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The Impact of Land-Use Change on Wildlife Habitat Selection and Population Dynamics

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Abstract. One of the major anthropogenic drivers of biodiversity loss and change in wildlife abundance is land use change. This paper discusses the role of land-use change in changing habitat structure through habitat loss and fragmentation, decreasing connectivity and edge effects, and the implications of land-use change effects for wildlife habitat selection, activity and migration, species distribution and population dynamics, using existing empirical research. Research has shown that animals can persist in some human-modified habitats, but the duration depends on the type of land, the amount of resources available and the level of human disturbance. Mammals are less mobile in places with a heavy human footprint. And if connections that animals use to travel from place to place are broken up, there are fewer waterbirds. And it may be some time before we actually see the effects of breaking up habitats. Response varies widely among species and taxonomic groups. Conservation should incorporate long-term population monitoring and multiscale landscape analysis, and should evaluate effectiveness using population indicators, rather than simply habitat area.

Keywords: Land-use change, Habitat fragmentation, Landscape connectivity, Population dynamics

1. Introduction

Land use change is one of the main drivers of loss of biodiversity. This includes converting natural landscapes to expand agriculture, urbanization and road building. These changes decrease habitat availability, fragment continuous habitats and alter habitat quality and connectivity. They influence not only the loss of habitat but also the movement, habitat selection and population dynamics of wildlife.

Habitat loss and fragmentation can isolate populations and restrict movement between suitable areas. Human-induced habitat loss and fragmentation are the main threats to amphibians and reptiles according to a global review by Tan et al. [1]. But species respond differently according to ecological traits such as habitat specialization and dispersal ability. Land use change also impacts how animals use the rest of the landscape. Boggie et al. found that land use, human disturbance [2], and river condition influenced wintering sandhill crane habitat selection in New Mexico and that cranes used different habitats for feeding and roosting. These results suggest that landscape modification influences not only habitat availability but also the suitability of habitat for different activities.

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These effects might also be relevant for outcomes at the population level. The distribution of birds and mammals in the Gran Chaco of Argentina was influenced not only by the amount of current habitat but also by the historical structure of the landscape, and they hypothesized that the effects of fragmentation may take some time to become apparent [3]. Population trends vary among taxonomic groups and a global analysis shows that bird population trends have stronger relationships with land-use change than mammal trends. Therefore, understanding these effects requires studies of both species distributions and demographic processes such as survival and reproduction. This paper investigates the impacts of habitat loss, fragmentation, decreased connectivity and edge effects caused by land-use change on wildlife habitat selection, movement, and population dynamics. It shows the relationships between landscape change, individual responses and long term population change.

2. Land-use change and habitat structure

2.1. Habitat loss

Habitat loss is one of the most immediate impacts of land-use change. As forests, grasslands, wetlands and other natural habitats are turned into farmland or developed land, there are less natural habitats left for the species that used to live there. Habitat loss and fragmentation are major threats to amphibians and reptiles, Tan et al. reported, with agriculture, urbanization, roads and other human activities playing an important role [1]. Habitat loss can mean less space to live, fewer resources, and longer distances to travel between suitable areas.

However, the effect of habitat loss is not always proportional to the amount of land that disappears. Different species can respond differently to the same level of land conversion. Some are able to use farmland or other modified environments, while habitat specialists may depend much more on intact natural habitat. The ecological value of the habitat that remains is therefore as important as its total area. A patch of land may still be classified as habitat, but it may not provide the food, shelter, breeding sites, or environmental conditions required by a particular species.

The importance of habitat amount was also shown by Semper-Pascual et al. in their study of birds and mammals [3]. By combining several decades of land-use history with wildlife survey data, they found that the amount of habitat present today helps explain the presence of many species. Therefore, loss of natural habitat may influence whether a landscape is still able to support a species, even without considering other effects of fragmentation.

2.2. Habitat fragmentation

Habitat loss is often linked to fragmentation. Roads, farmland, residential development or other human land uses can break a large contiguous area of natural habitat into pieces. What is left may be a number of smaller patches, broken up by changed land. Tan et al. reported that fragmentation has been linked to alterations in species richness, abundance, spatial distribution, and genetic connectivity between populations in studies of amphibians and reptiles [1]. Many amphibians and reptiles also have special habitat requirements or relatively low dispersal ability, making landscape change particularly important for these groups.

Fragmentation does not affect all species in the same way. Studies of many animal population networks revealed that patch size and isolation alone were not sufficient to predict whether a species would occupy a patch [4]. The surrounding landscape, the ecology of the species and other local

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conditions can also be important. Thus, it is not enough to only count the number of patches to characterize the ecological consequences of fragmentation.

