WREN SHORT SCIENCE SUMMARY

WIND ENERGY-ENVIRONMENTAL RESEARCH & ENGAGEMENT NETWORK

Impact of Wind Energy on Flying Wildlife in Leading Wind Energy Producing Countries of Latin America: Challenges and Priorities

SUMMARY

1. Wind energy production in Latin America is growing, but there are several constraints related to environmental, social, political, and economic factors.
2. Latin America hosts 40% of the world's biodiversity, including nearly 450 species of bats. It is also an essential corridor for migratory bird species.
3. Expanding wind energy in the region can help mitigate the impacts of global warming, but environmental impacts, such as collision risk for certain species of birds and bats, may contribute to biodiversity loss.
4. Sustainable wind energy development in Latin America is challenged by the lack of information about species and habitats vulnerable to wind energy development and the absence of guidelines and regulations to quantify and mitigate environmental impacts.
5. Developing standard protocols for monitoring impacts, improving data transparency, and implementing practical solutions to minimize impacts can help advance wind energy deployment in Latin America and promote a One Health approach, which recognizes the interconnectedness of human, plant, animal, and environmental health.

INTRODUCTION

The production of wind energy has undeniable benefits in reducing greenhouse gas emissions and dependence on fossil fuels. However, this renewable energy source can have negative impacts on the environment and wildlife. Hundreds of bird and bat species have been recorded as victims of various impacts associated with wind energy worldwide [1,2]. Most of these data come from North American and European countries [3,4]. However, little information exists regarding the impacts of wind energy production on birds and bats in Latin America [3,5].

The wind industry continues to grow in Latin America, with the region's installed capacity tripling between 2014 and 2019. In 2023, Latin America positioned itself as the fourth-largest producer of wind energy worldwide, with countries such as Brazil, Mexico, and Chile leading this sector [6]. However, there is concern regarding the lack of studies on the impacts to flying wildlife in Latin America, including those areas with great biodiversity [3,5]. The available information is scarce or nonexistent in regions like Central America and the northern section of South America, despite those regions hosting several bird species vulnerable to collision with wind turbines [4].

On the other hand, the lack of specific and mandatory guidelines to assess the impacts on flying wildlife in several Latin American countries has sometimes led to the use of inadequate methods and the underestimation of effects on local fauna [7]. Additionally, the diversity of tested methodologies makes it difficult to compare mortality rates between projects and regions. This highlights the urgency of conducting more rigorous and detailed research during the preconstruction phases of wind farms under a standardized methodology.

The rapid global expansion of wind energy development necessitates cooperation between industry and the biodiversity conservation community, especially those focused on bats and birds. Together, they must develop and implement rigorous guidelines identifying the magnitude of the effects on wildlife and outline strategies to minimize harmful impacts [8].

A flock of kelp gulls (*Larus dominicanus*) flies past wind turbines at sunset in Chubut Province, Argentina. *Photo from Gonzalo Herrera, INBIOTEC*

CURRENT STATUS AND PROJECTIONS OF THE WIND INDUSTRY IN LATIN AMERICA

In 2023, Latin America had a record year for new wind energy installations, with more than three-quarters of the additions coming from a single market: Brazil. The strong growth in this country has been primarily linked to projects developed through the free/bilateral private market. Comparatively, growth expectations for 2030 in other wind powerhouses of the region, such as Chile, Argentina, and Mexico, are also high (see Figure 1). Installed wind power capacity in Latin America and the Caribbean currently represents 5% of global capacity, but projects in the preconstruction, construction, and announced phases are expected to increase this number to 11% in the coming years [9]. All Latin American countries agree on the long-term projection, which is based on an energy transition toward a higher proportion of renewable energy sources, with wind energy playing a prominent role [10].

