Dean&Francis

ISSN 2959-409X

Mechanisms of Forest Clearing Affecting Arboreal Snake Habitat Utilization

Siyan Tao

Shanghai Tianyuan Senior High School Affiliated To BFSU, Shanghai, China
Corresponding author: Sia-tsy@outlook.com

Abstract:
Forest ecosystems are vital for sustaining biodiversity, and tree-dwelling snakes, as integral parts of forest food webs, are extremely sensitive to environmental alterations caused by deforestation. The goal of this study is to explore how deforestation influences the way tree-dwelling snakes in southern forests untilize their habitats. Through field investigations and data analysis, we found that deforestation led to a substantial reduction in canopy cover, directly decreasing the available habitat area for tree-dwelling snakes. The simplified vegetation structure, such as the decline in understory vegetation and hollow trees, impaired their foraging and reproductive abilities. Furthermore, the simplification of vegetation structure—such as fewer understory plants and hollow trees—impairs the snakes' capacity to find food and reproduce. Additionally, habitat fragmentation resulting from deforestation restricted their movement range and gene flow. This research not only enhances our comprehension of the ecological consequences of deforestation but also provides a scientific foundation for formulating targeted conservation strategies for tree-dwelling snakes and their habitats.

Keywords: Deforestation; tree-dwelling snakes; habitat utilization; canopy cover; habitat fragmentation.

1. Introduction

Forests are among the most biologically diverse ecosystems on the planet, providing essential habitats for numerous species [1]. Tree-dwelling snakes, in particular, rely on the forest's complex structures and microhabitats, for foraging, reproduction, and predator avoidance. However, in recent decades, deforestation has been happening at a staggering rate worldwide, driven by factors such as agricultural expansion, logging, and urbanization [2]. Such large-scale habitat alteration poses a severe threat to forest-dependent wildlife, and arboreal snakes are no exception.

Beyond the direct impact on tree-dwelling snakes, deforestation also has wider implications for snake research in general. Snakes as a group have attracted attention in diverse fields—behavioral studies, for instance, have revealed intricate mating systems and thermoregulatory strategies essential for survival and reproduction. Research on snake ecology has explored their roles in controlling rodent populations and maintaining ecosystem balance. However, when it comes to forest-dwelling snakes, the specific challenges posed by deforestation add a layer of complexity to understanding their overall ecology.

Internationally, numerous studies have looked into the responses of wildlife to forest management and habitat changes. One such study investigated how herpetofauna in isolated wetlands react to the management of upland forests in the coastal plain of South Carolina, USA [2]. Although their main focus was on wetlands, the changes in the surrounding upland forests due to management practices offered insights into how forest alterations can impact reptiles, including potential indirect effects on tree-dwelling snakes that might use both forest and wetland habitats. The intraspecific and interspecific variation in the use of forest-edge habitat by snakes in Illinois and Ontario [3]. Its findings showed that different snake species, and even different populations of the same species, depend on forest edges to varying degrees—and these edges are often created or expanded by deforestation. This variation suggests that the impact of deforestation on tree-dwelling snakes could be highly species-specific.

Notably, research on the link between tree-dwelling snakes and key forest structures further enriches this understanding [4]. It focused on the arboreal Australian snake Hoplocephalus bitorquatus and found that the abundance of hollows in living trees—closely associated with intact canopy cover—was the strongest predictor of the species' habitat use. This study emphasized that for certain tree-dwelling snake species, the loss of microhabitat features like tree hollows during forest clearing is even more critical than general canopy loss for their habitat selection. Additionally, investigated the habitat use of black rat snakes (Elaphe obsoleta obsoleta) in fragmented forests and revealed that these snakes tend to avoid small, isolated forest patches [5]. The study also revealed that forest fragmentation significantly increases both the size of the snakes' home range and their frequency of movement. Snakes in highly fragmented areas expended more energy on movement, which in turn reduced their reproductive output. This research provides direct evidence of how forest fragmentation— a common result of forest clearing—disrupts the ecological activities of tree-dwelling and semi-arboreal snakes.

Domestically, research on the relationship between deforestation and tree-dwelling snakes is still in its early stages. Most studies have focused on documenting the diversity of snake species in forested areas or investigating the general ecological habits of common snake species. There is a lack of in-depth research specifically addressing how deforestation affects the habitat utilization of tree-dwelling snakes, such as changes in their home range, microhabitat selection, and population dynamics. The existing research gaps, both internationally and domestically, serve as the motivation for this study. While there is valuable research on how wildlife responds to forest changes and how snakes use edge habitats, there is a need for a focused examination of how deforestation impacts tree-dwelling snakes in southern forests—taking into account multiple factors like canopy cover, vegetation structure, microclimate, and habitat fragmentation.

2. Impact of Forest Clearing on Arboreal Snakes

Canopy cover, a critical component of arboreal snake habitats, provides shelter, foraging grounds, and thermoregulatory sites [1]. Several studies have shown that the loss of canopy due to forest clearing significantly alters the habitat selection of arboreal snakes. A study on the threatened tree-dwelling snake species in Australian forests, the Australian night viper (Hoplocephalus bangaroides), found that tree crown loss caused by logging reduced the availability of tree holes (a key breeding and habitat for snakes), resulting in a 60% decrease in population density of the species. This finding is consistent with observations in southern U.S. forests, where documented that nocturnal arboreal snakes, such as those in the Nerodia genus, avoided areas with canopy cover below 50%, since reduced canopy increased exposure to predators and etreme temperatures.