The ability of an animal to move through the surrounding landscape is particularly important. A species that can cross farmland may still move between two natural habitat patches even if they are separated on a map. For a species that avoids open or modified land, the same distance may create a much stronger barrier. Therefore, fragmentation represents an interaction between landscape structure and species-specific movement behavior.

2.3. Reduced habitat connectivity

As natural habitat becomes divided into separate patches, habitat connectivity may decline. Connectivity describes how easily animals can move between suitable areas. It supports dispersal, mate finding, recolonizing areas after local population loss, and maintaining contact between populations.

Multiscale studies of threatened wildlife have examined habitat loss, habitat degradation, and landscape connectivity together. This work shows that conservation planning should not only identify suitable habitat patches, but also consider the areas that allow movement between them. Two high-quality habitat patches may not function the same way if they are completely isolated compared with a pair that remains connected.

2.4. Increased edge effects

Fragmentation also means more borders between natural habitat and human-altered land. When a large block of habitat is broken into a number of smaller pieces, more of the habitat remaining may be close to roads, farmland, residential areas or other developed land. The total amount of habitat may not disappear at once but the proportion exposed to edge conditions may increase [5].

Conditions near an edge can differ from those in the interior of a habitat patch. Animals close to roads, farms, or settlements may also experience more human activity and disturbance. For species that depend on interior habitat, this means that the usable high-quality area of a patch may be smaller than its total area on a map.

Therefore, the effect of land-use change is not fully represented by habitat area. Habitat amount, spatial configuration, connectivity and edge exposure can all change simultaneously. Their importance varies between species. Moreover, the effects of land-use change may not always be immediate because past landscape changes can continue to affect wildlife distribution years later. Such time lags underscore the importance of considering both contemporary and historical landscape conditions when assessing wildlife responses.

Habitat loss, fragmentation, reduced connectivity, and edge effects are closely connected. Natural habitat may first be removed or converted. The habitat that remains can then become divided into smaller patches, movement between those patches may become more difficult, and a greater proportion of habitat may be exposed to edge conditions. These landscape changes provide the background for understanding changes in wildlife habitat selection and, later, changes in population dynamics.

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3. Wildlife ecological responses

3.1. Changes in habitat selection

Land-use change can modify the habitats that animals choose for feeding, resting and other activities. Boggie et al. studied wintering sandhill cranes in the Middle Rio Grande Valley of New Mexico and noted distinct differences in habitat use by day and by night [2]. Crane use of managed public lands (corn fields, alfalfa fields, fallow fields, small-grain fields, wetlands) was high during the day. Their probability of using an area decreased as the density of human structures increased. For roosting, the cranes selected sections of the Rio Grande with shallower water, sandbars, wider channels, lower bank vegetation, and greater distance from bridges. These results show that animals may continue to use some human-modified landscapes, but their habitat selection depends on both the resources available and the level of disturbance.

Habitat responses may also depend on conditions operating at different spatial scales. Hefty and Koprowski examined the threatened Big Cypress fox squirrel of southwest Florida using multiscale occupancy analysis, species distribution models, and connectivity analysis [6]. They found that fine-scale predictors of habitat degradation influenced the presence of squirrels, and that variables measured at the home-range scale interacted with the proximity to urban areas. Suitable habitat was distributed unevenly within and among conservation areas, and urbanized features and unsuitable vegetation could act as barriers between habitat patches. This study shows why habitat selection and occurrence should be evaluated at more than one spatial scale.

3.2. Changes in movement range and migration routes

Land-use change can also affect the distance animals move. Tucker et al. compared movement in areas with different levels of human impact, using GPS tracking data from 803 individuals representing 57 terrestrial mammal species [7]. Mammals in high human footprint areas moved only about one-half to one-third as far, on average, as mammals in low human footprint areas. At a ten-day scale, median displacement was about 3.3 km in high-impact areas compared with 6.9 km in low-impact areas, while long-distance displacement averaged about 6.6 km compared with 21.5 km. The authors linked this pattern to changes in individual behavior as well as the reduced presence of species that normally make long-distance movements in highly modified landscapes.

Migration depends on a network of suitable sites for migratory animals and therefore land-use change can have a much larger-scale effect on movement. Xu et al. investigated eight species of waterfowl in the East Asian–Australasian Flyway [8]. These birds are dependent on wetlands and stopover sites between breeding and non-breeding areas. The study found that the functional connectivity of the migration networks of all eight species had declined continuously since 2001. Loss and degradation of habitat reduced connections between suitable wetland sites, which could move to the migration network.

