# Book of

# The First Scientific Conference of the Faculty of Sciences

## "Environmental Pollution and Challenges of Environmental Sustainability"

**(Reconciliation with the Environment)**

**Sirte, October, 14, 2025**


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# The First Scientific Conference of The Faculty of Science – Sirte University "Environmental Pollution and the Challenges of Environmental Sustainability"

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The First Scientific Conference of the Faculty of Science – Sirte University
Environmental Pollution and Challenges of Environmental Sustainability (EPESC), Oct.14, 2025

# Impacts of Renewable Energy Sources on Biological Diversity and Conservation, An Overview

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**Keywords: Renewable energy sources; impacts; biodiversity; wildlife; terrestrial, aquatic.**

***Abstract:*** Renewable energy is now seen as a clean and alternative energy source. This research aims to illustrate how the biological variety of both terrestrial and aquatic animal ecosystems is affected by renewable energy sources including solar photovoltaic (PV), wind farms, and hydropower generation. Bird death rates vary from 0.0 to 2.0 fatalities/turbine/year in 55% of the prior studies that have been conducted on wind farm turbines, while 79.4% of the examined mortality rates for raptors range from 0.0 to 0.1 fatalities/turbine/year. This depends on where and how the turbine is installed. Grassland birds (common quail, corn crake, lapwing, ringed plover), migratory birds (migrant goose, crane, lapwing, golden plover), water birds (geese species), and raptors (common buzzard, common kestrel, and red kite) are the most often cited threats. At various wind farms, bat mortality rates vary from 0.0 to 47.5 deaths per turbine annually. The study also examines the negative consequences of PV facilities on wildlife and ecosystems, as well as the detrimental effects of hydroelectric reservoirs on biodiversity, including freshwater turtles and aquatic and terrestrial animals. Nonetheless, these effects were reflected in the loss of habitats and the wildlife creatures' regular migration routes.

## Introduction

Research on how renewable energy affects biodiversity is included in this special issue. To slow down the rapid extinction of species brought on by climate change, we must switch from fossil fuels to renewable energy sources (Bellard et al., 2012; Maclean & Wilson 2011; Malhi et al., 2020; Ohashi et al., 2019).

For example, an empirical analysis of breeding bird trends in the United States (Figure 1) shows a negative correlation with increasing atmospheric ozone concentrations caused by fossil fuel combustion (Liang et al., 2020). The effects of temperature (orange arrows) and renewable energy (black lines) on biota are mediated by habitat, as shown in Figure 1. Changes in water temperature, hypoxia, and acidity are the main drivers of climatic impacts in aquatic habitats. These factors have led to both ancient extinctions (Penn et al., 2018) and contemporary range constriction (Charbonnel et al., 2016; Smale and Wernberg 2013). Climate change can have direct impacts on terrestrial systems (Pacifici et al., 2020) or be mediated by changes in resources (vegetation, for example) or disturbance from wildfires (Jager et al., 2021; Ward et al., 2020).
Furthermore, Figure 1 shows how marine, freshwater, and terrestrial biota are affected by the generation of renewable energy (from left to right, icons represent wave energy, hydropower, renewable natural gas, biopower, sun, and wind). Mortality brought on by interactions with energy infrastructure is referred to as a direct consequence. Degradation of habitat or the use of fossil fuels to delay climate change are examples of indirect consequences. Take note of the purple arrows representing the response of the renewable energy industries to climate change.