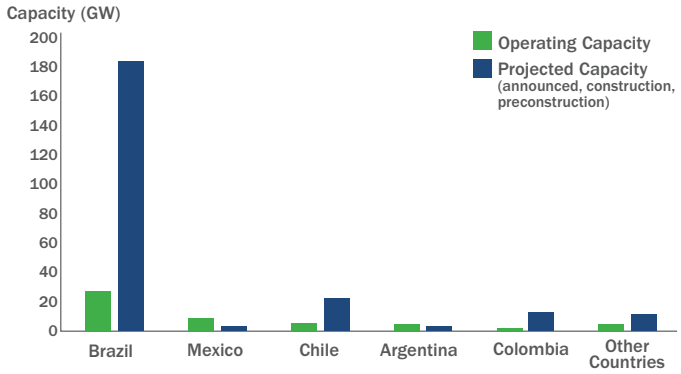

Figure 1. Wind energy capacity for operating and projected projects in Latin America. *Data from [9]*

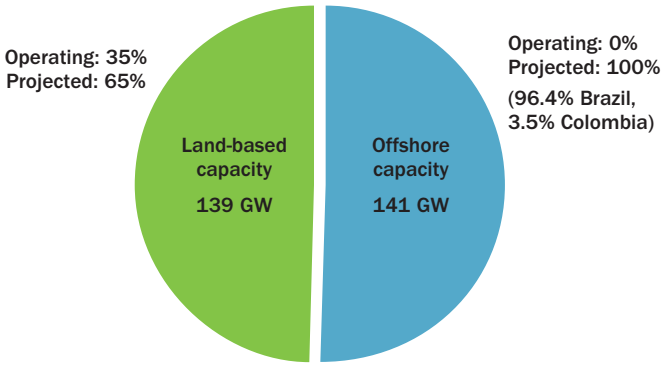

Figure 2. Land-based versus offshore wind energy capacity in Latin America and the Caribbean. *Data from [9]*

Although there are currently no offshore wind farms in operation in the region, installed offshore capacity is projected to equal or even exceed the land-based wind sector. About 66 offshore wind projects are planned—mostly in Brazil and some in Colombia (see Figure 2)—with an approximate capacity of 140 gigawatts (GW) [9]. The planned growth of offshore wind energy raises concerns, as environmental impact assessments are not currently conducted in a standardized manner in Latin America. The scarcity of studies evaluating the negative consequences for marine wildlife in the region pose a challenge to managing the impacts of offshore wind development on wildlife [11].

Key Ideas

Latin America, led by Brazil, is experiencing strong growth in wind energy capacity; expansion is planned for both onshore and offshore projects. However, this poses management challenges, as a lack of wildlife impact studies and consensus on environmental regulations in the region make it difficult to adequately address how this accelerated growth will affect wildlife.

Wind farm in Baja California, Mexico. *Photo from Minerva Uribe-Rivera, University of Baja California*

CHARACTERISTICS THAT INCREASE THE POTENTIAL IMPACT OF WIND FARMS IN LATIN AMERICA ON FLYING WILDLIFE

Latin America has around 40% of the global biodiversity. Six countries in the region are considered "megadiverse," possessing 70% of global biodiversity [12].

For birds, Latin America and the Caribbean are home to 775 endemics[1] bird species, representing 18% of the total, many of which are potentially threatened by wind farms [13]. The neotropical[2] realm, hosts between 4,400 and 4,560 bird species [14,15] and serves as an important corridor for many migratory species [16]. However, the installation of wind farms in areas used as migratory routes can lead to habitat fragmentation[3]

[1] "Endemic" refers to a species or group of organisms found only in a specific geographic location.

[2] A biogeographical area that covers almost all of South and Central America, Mexico, and the Caribbean.

[3] Habitat fragmentation happens when continuous habitats are broken up into smaller, isolated patches due to human activities.

and the loss of functional habitat. When birds are forced to alter their usual flight paths to avoid wind turbines [17,18], the ecological connectivity of migratory species is disrupted, leading to increased energy expenditure and lower survival rates. Furthermore, two of Chile's three endemic bird species are found in the Coquimbo region, which has the highest wind energy production in the country.

Latin America and the Caribbean also have 450 recorded species of bats [19]. The neotropical chiropteran[4] fauna is the most diverse in the world [20] and includes families exclusive to the region such as leaf-nosed bats (Phyllostomidae) and ghost-faced bats (Mormoopidae). While some bat species are solitary, many others form large colonies in warm caves in countries like Mexico, Colombia, and Brazil and travel long distances at high altitudes to feed. The risk of bat collisions with wind turbines increases near feeding or migratory areas [13,21]. Another important characteristic is the endemism of this region among bats. In Chile, endemism is a key feature that makes the central region a global biodiversity hotspot. Recently, a new endemic bat species, gray Andean myotis (*Myotis arscens*), was discovered and described in Chile. This species only occurs in the Coquimbo Region, increasing its extinction risk because of the prevalence of wind turbines in the region. Additionally, there are 77 endemic bat species in Latin America and the Caribbean, representing 17% of the region's bat diversity [13].

