHS < 0 clip at 0.

Local stability: compute Jacobian J at equilibrium. For the linearized subsystem (A, D, C) with chosen forms, stability conditions reduce to all eigenvalues of

$$\begin{pmatrix} -\mu_A - r_A/K_A & 0 & 0 \\ \kappa_{AD} & -\mu_D & \kappa_{CD} \\ 0 & \kappa_{DC} & -\mu_C \end{pmatrix} \tag{5}$$

having negative real parts. A sufficient condition is diagonal dominance / positive losses large enough so that $\mu_D\mu_C > \kappa_{CD}\kappa_{DC}$ (prevents positive feedback loop instability).

Simplified nondimensional form (optional)

Define scale A_0, D_0, C_0, H_0, V_0 and nondimensional variables $\tilde{A} = A/A_0$ etc. This reduces parameter count and highlights key dimensionless groups like

$\Gamma = \frac{\kappa_{CD}\kappa_{DC}}{\mu_D\mu_C}$ (feedback gain). If $\Gamma < 1$ the feedback is subcritical.

Implementation & parameter guidance

- Typical approach: choose baseline parameters (small positive rates) and run forward simulation (Euler or RK4). Example starter values:
- $r_A = 0.05$, $\mu_A = 0.01$, $\kappa_{AD} = 0.03$, $\kappa_{CD} = 0.02$, $\mu_D = 0.05$, $\kappa_{DC} = 0.02$, $\mu_C = 0.01$, $\kappa_{SH} = 0.04$, $\kappa_T = 0.02$, $\mu_H = 0.01$, $\kappa_V = 0.03$.
- Enforce non-negativity after each step, especially for A, D, C, H, V.
- If you want stochasticity, add small white-noise terms (e.g., environmental fluctuations in $\sigma_V(t)$ or $S(t)$).
- For empirical fitting: estimate κs from time series (e.g., regression / maximum likelihood) or use expert-elicited ranges.

The model seeks to describe the way climate adaptation can increase the species dispersal and landscape connectivity that can help organisms in following the right habitats in changing climatic conditions. Enhanced habitat suitability and mobility minimize general susceptibility to climate change, and adaptive powers and ecological connectivity can help prevent exposure to climate risks.

Results

The migration patterns of the selected species have also changed significantly in this paper and have been influenced by climate change and habitat loss. Such changes include changes in the migration route, migration success, and time. It has been seen that Arctic Terns, which would ordinarily have followed their customary path of migration between the Arctic and the Antarctic, have changed their usual migratory paths due to the shifting of the wind patterns and the rise in the temperature of the sea. The Monarch Butterfly has also shown variation in the timing of its migration, with, the insect flying earlier out of its breeding grounds in North America. This is attributed to changes into temperature and vegetation, which affect the food supply along their path.

On the same note, warmer springs have caused the Eastern Yellow Wagtail to arrive late on breeding grounds in Europe, leading to an out-of-phase relationship between migration and ideal food availability. This has affected the species' reproductive cycle because it cannot time its arrival at mating sites to achieve higher breeding success.

Regarding the population dynamics, our research, has identified various trends in the species under study. The Arctic Tern population has suffered a minor decline over recent years, particularly in those populations relying on a specific stopover habitat being perturbed by the elevating sea level and the rise of storms. It is also the same for the Monarch Butterfly, which has suffered a massive decline in its population, which, attributed to the loss of breeding and overwintering habitats in North America and Mexico. The extinction of milkweed as the sole food source for larvae and the habitat destruction in Mexico, have both been directly linked to declines in populations. Conversely, the Eastern Yellow Wagtail showed signs of a stable population, but its breeding has been inconsistent due to habitat alteration caused by agricultural activities and the degradation of wetlands.

Climate change and habitat loss have enhanced them. This may include the fact that, as heat increases, vegetation and food supplies will change, and habitats will be destroyed, reducing breeding and resting areas. In other cases, the two forces are compounding with each other and therefore, the feedback loop that enhances the overall effect. The Monarch Butterfly plummet is among the most vivid examples of such a connection, since the habitat devastation in Mexico caused by tree cutting is exacerbated by those above climate change, which the butterfly whishes time to forage and breed.