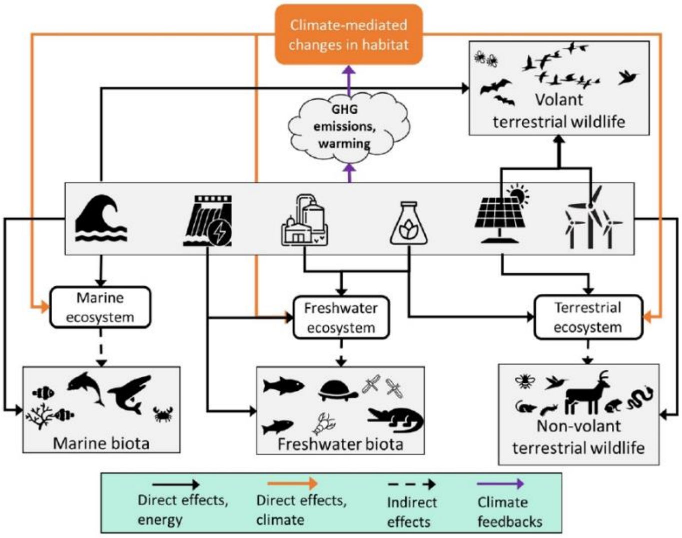


**Figure 1**. Effects of renewable energy production

While switching to renewable energy sources will lessen greenhouse gas emissions and the risks that come with climate change, the growth of renewable energy can also endanger biodiversity. This study emphasises the importance of comprehending how renewable energy technologies affect biodiversity. It also offers a compilation of reviews of energy technologies, renewable energy sources, and the lesser-known effects of emerging renewable energy on biodiversity. It also shows promise in the transition to a low-carbon future.
Wind, hydro, and solar energy are examples of variable renewables that are becoming more and more significant. A concept for resource extraction from the ocean that incorporates marine renewable energy is known as the "blue economy."

Electricity as a percentage of total energy should increase from 26% to 57% in 2030 and 86% in 2050 in order to reach the decarbonisation targets outlined in the Paris Agreement (IRENA 2020). By 2030, 17.7% more hydropower will be required, and by 2050, 34.7% more. Wind energy should increase to 35% of the world's electricity portfolio by 2050 in order to meet the Paris climate targets, which would result in a 6.3% reduction in emissions (IRENA, 2019b). The International Energy Agency baseline for 2018 is used to predict the demand for renewable energy output by IRENA (2020) in Figure 2.

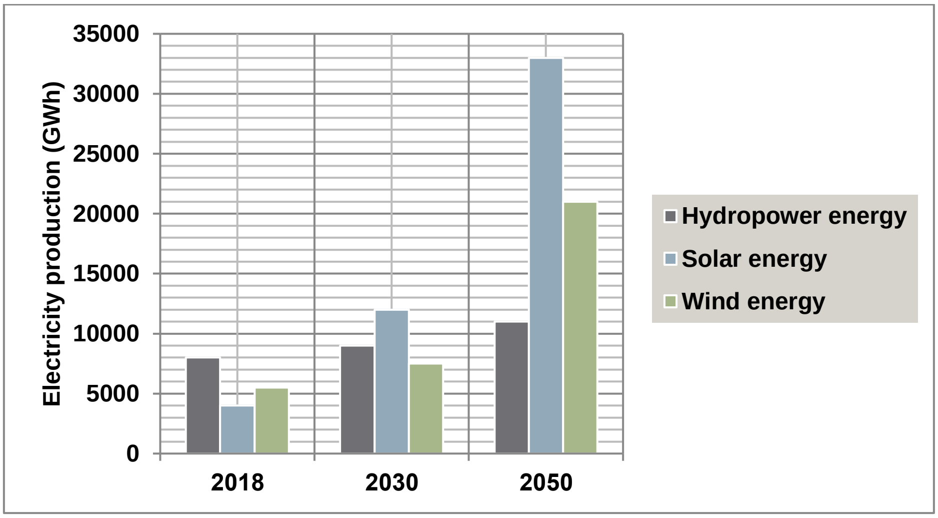


**Figure 2**. Projections of renewable energy (Modified after IRENA, 2020)

Biological conservation studies frequently standardize ecological indicators, for instance, on a per-kWh basis in an effort to assess the effects of different energy sources. However, operational stability and services, such as variations in how energy sources contribute to grid resilience (Shove, 2020) and fulfilling peak energy requirements, are not taken into consideration in per-kWh comparisons. Biomass energy, for instance, can take the place of liquid fuels derived from fossil fuels, but it might not contribute as much to the electrical grid. Power density and intermittency are trade-offs among renewable energy sources; the most variable sources, such as solar and wind, have greater energy densities than dispatch able energy sources, such as hydropower and biomass. When measured in relation to the areal footprint the amount of land needed to generate electricity the energy density of fossil fuels is higher than that of renewables. (Figure 3). Applying concepts of an ecological footprint to compare the effects of energy sources that supply global markets on various ecosystem types and species, however, presents considerable difficulties (Wachs & Engel 2021). The Supplemental Information (SI) contains documented energy footprints that we discuss. Gasparatos et al. offer another excellent summary of the sustainability issues related to various renewable energy sources (2017).