Key Ideas

The migratory corridors over Latin America are critical for many bird species, and wind farms located in these corridors can lead to flight path changes, habitat fragmentation, and disrupted ecological connectivity. Additionally, for the region's high diversity of bats, the presence of wind farms near feeding or migratory areas increases collision risk.

SPECIES AFFECTED BY MORTALITY IN WIND FARMS IN LATIN AMERICA

As of 2020, at least 69 bird species had been recorded as collision victims with wind turbines across Latin America. The most affected bird orders include Passeriformes, followed by Columbiformes, Galliformes, Cathartiformes, and diurnal raptors (Accipitriformes and Falconiformes). The species with the highest proportion of mortality records was the northern bobwhite (*Colinus virginianus*), classified as "near threatened"

Clockwise from top left: Leaf-nosed bats (Phyllostomidae). *Photo from Adobe Stock #869281327*; Chilean Swallow (*Tachycineta meyeni*) in Chile. *Photo from Adobe Stock #824381678*; Northern Ghost Bat (*Diclidurus albus*) in Costa Rica. *Photo from Adobe Stock #21534612*; Southern Lapwing (*Vanellus chilensis*) in Brazil. *Photo from Getty Images 588616714*

[4] Chiropteran fauna are bat species that are native to the tropical and subtropical areas of the Americas.

Andean condor (*Vultur gryphus*) in Chile. *Photo from Adobe Stock 202990465*

by the International Union for Conservation of Nature.[5] The turkey vulture (*Cathartes aura*), and the white-tipped dove (*Leptotila verreauxi*) [3] also had a high proportion of mortality records; both of these species are classified as "least concern." Additionally, recent mortality monitoring reports from a wind farm in Chile indicated that at least nine Andean condors (*Vultur gryphus*) were killed by colliding with wind turbines [20]. This is particularly concerning given that this species is categorized as vulnerable globally and is in some category of national concern in all countries where it is found.

Regarding bats, most mortality records available in Latin America correspond to the family Molossidae (415 carcasses), followed by Mormoopidae (313), Vespertilionidae (125), and Phyllostomidae (93).[6] There are records of at least 983 bat deaths across 40 species, with mortality ranging from zero at a wind farm in western Mexico to 336 at the Osório Wind Farm in Brazil. The species with the highest number of mortality records are the Mexican free-tailed bat (*Tadarida brasiliensis*) (Figure 3) and Davy's naked-backed bat (*Pteronotus davyi*), with 274 and 219 carcasses, respectively [3].

Figure 3. Mexican free-tailed bat (*Tadarida brasiliensis*) in Mato Grosso, Brazil. *Photo from Adobe Stock 368623974*

To highlight the significant diversity of bats in Latin America, it's notable that the United States recorded bat mortality for 27 species across 482 studies conducted between 1995 and 2018 in their country, spanning 221 projects. In contrast, Latin America reported bat mortality for 40 species but has fewer projects and less available data compared to the United States [3].

In Argentina, information on this topic remains scarce. Consequently, several bird and bat species have been assigned a high priority for study based on their susceptibility to collisions, threat status, and restricted distributions [22]. Some bird species with high priority are the ruddy-headed goose (*Chloephaga rubidiceps*), Andean condor (*Vultur gryphus*), threatened species such as the Chaco eagle (*Buteogallus coronatus*) and the yellow cardinal (*Gubernatrix cristata*) (Figure 4), and the critically endangered and endemic hooded grebe (*Podiceps gallardoi*). Priority bat species include the southern big-eared brown bat (*Histiotus magellanicus*), hoary bat (*Lasiurus cinereus*), cinnamon red bat (*Lasiurus varius*), southern myotis (*Myotis aelleni*), and Chilean myotis (*Myotis chiloensis*).