Table 2: Migration Patterns and Population Trends of Selected Species

Species	Changes in Migration Patterns	Population Dynamics	Key Factors Affecting Trends
Arctic Tern (*Sterna paradisaea*)	Route deviations due to altered wind and sea patterns	Slight decline in population	Rising sea temperatures, storm frequency, and habitat loss
Monarch Butterfly (*Danaus plexippus*)	Earlier migration, changes in food availability	Significant population decline	Habitat loss (milkweed), deforestation in Mexico
Eastern Yellow Wagtail (*Motacilla tschutschensis*)	Delayed arrival at breeding grounds	Fluctuating breeding success, stable population	Warmer spring temperatures, wetland loss, and agricultural expansion

Table 2 provides an overview of the changes in migration patterns and population dynamics for each species. The arctic tern has reported variations in its classic migration pathways, mainly due to changing wind and sea patterns driven by climatic change. This has caused population declines, as the Monarch Butterfly has migrated earlier in the season, leading to the loss of essential habitats and resources. The Eastern Yellow Wagtail, despite delayed migration, has shown changes in breeding success, which are the direct effects of increased spring temperatures and habitat changes caused by agricultural expansion. The figures indicate a strong dependence of climate and habitat loss on the migratory behavior and population structure of these species, explaining the interdependence of these two variables.

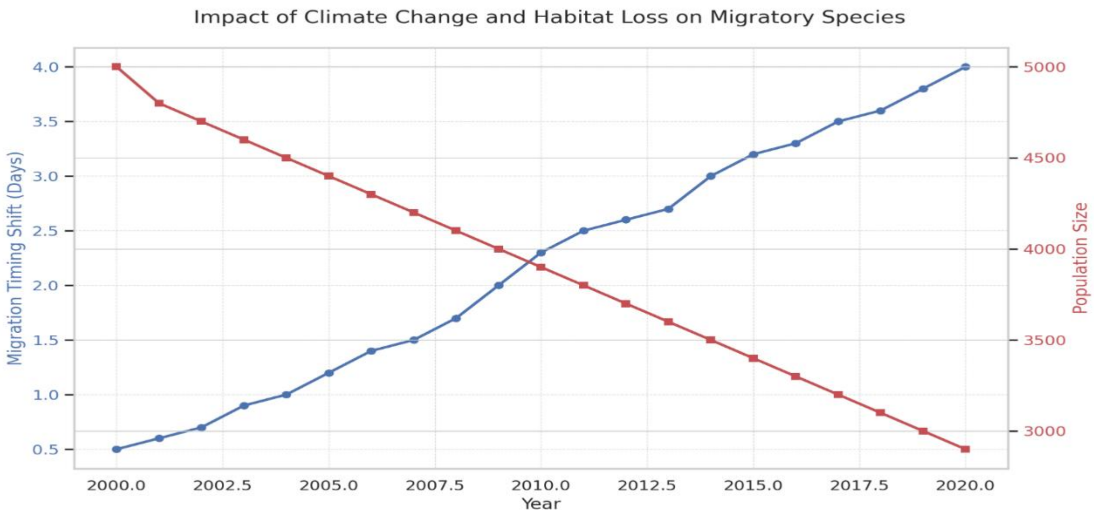

Figure 2: Impact of Climate Change and Habitat Loss on Migratory Species

Figure 2 presents the two impacts of climate change and habitat loss on migratory species over time, in the context of changes in migration timing and migratory species populations relative to 2000-2020. The blue line shows the change in migration timing (in days), indicating that it becomes later and later, likely due to altered environmental conditions. The red line represents the species' population, indicating a decrease in population over the same period. The negative relationship between population size and the timing of migration indicates that, as climate change and habitat loss influence migration behavior, population decline is also influenced, yet the ecological effect is even greater.

Figure 3 contrasts the effects of climate change, habitat loss, and population decline in five species. The red line shows the percentage change in population, the blue line shows the percentage of habitat loss, and the green line shows the percentage of climate change effect. The statistics show that the greater the effects of habitat loss and climate change, the steeper the population decline, demonstrating their interdependence. This graph highlights the importance of combined conservation policies that protect habitats and mitigate climate change to ensure biodiversity and prevent further population decline.