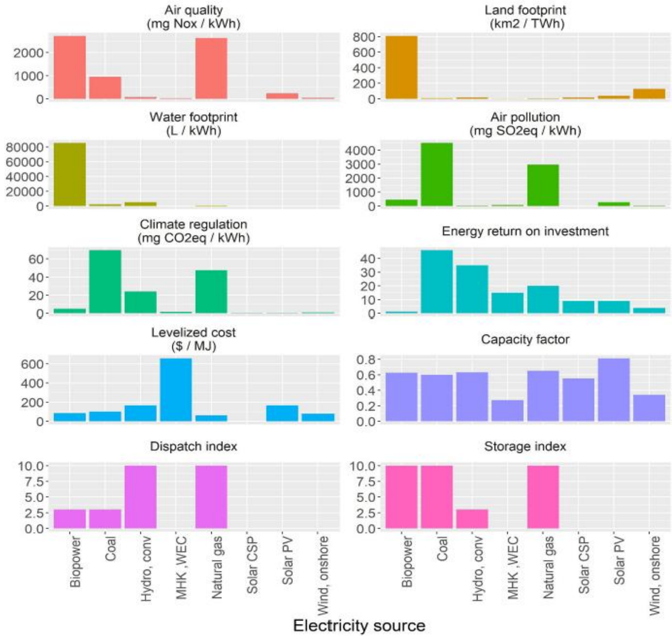


**Figure 3**. Indicators of environmental impact (IRENA, 2020)

Air quality, land footprint, water footprint, air pollution, and climate regulation are among the environmental impact indicators shown in Figure 3. Energy value indicators, such as energy return on investment, levelized cost, capacity factor, dispatch index, and storage index, are plotted for each of the six renewable energy sources biopower, conventional hydropower, marine hydrokinetic (MHK), concentrated solar power (solar CSP), photovoltaic solar power (solar PV), wind, and conventional hydrFig. 2 Projections of renewable energy (Modified after IRENA, 2020).

## 2. Study Objectives

The following is an expression of the study's primary goals:

1. Examine the effects on biodiversity of using renewable energy sources.
2. Determine which energy source affects ecosystems and wildlife the most.
3. Distinct deterioration of aquatic and terrestrial ecosystems.

## 3. Methodolgy

The material included in this review research was gathered from a variety of literature sources that were relevant to these investigations, including:

1. The Wildlife Institute for Renewable Energy (REWI, 2023).
2. The Documents Library of the American Wind and Wildlife Information Centre.
3. Database of Energy Literature Reviews.
4. The Energy and Wildlife Program of the USGS.

## 4. Renewable Energies Effects on Biodivesity

### 4.1. Wind Power Energy Effects

By 2050, onshore and offshore wind energy would provide 25% of all power demands under future scenarios created to satisfy the climate targets of the 2015 Paris Agreement (IRENA's "TES" scenario) (IRENA, 2019b). According to IRENA (2020), this would need doubling installed capacity from 624 GW to 2526 GW between 2018 and 2030, then increasing significantly again to reach 6044 GW by 2050 (generation in Figure 2).

The majority of research on how wind energy affects wildlife has been on bird and bat death and habitat displacement (Agha et al., 2020). Bird species' habitat associations, post-construction land management changes, and distances to turbines all influence how much a bird species is displaced by wind energy installations (Cook et al. 2018; Fernandez-Bellon et al., 2019). For instance, species abundances (Garvin et al., 2011; Strickland et al., 2011) and landscape characteristics (Fernandez-Bellon et al., 2019) are linked to raptors' susceptibility to collision with turbines.

The number of bat deaths documented globally has surpassed deliberate homicides due to collisions with wind turbines (O'Shea et al. 2016). Direct collisions with wind turbines and the resulting barotrauma have an impact on bats (Grodsky et al., 2011). The reasons for bat deaths at turbines and whether or not bats are drawn to turbines have been the subject of much investigation (Cryan et al., 2014; Kunz et al., 2007).