Figure 4. Yellow cardinal (*Gubernatrix cristata*) in La Pampa, Argentina. *Photo from Getty Images 1498243299*

In Colombia, while there is also insufficient information regarding the impacts of active wind farms, an impact study conducted in La Guajira, the region with the highest wind energy potential, identified 65 bird species inhabiting the area, denoting potential impacts [23].

In Chile, the southern populations of the Mexican/Brazilian free-tailed bat—the most recorded and seemingly the most abundant species—are protected by Chile's hunting law because of their role in controlling agricultural pests [24]. A study found that bat carcasses exhibited both macroscopic and microscopic injuries associated with trauma and hypothesized that sustained mortality in wind farms with a long operational history could reduce local bat abundance. Additionally, a publication mentioned that between 2010 and 2012, 20 bat deaths were

[5] The International Union for Conservation of Nature (https://iucn.org/), a global organization founded in 1948 dedicated to the conservation of nature and the sustainable use of natural resources, works alongside governments, civil society organizations, scientists, and experts.

[6] Scientific names refer to different families within the order Chiroptera, which is the scientific classification for bats. Each family groups together species of bats that share certain characteristics and evolutionary traits.

recorded at the Totoral (9) and Monte Redondo (11) wind farms, with Mexican/Brazilian free-tailed bats being the most affected (17), followed by the hoary bat (2) and the southern big-eared brown bat (1) [8]. This finding led to the first confirmation of barotrauma-induced death[7] in Mexican/Brazilian free-tailed bats at a Chilean wind farm [25].

In Brazil, a 2014 study indicated that 70% of the areas with the highest potential for wind energy generation in the country lack data on bats, with a total absence of basic information on species richness and occurrence [26]. Another study conducted over three years at the Osório Wind Farm identified bat species with mortality records due to wind turbines, finding a total of 336 deaths and recording 13 regional bat species [27]. Additionally, proposed offshore wind farms in the southern part of the country could impact some seabird species, including the Atlantic yellow-nosed albatross (*Thalassarche chlororhynchos*), Atlantic petrel (*Pterodroma incerta*), the white-chinned petrel (*Procellaria aequinoctialis*), and great shearwater (*Ardenna gravis*) [11].

In Mexico, the bat families with the highest number of mortality reports are Mormoopidae and Molossidae. These records come from only three wind farms located in the tropical region of the country, so the precise magnitude of the impact on bats across the 75 operational wind farms remains unknown. At the species level, at least 33 have been recorded as having suffered mortality from collisions with wind turbines, representing 22% of the total bat species in the country. Of these species, the lesser long-nosed bat (*Leptonycteris yerbabuenae*) is listed as near threatened by the International Union for Conservation of Nature, and the southern long-nosed bat (*Leptonycteris curasoae*) is listed as vulnerable [27].

Key Ideas

Available records for Latin America show that passerines have the highest number of documented mortalities in published studies, followed by Columbiformes, Galliformes, Cathartiformes, and diurnal raptors. Recent mortality monitoring reports from a wind farm in Chile indicated that at least nine Andean condors died due to collisions with wind turbines.

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POTENTIAL CONSEQUENCES OF BIRD AND BAT MORTALITY FOR ECOSYSTEM AND HUMAN WELL-BEING: A ONE HEALTH PERSPECTIVE

From a One Health perspective[8] (Figure 5), the loss of biodiversity caused by bird and bat mortality at wind farms can have significant consequences for the environment, plants, animals, and human well-being.

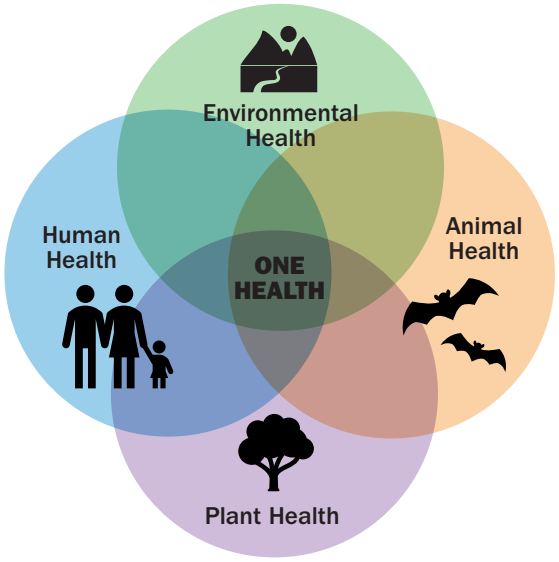

Figure 5. The One Health perspective considers the interconnectedness of environmental, human, plant, and animal health.