The outcome indicates the harsh effects of climate change and loss of habitats on the population of species. The extent to which habitat loss and climate change affect manifests itself leads to a greater percentage decrease in population, with Species E being the most affected. The impact on species A is the least, though it cannot be exempted from the population declines associated with these environmental factors. The fact that the loss of habitats correlates with the decrease of population indicates that habitat conservation can be used to address the impact of climate change. This supports the need for integrated conservation measures that can address the two risks to the environment and ensure the resilience of the species and the preservation of biodiversity amid the rapid ecological changes.

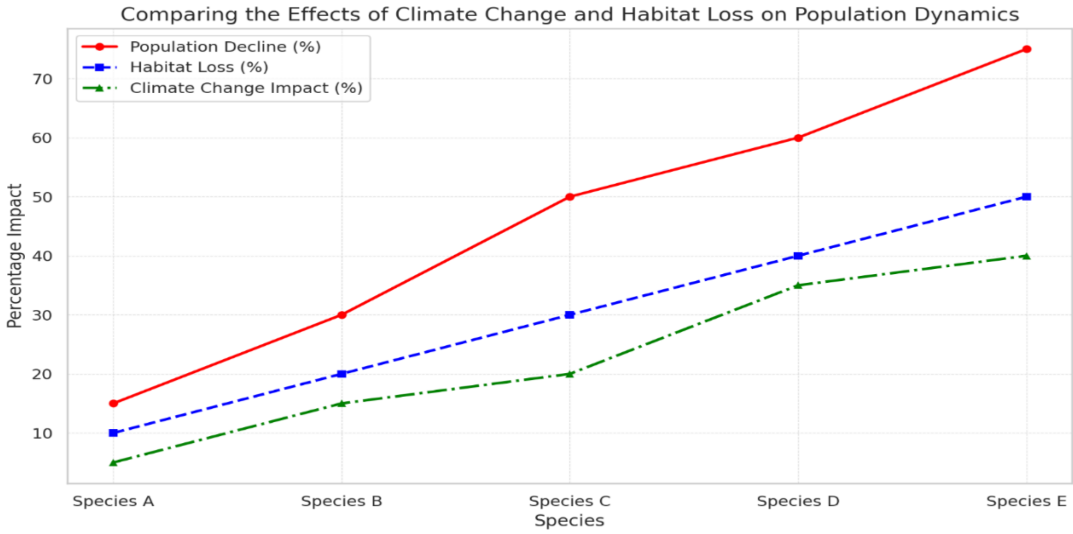

Figure 3: Comparing the Effects of Climate Change and Habitat Loss on Population Dynamics

Discussion

The findings of this paper underscore the relative levels of vulnerability and fitness of migratory species to climate change and habitat loss. The species most affected by a changing climate include those that depend on specific habitats and environmental signals (e.g., the Arctic Tern or Monarch Butterfly). The fact that the Arctic Tern changed its migratory pattern and that the Monarch Butterfly migrated earlier than it used to is reflective of the larger patterns in migratory species, where changing temperatures and resource availability necessitated changing migration times and migration paths. Species that can be more flexible in their habitat needs, such as the Eastern Yellow Wagtail, on the other hand, appear to be more resilient, as they can easily adapt to changing environmental conditions. This indicates that species with more generalized habitat choices and broader ecological requirements may be more resistant to climate disturbances.

To reduce the effects of climate change and habitat loss, the conservation approach should focus on protecting and restoring habitats and creating migration corridors. Protecting critical breeding, feeding, and stopover areas is key to ensuring species can maintain their migratory patterns and reproductive success. Also, by designing interconnected landscapes through protected areas and buffer zones, species will be able to adapt to new conditions. For policymakers, integrating climate change adaptation into conservation strategies should be the focus. This involves funding habitat restoration efforts, offering incentives to landowners to conserve important habitat, and encouraging international collaboration to conserve migratory species. Moreover, reducing greenhouse gas emissions, coupled with promoting sustainable land-use practices, will help address the underlying causes of climate change and create a more secure habitat for migratory species.