Because infrastructure (roads, substations, turbine pads, and service buildings) displaces habitat, land-based wind energy projects also have indirect consequences on wildlife. Compared to an area mined for coal providing a similar amount of electricity, the land utilised for wind turbines in a wind facility frequently replaces more ground suitable for wildlife and has far lesser consequences on birds (Denholm et al. 2009).

#### 4.1.1. Offshore Wind Energy Impacts on Marine Species

The maritime environment and related animals may be impacted by offshore wind farms. Certain impacts—like the artificial reef effect, which is covered below—may be advantageous rather than negative. OWF operations can generally affect animals in the following ways:

1. modification of maritime ecosystem,
2. danger of collision,
3. power cable-related electromagnetic field (EMF) impacts;
4. noise effects; and 5. water quality (such as pollution).

Floating structures, which are not anchored to the ocean floor (Figure 4), are being used by the offshore wind sector (NOWRD, 2019). Instead of being supported by a foundation, these floating constructions are attached to the bottom by cables or legs. Projects located in deep water (around 60 meters, or 200 feet)—such as those in the Gulf of Maine, off the Pacific Coast, and in Hawaii—frequently utilise floating buildings.28 The majority of proposed floating projects are used.

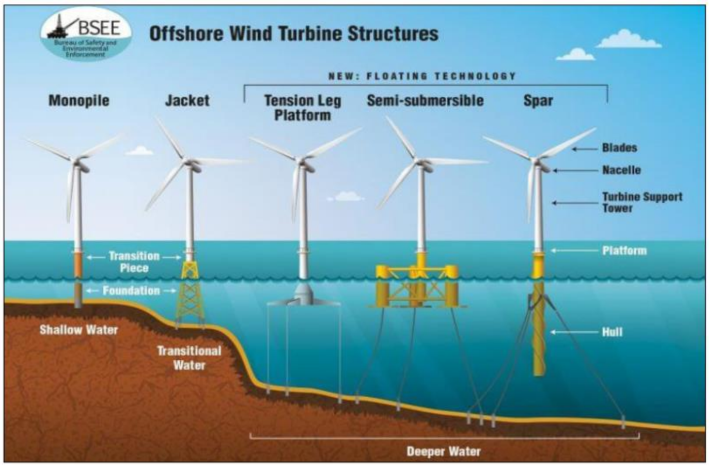


**Figure 4**. Offshore wind turbine components and foundation structures

The short-term negative effects and positive effects of offshore wind development on marine animals, invertebrates, fish, sea turtles, birds, bats, and other marine ecosystem components are examined in the scientific literature (Table 1). The majority of consequences (like habitat modification) happen in the local area of the wind turbine array, according to modelling and observational studies (mainly from the North Sea). Other impacts (like noise effects) can spread up to tens of kilometres beyond the array. Some of these assessments extrapolate observations from current offshore wind farms (OWFs), mostly in the North Sea, to proposed offshore wind energy projects, while others employ land-based wind energy measurements to forecast possible offshore wind scenarios. Laboratory studies that replicate variables (such as noise levels) frequently found in offshore wind farms provide information on additional possible effects.

**Table 1. Potential impacts associated with offshore wind energy projects**

| Animal type | Oceanic change | Habitat alteration | Collision risk | Electromagnetic field (EMF) effects | Noise effects | Water quality |
|---|---|---|---|---|---|---|
| Marine mammals | -- | Y | Y | -- | Y | Y |
| Invertebrates | Y | Y | -- | Y | Y | Y |
| Fish | -- | Y | Y | Y | Y | Y |
| Sea turtle | -- | Y | Y | -- | Y | Y |
| Birds | Y | Y | Y | -- | -- | Y |

Nevertheless, wind farms are built in different locations without taking into account the presence of protected animal species. Some mitigating measures have been implemented in problem locations. Bird fatality rates vary from 0.0 to 2.0 fatalities/turbine/year in 55% of the studies. 79.4% of the raptors' assessed mortality rates fall between 0.0 and 0.1 deaths per turbine annually. The red kite (Milvus milvus) is the only species that has been listed as a threatened and wind turbine mortality. Raptors (common buzzard, common kestrel, and red kite), grassland birds (common quail, corn crake, lapwing, ringed plover), migratory birds (migrant goose, crane, lapwing, golden plover), and waterbirds (geese species) are the species most frequently regarded as vulnerable. At various wind farms, bat mortality rates vary from 0.0 to 47.5 deaths per turbine annually. According to reports, the bat species Laisurus cinereus, Lasiurus borealis, Lasionycteris noctivagans, and Nyctalus noctula had the greatest fatality rates.