Birds and bats play essential roles in ecosystems such as predator or scavenger, pest controller, pollinator, and seed disperser for various plant species [21]. Their loss can lead to ecological imbalances affecting biodiversity and ecosystem health. These imbalances can have direct and indirect impacts on plants, animals, and human health, including reduced reproductive rates, diminished regeneration, increased pest populations leading to crop loss, and decreased ecosystem services[9] [28].

Moreover, the mortality of these species at wind farms can impact public perception of renewable energy and its acceptance. This is crucial for the transition to more sustainable energy sources needed to combat climate change, a central issue in the One Health concept [29].

In this regard, mitigation and adaptation strategies for global warming and biodiversity loss may conflict, as both can impact the overall health of animals, plants, ecosystem processes, and people. As climate change strategies such as decarbonizing the energy matrix through wind power continue to impact biodiversity loss, we may struggle to achieve the

[7] Barotrauma may occur if bats experience a rapid change in pressure caused by the spinning blades of wind turbines.

[8] The One Health approach recognizes that the health of people, animals, plants, and the environment are closely linked and interdependent.

[9] This term refers to the direct and indirect benefits that ecosystems can provide to humans.

vision proposed by the quadripartite committee.[10] This vision is "a world better prepared to prevent, predict, detect, and respond to health threats, as well as to improve the health of humans, animals, plants, and the environment and contribute to sustainable development" [30].

Limitations and Additional Impacts of Wind Energy

Among the limitations underlying the growth of the wind sector in the region, political and economic conditions are of key importance, especially in emerging and developing countries [31]. For example, the unfavorable energy policy environment in Mexico and the economic and political instability in Argentina have slowed wind energy growth. Additionally, the limited electric transmission infrastructure and connectivity of the electrical grids in many countries can be a significant challenge when establishing locations for new wind farm development [32]. This is compounded by the lack of regulatory frameworks, which can delay foreign investments [32].

Finally, social perception of wind energy can also influence growth in the region. Public discontent with wind projects because of their perceived environmental impacts, such as biodiversity loss, territorial conflicts, landscape impact, and degradation of quality of life for those living near wind turbines, conflicts with the portrayal of wind energy as being environmentally friendly and sustainable [33]. For example, in Chile's Biobío and Araucanía regions, there are more than 294 wind turbines from at least six wind farms near three contiguous urban and rural areas that residents say cause them to be depressed from the landscape alteration, constant noise, and flicker effects [34]. Although there are evaluation guides for wind projects [35,36], these are merely advisory, so the main cause of impacts is the lack of national regulations addressing aspects such as the minimum distance between homes and wind turbines and mitigation measures to reduce biodiversity loss.

Regulations for Wind Farms and Protection of Flying Fauna in Latin America

Although mortality at wind farms is a threat to birds and bats, Latin America lacks mandatory regulations to assess, prevent, mitigate, or compensate for these impacts. This has led to an underestimation of negative effects and a lack of measures to protect flying wildlife.

Chile has established a *Guide for Environmental Impact Assessment of Wind Energy Projects and Transmission Lines on Wild Birds and Bats*, which helps evaluate the environmental impact caused by wind energy projects and transmission lines on wildlife [37]. However, this guide is advisory rather than mandatory, meaning companies may choose whether to follow its recommendations.

On the other hand, Brazil has a wind farm licensing process managed by individual states, but the process lacks standardization. While each Brazilian state adopts its own procedures, most states use a simplified procedure called the *Relatório Ambiental Simplificado*, which often does not require on-site sampling, resulting in theoretical and uncertain information.

Colombia established a *Guide for Environmental Impact Assessment for Wind Energy* in 2016. However, its content is as general as a standard environmental impact study.