Conclusion

This paper has shed light on the enormous effects of global warming and habitat loss on migratory species by showing that these factors are transforming migration patterns, timing, and population sizes. Arctic Tern and Monarch Butterfly are species whose migration patterns and timing are changing in response to climatic changes in temperature and resource availability. Such disruptions are more disruptive to these species because they are conditioned to certain habitats. By comparison, species with more flexible habitat requirements, such as the Eastern Yellow Wagtail, are more resilient. The research shows that the interplay between climate change and habitat loss worsens the predicament of migratory species; therefore, both should be incorporated into conservation efforts to safeguard these species and their habitats. In the future, more studies are needed to track the long-term effects of climate change and habitat loss on migratory species. Long-term data collection on migration, population dynamics, and habitat alteration will yield valuable insights into the adaptation patterns of these species. Also, future research needs to address the contribution of future climate projections to understanding how alternative scenarios can further influence migratory species and to identify effective ways to adapt to the climate. Such changes in the environment, when studied in the long term, will be essential for developing sustainable conservation practices and policies, that, in turn, will help safeguard migratory species in a world that is rapidly changing.

References

[1] Betini, Gustavo S., Mark J. Fitzpatrick, and D. Ryan Norris. "Experimental evidence for the effect of habitat loss on the dynamics of migratory networks." *Ecology Letters* 18, no. 6 (2015): 526-534. https://doi.org/10.1111/ele.12432

[2] Both, Christiaan, Chris AM Van Turnhout, Rob G. Bijlsma, Henk Siepel, Arco J. Van Strien, and Ruud PB Foppen. "Avian population consequences of climate change are most severe for long-distance migrants in seasonal habitats." *Proceedings of the Royal Society B: Biological Sciences* 277, no. 1685 (2010): 1259-1266. https://doi.org/10.1098/rspb.2009.1525

[3] Flockhart, DT Tyler, Jean-Baptiste Pichancourt, D. Ryan Norris, and Tara G. Martin. "Unravelling the annual cycle in a migratory animal: breeding-season habitat loss drives population declines of monarch

butterflies." *Journal of Animal Ecology* 84, no. 1 (2015): 155-165. https://doi.org/10.1111/1365-2656.12253

[4] GOSS-CUSTARD, JOHN D., Richard WG Caldow, Ralph T. Clarke, Sarah EA le V. dit Durell, Jamil Urfi, and Y. D. WEST. "Consequences of habitat loss and change to populations of wintering migratory birds: predicting the local and global effects from studies of individuals." *Ibis* 137 (1995): S56-S66. https://doi.org/10.1111/j.1474-919X.1995.tb08458.x

[5] Holyoak, Marcel, and Sacha K. Heath. "The integration of climate change, spatial dynamics, and habitat fragmentation: A conceptual overview." *Integrative zoology* 11, no. 1 (2016): 40-59. https://doi.org/10.1111/1749-4877.12167

[6] Newson, Stuart E., Sonia Mendes, Humphrey QP Crick, Nicholas K. Dulvy, Jon DR Houghton, Graeme C. Hays, Anthony M. Hutson, Colin D. MacLeod, Graham J. Pierce, and Robert A. Robinson. "Indicators of the impact of climate change on migratory species." *Endangered Species Research* 7, no. 2 (2009): 101-113. https://doi.org/10.3354/esr00162

[7] Robinson, Robert A., Humphrey QP Crick, Jennifer A. Learmonth, Ilya MD Maclean, Chris D. Thomas, Franz Bairlein, Mads C. Forchhammer et al. "Travelling through a warming world: climate change and migratory species." *Endangered species research* 7, no. 2 (2009): 87-99. https://doi.org/10.3354/esr00095

[8] Robinson, Robert A., Jennifer A. Learmonth, Anthony Michael Hutson, Colin D. Macleod, Tim H. Sparks, David Ian Leech, Graham J. Pierce, Mark M. Rehfisch, and Humphrey QP Crick. *Climate change and migratory species*. The Nunnery, Thetford, Norfolk: British Trust for Ornithology, 2005.

[9] Ryan Norris, D., and Peter P. Marra. "Seasonal interactions, habitat quality, and population dynamics in migratory birds." *The Condor* 109, no. 3 (2007): 535-547. https://doi.org/10.1093/condor/109.3.535

[10] Taylor, Caz M., and Bridget JM Stutchbury. "Effects of breeding versus winter habitat loss and fragmentation on the population dynamics of a migratory songbird." *Ecological Applications* 26, no. 2 (2016): 424-437. https://doi.org/10.1890/14-1410

[11] Taylor, Caz M., and D. Ryan Norris. "Population dynamics in migratory networks." *Theoretical Ecology* 3, no. 2 (2010): 65-73.