Table 2 summarises the yearly fatality rates from North American and European research to help understand the scope of the issue (Arnott et al., 2016).

**Table 2. Wind turbine annual mortality rates for bats from different habitats and geographical regions**

| Region | Habitat | Annual death rate per MW installed capacity |
|---|---|---|
| USA and Canada | Northeastern deciduous forest | 6.1–10.5 |
| USA and Canada | Midwestern deciduous forest – agricultural | 4.9–11 |
| USA and Canada | Great Plains | 6 |
| USA | Great Basin/Southwest Desert region | 1–1.8 |
| Germany | Black Forest | 10.5 |
| Europe | Agricultural land | 0.6–5.3 |

### 4.1.2. Threats to Wildlife

Several bird and animal species have been killed by fast-moving turbine blades. According to early research conducted in California, raptors have significant death rates, particularly when weighed against their low rates of reproduction and population levels (Smallwood & Thelander, 2004; Hunt, 2002). Certain wind farms that employ outdated technology and are located along migratory routes in regions with significant bird populations have been found to have high fatality rates in a number of studies (Smallwood & Thelander, 2004; Hunt, 2002; Thelander & Rugge, 2000).

Bat deaths at wind energy installations have been the subject of more recent research. It has been discovered that migratory, tree-roosting species are particularly at risk from wind turbines, notably in the United States, where installations are located on forested, eastern slopes. Mortality rates in the eastern United States are estimated to be between 20.8 and 69.6 deaths per turbine. Scientists believe that these losses have a significant effect on bat populations (Arnett et al., 2008).

Although crashes can happen to songbirds as well, the number of fatalities is often too low to affect populations that are healthy (Erickson et al., 2001; Strickland et al., 2001; Kuvlesky et al., 2007). If wind turbines are located in high concentration regions or crucial habitat, they may increase the mortality of migratory and resident species that are decreasing or of special concern (Arnett et al., 2007).

Wind turbines have the greatest impact on migrating birds, including the red bat (Lasiurus borealis) (Figure 5, 6, & 7). As they move south over turbine-lined ridges to their winter habitats, thousands of insectivorous bats are killed annually (Arnett et al., 2007).

**Figure 5**. Red bat (*Lasiurus borealis*) is killed by wind turbines

**Figure 6**. A Greater flamingo dead due to collision with power lines

**Figure 7**. Birds pass through power lines in wetlands

### 4.1.3. Habitat Degradation

Compared to other land uses, wind energy can permanently modify a relatively modest quantity of habitat (Bureau of Land Management, 2005). However, roads, building, noise, human activity, and fragmentation continue to harm the surrounding ecosystem over the long and short terms.10. Grassland birds and some animals, such as elk and mule deer, have been seen to steer clear of turbine pads, particularly when building is underway (Leddy, 1996; Leddy et al., 1999; Johnson et al., 2000). Particularly at risk are species that depend on intact, congruent habitat or that deliberately steer clear of human activities (Johnson, 2000). For species like prairie grouse that avoid highways, buildings, and power lines, entire wind farms and the substantial buffer surrounding them are inappropriate (Braun et al., 2002; Robel et al., Pitman et al., 2005).

The damage and fragmentation of habitat resulting from the development of roads, wind turbines, and other infrastructure is seen in Figure 8. For many animal species, habitat loss and associated degradation can have negative effects.

**Figure 8**. Habitat destruction from the construction of wind turbines

According to research, bat species that are most at risk from wind turbines are often most active during autumn migration, before and after storms, and in low wind conditions (Reynolds, 2006; Johnson, 2005). According to one research, about 90% of bat deaths happen during the autumn migration20 between mid-July and late-September, while other studies revealed that the majority of bat deaths happen on nights with low wind (Fiedler, 2004; Horn, et al., 2008). Turning down wind turbines during these high-risk periods can significantly lower bat mortality (Baerwald et al. 2009). To prevent excessive bird fatality rates, turbines can be positioned outside of migratory routes in areas of lesser abundance. Compared to wind farms with huge populations, raptors died at a far lower rate in those wind farms with fewer birds. (Smallwood and Thelander. 2004; Anderson, et al., 2004, 2005).