In Mexico, the Secretariat of Environment and Natural Resources provides a guide for preparing environmental impact statements for wind farms. However, this guide does not include specific recommendations for assessing impacts on birds and bats, and compliance is voluntary [7].

Finally, in Argentina, there is currently no national regulation addressing the impacts of wind farms on wildlife. Only one province, Chubut, has specific regulations for evaluating impacts on birds and bats. Instead, there is a Good Practice Guide for wind development, which outlines guidelines and methodologies for identifying potential impacts [29].

Red-headed turkey vultures (*Cathartes aura*) flying above the hub of a wind turbine in a wind farm in the province of Chubut, Argentina. *Photo from Gonzalo Herrera, INBIOTEC*

Key Ideas

Although mortality in wind farms poses a threat to birds and bats, much of Latin America lacks mandatory regulations to assess, prevent, mitigate, or compensate for these impacts. This has led to an underestimation of the negative effects and a lack of effective measures to protect flying wildlife.

As decarbonization policies advance through wind energy production, the realization of a One Health vision for animals, plants, the environment, and humans may not be fully achieved.

[10] From the One Health context, the quadripartite committee refers to a collaborative effort among four major international organizations to address global health challenges: the World Health Organization, Food and Agriculture Organization of the United Nations, World Organisation for Animal Health, and United Nations Environment Programme.

RECOMMENDATIONS: URGENT CHALLENGES AND PRIORITIES

The main challenges for the sustainable development of wind energy regarding flying fauna in Latin America are the lack of information about species suffering direct or indirect impacts and the lack of regulations to mitigate these impacts. Due to the rapid development of wind energy in Latin America and its potential impacts on this region of high bird and bat diversity, it is necessary to take action on six main fronts:

1. Create a framework for assessing environmental impact on wildlife

First, environmental impact studies must be designed. To effectively assess whether installations will have any influence on bats or birds, the design of the studies should 1) compare what will be measured (diversity, activity) before and after construction at the same site or 2) compare the construction site with a control site of similar conditions. For future monitoring (post-construction), control sites should be evaluated. Additionally, it is important to define the level of comparison to be established within preconstruction sampling (e.g., comparing between seasons, between microhabitats) [12].

The results of post-construction mortality monitoring studies should be published in public and freely accessible repositories to help identify affected species, peak mortality periods, and other factors related to mortality at wind farms. These data will facilitate the development of prevention and mitigation measures, as well as the creation of environmental policies focused on protecting affected species in wind farms.

2. Standardize methods for recording bird and bat mortality

Conduct post-construction mortality monitoring studies using standardized methodologies with estimators such as the generalized mortality estimator [38] to ensure that mortality estimates are comparable across projects.

3. Develop specific guidelines

Promote the development of specific and mandatory guidelines for the assessment, prevention, mitigation, and/or compensation of impacts on birds and bats in Latin America with an adaptive approach [39]. Considering other existing works as references, such as the guides from the United States, Eurobats, the International Finance Corporation, and others.

4. Implement strategies to protect species at the regional level

Incorporate Latin American countries that are not yet part of the Convention on the Conservation of Migratory Species of Wild Animals[11] to protect more species from threats posed by wind energy development.

Develop a regional strategy for the conservation of birds and bats in Latin American wind farms, involving specialist groups such as the Latin American and Caribbean Network for the Conservation of Bats[12] or the Global Union of Bat Diversity Networks.

5. Identify species of birds and bats susceptible to impacts

Identify bird and bat species susceptible to threats from wind energy impacts and identify areas where the problem is most pressing. This information is crucial for planning potential mitigation strategies.

6. Community engagement & outreach

Involve social science researchers, citizen science groups, and other non-governmental organizations to facilitate community involvement and access to information regarding the benefits and potential environmental effects of wind energy development.

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[11] The Conservation of Migratory Species of Wild Animals is an environmental treaty of the United Nations that provides a global platform for the conservation and sustainable use of migratory animals and their habitats (https://www.cms.int/).

[12] The Latin American and Caribbean Network for the Conservation of Bats (https://www.relcomlatinoamerica.net/) seeks to stop the loss of bat species and populations in Latin America and works to ensure that bats are appreciated, recognized, respected, and conserved.

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