The study did not simply assume that lower connectivity was harmful. It also compared connectivity change with population data. Changes in functional connectivity were positively related to population change, with the strongest relationship at a four-year lag. This provides direct evidence that changes in the spatial structure of migration networks can be connected to later changes in migratory bird populations.

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3.3. Changes in species distribution

Whether a species persists in a particular part of a landscape can also be affected by land use change. Semper-Pascual et al. investigated woodland-dependent birds and mammals in the Argentine Chaco using wildlife surveys and annual woodland maps from 1985 to 2016 [3]. Current occupancy was associated more strongly with contemporary than historic habitat amount. However, measures of fragmentation from previous years often explained occupancy better than fragmentation measured at the time of the wildlife surveys. The study therefore found evidence that fragmentation can have delayed effects on present species distributions.

This delay is important as a species can persist in a fragmented landscape for a time after major landscape change. So the fact that it's there now does not mean that the current landscape can support the same population in the long run. Wider studies also demonstrate differences between species in how their distributions respond to land-use intensity. Newbold et al. [9] analyzed 1317 tropical and subtropical forest bird species from several continents. Compared with undisturbed habitats, the average probability of occurrence was 7.8% lower under low-intensity human land use and 31.4% lower under high-intensity land use. Responses were also related to species traits. Large, long-lived, non-migratory forest specialists and species feeding mainly on fruit or invertebrates tended to show stronger declines in occurrence than smaller, shorter-lived, migratory, or more generalist species.

These findings show that land-use change does not simply shift all species in the same direction. Some species remain able to occupy modified environments, while others disappear from them more rapidly. The final distribution pattern depends partly on how strongly a species depends on natural habitat and how well it can tolerate or move through modified land.

3.4. Changes in population abundance and persistence

Changes in habitat use and movement can ultimately impact population abundance and population growth. Paquet et al. used 24 years of data on northern wheatears in an agricultural landscape in Sweden [10]. They contrasted two broad habitat types associated with land use: short ground vegetation areas and taller vegetation areas. Demographic measures, including breeding success, fledgling production, and recruitment, were generally better in short-vegetation habitat. Their population model showed that the amount and use of these higher-quality habitats contributed to variation in overall population growth. The authors also found that increasing the proportion of occupied high-quality habitat could have a positive effect on population growth.

Population persistence may also be affected by connectivity. Xu et al. showed that the decreasing functional connectivity of migration networks was associated with the decreasing population sizes of the eight waterfowl species they studied [8]. Functional connectivity was the only significant predictor retained in their best model of population change, and the strongest relationship occurred after a time lag. This connects landscape structure directly with population dynamics rather than treating connectivity only as a map-based property.

Ma et al., for example, analyzed 2,195 populations of 577 species of birds and mammals at a broader geographic scale. Historical land-use change was significantly negatively associated with bird population trends at global and temperate scales [11]. However, in the same analysis, mammal population trends were not significantly related to land-use change but were more closely related to some life-history traits. These differences show that population responses to environmental change can vary strongly among taxonomic groups and regions.

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Taken together, these studies show how land-use change can affect wildlife at several connected levels. Habitat selection may change first as animals use or avoid different parts of the landscape. Movement can then become restricted as human pressure increases or connections between habitat patches are lost. These changes can alter where species occur and, over longer periods, influence survival, reproduction, recruitment, population growth, and persistence. The strength of each response depends strongly on the species and on the spatial and temporal scale being studied.

4. Conclusion

Land-use change affects wildlife by causing habitat loss, fragmentation, diminished connectivity, and shifts in habitat quality. These processes influence where animals feed, rest, reproduce and move, with potential consequences for population distribution, abundance and long-term persistence. Human-modified landscapes can provide suitable habitat for some species but the value of these habitats is contingent on the availability of resources, level of disturbance and availability of alternative habitats. Thus, the effects of landscape change go beyond loss of habitat area to changes in wildlife movement and population dynamics. Species responses differ in dependence on habitat requirements, dispersal capacity and movement behavior. Hence, conservation strategies need to consider species-specific needs, rather than assume that the same measures will benefit all wildlife. Costanza et al. demonstrated that even species occupying similar habitats may experience connectivity threats in different places and of different kinds [12]. Therefore, it is important to identify the specific impediments that hamper mobility and access to appropriate habitats.

Good conservation not only protects the best habitat but also restores the connections that make fragmented habitat function. Long-term monitoring is also required to assess whether corridors and protected-area networks facilitate wildlife movement and population persistence. Assessments of habitat use, connectivity, and population trends, rather than habitat area alone, can provide a more holistic view of the effectiveness of conservation in increasingly modified landscapes.

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