Planning at the landscape level is crucial to lessening the effects of wind energy development on animals. Wind farms can be positioned to avoid important habitat, including migratory routes or leks of sage grouse.10. To lessen the consequences of fragmentation, developers can also figure out how to construct turbines using the fewest possible roads, transmission lines, and other infrastructure (Kuvlesky et al., 2007). In order to utilise existing infrastructure and prevent upsetting intact habitat regions, it is frequently ideal to locate turbines on previously developed land (Kuvlesky et al., 2007).

A wind farm in Columbia Hills is viewed by mule deer (Figure 9). The noise, building, and human activity that come with wind energy development can displace wildlife.

**Figure 9**. The effect of wind turbines on wildlife

#### 4.1.4. Marine Renewable Energy

Two expanding electricity sources are marine hydrokinetic energy (MHK) and offshore wind (Copping et al. 2021). Concerns for conservation are greatest for migratory seabirds, especially uncommon species, for both technologies (Mendel et al. 2019). Timing construction to avoid crucial times for species of concern (Best and Halpin 2019; Mooney 2020) might reduce negative consequences to aquatic biota, such as noise disturbance, which often occur during the building phase (Astariz and Iglesias 2017). According to Khan et al. (2017), wave facilities generate electricity using wave energy converters and send it to the grid via undersea cables that run along the ocean floor. It is believed that there are more than 2 terawatts of wave power in the world (Gunn & Stock-Williams 2012).

The dispersion and colonization-extinction dynamics of marine larvae may be impacted by changes in the flow patterns close to MHK installations. Animal migrations to and from nearby ecosystems may be hindered by modifications to the flow fields surrounding MHK installations (Hooper & Austen 2013). According to Langhamer et al. (2010), these effects are believed to be the lowest and most transient for tidal-stream turbines and the largest for tidal barrages.

### 4.2. Hydro Power Energy Effect

About 80% of the energy generated in many nations comes from hydroelectric power generation, making it the most significant source of electric energy.

Globally, hydropower is a significant and expanding energy source (He et al., 2021). By storing water for future generation, hydropower can facilitate the integration of other renewable energy sources and aid in the shift to a low-carbon future. There is a causal link between lower GHG emissions and increased hydropower output (Xia and Wang 2020). In addition, hydropower has the best energy-return-on-investment (EROI) of all renewable energy sources, has low operating costs, is somewhat flexible in response to demand, and stores energy in reservoirs.

This special issue discusses the well-known ecological consequences of hydropower as well as its possible worldwide repercussions (Anderson et al., 2021; He et al., 2021). Dams can endanger lotic species with delicate life cycles, particularly when they are positioned too near to one another, even while the addition of lentic reservoir habitat may improve total freshwater variety.

The biggest consequences of reservoir construction are habitat loss and modification, which in turn affect biodiversity. Large reservoirs change the ecology associated with rivers, including riparian plants, and flood the land. When opposed to the flowing water of rivers, the water in reservoirs is typically stagnant (lentic), which changes the water quality and has an impact on aquatic life, including aquatic mammals and other freshwater species. Furthermore, a dam's impact on aquatic and freshwater turtle species, whose movements are in sync with the regular flow of rivers, is such that it changes the river's normal seasonal hydrological cycle (1-dry season or lower water; 2-rising water season; 3-wet season or high water; 4-falling phase or river discharge when one end of the reservoir is closed to store water for hydroelectric generation) the river (Alho & Pádua 1982b). Because the periodic pulse typical of river hydrology is transformed into a reservoir that holds water, the reservoir might restrict the usual seasonal migration of aquatic organisms in quest of biological resources.

#### 4.2.1. Effects of Hydropower Reservoirs wildlife

Reviewing the detrimental effects of hydropower reservoirs on biodiversity, this study includes freshwater turtles and aquatic and terrestrial animals in various locales.

#### 4.2.2. Effects of Reservoirs on Terrestrial Mammals

Generally speaking, the type of habitat an animal chooses has an impact on the extent of its home range. Densities of wild mammals are often impacted by habitat elements that impact population abundance and perhaps spatial and social organization. Every mammal species is thought to occupy a range within the environmental gradient, which may have an impact on behavioral interactions and population growth. Among other requirements, mammals actively choose their habitat based on environmental signals that provide appropriate feeding and reproductive niches. Furthermore, the natural hydrological phases of the river where the reservoir dam is constructed determine how the habitat resources fluctuate seasonally (Alho et al. 2000). As a result, the creatures that have been displaced by the reservoir's impacts will either die or relocate, causing the former biological densities to reappear. Ultimately, this will lead to the displaced species' futile attempt to establish themselves in a new location.

As one of the most serious human-caused factors in habitat alteration and biodiversity loss, the reservoir's existence exacerbates the negative effects of forest reduction with habitat fragmentation (Laurance & Bierregaard, 1997, 2009; Alho & Oecol, 2011).

#### 4.2.3. Effects of Hydropower Dams on freshwater biodiversity

Hydropower has a wide range of effects on biodiversity, depending on the size and kind of plant. The degradation of habitat is the most significant consequence. Furthermore, the construction of several plants fragments the river network, making it impossible for fish to migrate upstream or downstream to meet their lifecycle requirements.

#### 4.2.4. Effects of Hydropower Plants on iconic marine species

These plants would affect all of Europe's great iconic species, including the Atlantic salmon, European eel, and the few remaining populations of sturgeon. The biggest concentration of endemic biodiversity is located in southern Europe, and the Balkans in particular, where there are several hotspots. Should the proposed plantings proceed, almost all of the unique fish species in the Balkans would be at risk of drastic declines. Insects, a fundamental component of the food chain of the entire riverine environment, are among the many species that hydropower affects. In addition to directly affecting fish, hydropower dams also have an impact on riverine life more generally, including semi-aquatic species like fish otters and a diverse range of birds, especially fish-eating birds like pelicans or kingfishers. Because of the fragmentation brought about by the building of the plants and reservoirs, animals like lynxes, wolves, and local deer species are unable to follow their regular migratory routes and have perished as a result of the hydropower projects' impact on the terrestrial landscape (Figure 10).

### 4.3. Solar Energy Effect

Due to rising demand, solar-generated power is expanding quickly worldwide. Photovoltaic (PV) and concentrating solar-thermal power (CSP) are the two primary solar technologies that are used at the utility level. By 2050, solar systems would provide 36% of global power demands under future scenarios created to satisfy the climate targets of the 2015 Paris Agreement (IRENA 2020). By 2050, installed capacity would have increased from 582 GW to 8,828 GW (IRENA 2019a, 2020). These are lofty objectives.

The scale and quantity of solar energy facilities have grown during the last 20 years (Chock et al., 2020; Hernandez et al., 2014). Although there are currently few researches on the effects on wildlife, it is anticipated that habitat loss, especially fragmentation by access roads, would be a major impact of large-scale solar energy plants on wildlife (Lovich and Ennen 2011). There may be significant changes in indirect land use and land demand (Hoffacker et al. 2017; Van De Ven et al., 2021). Additionally, grassland or natural habitats ar ypically the location of solar energy installations (Hernandez et al., 2015b).

**Figure 10**. Dead fish, jumping trout and migratory pathways near hydropower dam

### 4.3.1. Species and Habitat Impacts

The regions most affected by solar PV growth are species of concern, taxonomy, or important natural groups. Responses about species of concern were generally divided into five major groups:

1. Ungulates that have solar sites within their geographic ranges;
2. Avian species that migrate, nest, or browse in and around solar sites;
3. Aquatic species that are heavily reliant on water quality;
4. Small animals and reptiles that burrow in or near solar sites; and
5. Pollinators that can engage with the flora at a solar site.

Respondents characterized habitat loss, habitat fragmentation, habitat degradation, and collision danger as possible effects of solar development on species. The following categories apply to the impact of solar radiation on wildlife:

**Habitat changes:** The surface area required for utility-scale solar development to help meet decarbonization goals will require some level of habitat loss, habitat fragmentation, and changes in land use.

**On-site plant and animal habitat:** Solar energy facilities can implement strategies to manage on-site habitat for the benefit of native wildlife communities (e.g., seeding with native plants).

**Construction impacts:** The development of utility-scale solar projects, as is the case with all forms of development.

**Collisions with supporting infrastructure:** The various structures needed to operate a solar energy facility (e.g., PV panels, overhead transmission lines, CSP towers) have the potential to pose a collision risk to wildlife, which may lead to injuries or fatalities.

### 4.3.2. Species Potentially Impacted by Solar Energy

The following species can be affected by scale solar energy projects for both wildlife and Habitats (Table 3).

**Table 2. wildlife and habitats solar energy impacts**

| wildlife impacts | |
|---|---|
| species | Examples |
| Amphibians | Gopher frog<br>Striped newt |
| Aquatic species | Black creek crayfish<br>Endangered or threatened mussels<br>Fairy shrimp |
| Birds | Bald eagle<br>Golden eagle<br>Gray flycatcher |
| Insects | Monarch butterfly<br>Rusty patched bumble bee |

| | |
|---|---|
| Mammals | Bats<br>Desert burro deer<br>Elk |
| Reptiles | Blunt-nosed leopard lizard<br>Eastern box turtle<br>Garter snake |
| Habitats impacts | |
| Desert | Aeolian sands<br>Desert wash<br>Sand flat and dunes |
| Forests and woodlands | Joshua Tree woodlands<br>Mesquite woodlands |

The detrimental effects that PV facilities have on animals and environments have been the subject of several studies. These studies emphasize how PV infrastructure at the landscape level reduce connection between appropriate ecosystems or populations.

Nonetheless, these effects were reflected in the loss of habitat and the migration of species (Figure 11).

**Figure 11**. Sheep grazing below solar panels (right) and habitats reduction (left)

Nonetheless, there have been reports of wildlife remains—which are classified as fatalities—at PV projects and the infrastructure that goes along with them.

### 4.4. Complementarity among renewable energy sources

Every renewable energy source has advantages and disadvantages, and the most reliable grids are frequently achieved by the synergistic deployment of complementary producing assets (Shove 2020). In order to include variable renewables, generators will need to provide quicker ramping cycles, or the capacity to swiftly increase or reduce power. These operational adjustments will probably have an impact on the environment by increasing emissions and reducing the lifespan of working components because of thermal stress (Heptonstall and Gross 2020). The various forms of renewable energy, however, clearly have detrimental effects on biological variety in a number of ways.

## Conclusion

Based on the previous study the following conclusions can be drawn:

1. Nowadays renewable energy regards as an alternative and clean source for energy.
2. The study highlights the impacts of renewable energy sources such as solar photovoltaic (PV), wind farms and hydropower generation on the biological diversity for both terrestrial and aquatic animals environments.
3. About 55% of previous studies for turbines of wind farms indicated that bird mortality rates range from 0.0 to 2.0 fatalities/turbine/year. 79.4% of the evaluated mortality rates for raptors range from 0.0 to 0.1 fatalities/ turbine/year.
4. This turbine installation and location has a negative impact on the wildlife.
5. The most commonly considered threatened are the raptors (common buzzard, common kestrel and red kite), grassland birds (common quail, corn crake, lapwing, ringed plover), migrating birds (migrant goose, crane, lapwing, golden plover) and water birds (geese species). Bat annual mortality rates range from 0.0 to 47.5 fatalities/turbine/year at different wind farms.
6. Also, the study reviews the adverse impacts of hydroelectric reservoirs on biodiversity, taking terrestrial and aquatic mammals and freshwater turtles.
7. Many species are impacted by hydropower, including lots of insect life.
8. Hydropower dams do indeed affect fish directly but also riverine life more broadly – such as semi-aquatic wildlife (like fish otters) and a wide array of birdlife, particularly fish-eating birds like kingfishers or pelicans.
9. The hydropower projects also affect the terrestrial landscape, including species like the lynx, wolf and local deer species, as they can't carry out their normal migratory pathways and died due to the fragmentation caused by the construction of the plants and reservoirs
10. The adverse effects of PV facilities on wildlife is represented by habitats reduction and the migratory pathways of wildlife animals.

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