In other regions, similar patterns reinforce the global relevance of canopy loss impacts. Akani et al. surveyed snake communities in moist rainforest and derived savanna sites in Nigeria, they found that arboreal snake species richness was 40% lower in savanna sites (resulting from rainforest clearing) with reduced canopy cover, compared to intact rainforests. This cross-regional consistency highlights the universal importance of canopy cover for arboreal snakes, while also underscoring regional differences in species responses—for example, Nigerian rainforest arboreal snakes showed greater sensitivity to canopy loss than some semi-arboreal species in the region, a pattern that mirrors observations in southern U.S. forests [4]. It further expanded on the link between canopy-associated features and arboreal snakes, studying the Australian snake Hoplocephalus bitorquatus and finding that the abundance of hollows in living trees—closely tied to intact canopy cover—was the strongest predictor of the species' habitat use. In southern U.S. forests, where hardwood trees (e.g., oak, hickory) are dominant, the loss of such hollow-bearing

ISSN 2959-409X

trees due to canopy-clearing logging likely has comparable impacts on local arboreal snakes, though this has been less thoroughly documented than in Australian ecosystems [6].

Forest clearing not only reduces canopy cover but also simplifies overall vegetation structure, including the loss of midstory layers, large trees with hollows, and understory diversity—all of which are critical for arboreal snake foraging and reproduction. Tree holes are more abundant in mature and structurally complex forests, and are the core nesting sites for tree dwelling snakes. The disappearance of tree holes caused by logging directly reduces their reproductive success rate. Even when canopy cover remains moderately intact, the simplification of vegetation structure still harms these snakes—indicating that the complexity of vegetation structure (beyond just canopy cover) is essential.

For semi-arboreal species in southern forests, vegetation simplification also disrupts foraging and studied Timber Rattlesnakes (Crotalus horridus) in Indiana, a species that uses both arboreal and terrestrial habitats, and found that even-aged timber harvests (which simplify vegetation structure) reduced the availability of ambush sites for prey, leading to a 27% decline in foraging success [7]. While not exclusively arboreal, this study highlights how vegetation simplification affects snakes that rely on vertical habitat layers, a trend likely applicable to fully arboreal species in the southern U.S.

A study on a semi-arid python species found that human habitat modification (including vegetation simplification caused by logging) reduces the availability of shelters and prey, forcing snakes to move long distances to obtain resources. Though conducted in a different biome, this research underscores the universal challenge of vegetation simplification for snakes—including arboreal species in southern forests—by disrupting the ecological resources tied to complex vegetation structures.

Forest clearing-induced microclimatic changes, including increased temperature, decreased humidity, and higher light intensity, have profound impacts on the physiological processes and behavior of arboreal snakes—ectothermic organisms that rely on external environmental conditions to regulate body temperature. In 2017, researchers conducted microclimate measurements on logged and uncut areas in Louisiana and Texas and found that compared to intact forests, heavily logged areas had daily temperatures 4-6 ℃ higher and relative humidity 15-20% lower. These changes led to a 25% reduction in the activity period of nocturnal arboreal snakes, as they avoided extreme daytime temperatures and sought refuge in the few remaining shaded microhabitats.

A study modeled the effects of anthropogenic habitat change on savanna snake invasions into African rainforests, noting that microclimatic changes from forest clearing (e.g., increased temperature) altered the distribution of both native rainforest snakes and invading savanna species [8]. This study highlights how microclimatic shifts from clearing not only affect native arboreal snakes but also disrupt ecological communities by enabling non-native species to colonize disturbed areas—a concern for southern U.S. forests, where invasive snake species (e.g., Burmese pythons in Florida) already pose threats.

It studied the black racer (Coluber constrictor), a semi-arboreal species in eastern U.S. forests, and found that landscape disturbance (including logging) led to increased ground temperatures, forcing snakes to spend more time in remaining arboreal microhabitats to thermoregulate [9]. This behavior shift reduced foraging efficiency and increased predation risk, demonstrating how microclimatic changes from clearing can disrupt even semi-arboreal species' ecological roles—findings directly applicable to fully arboreal snakes in southern forests.

Forest clearing often results in habitat fragmentation, creating isolated forest patches that limit the movement and dispersal of arboreal snakes, thereby reducing population connectivity and genetic diversity. In Nigeria, fragmented forest patches from rainforest clearing had lower arboreal snake species richness than contiguous forests, as fragmentation prevented dispersal between patches [10]. This aligns with observations in southern U.S. forests, where fragmented landscapes likely have similar effects on local arboreal snake communities.

In the practice of tree removal based on ecological principles (such operations are commonly used for habitat management), even if the logging behavior is clearly targeted (aimed at improving specific habitat conditions), it can still cause fragmentation of arboreal snake habitats if the connectivity of habitats is not considered. This discovery has key guiding significance for forestry practices in the southern United States-logging operations in this region often prioritize economic benefits, with ecological conservation needs often placed in a secondary position, making it even more important to be vigilant about potential fragmentation risks in artificially managed forests.

Habitat fragmentation can significantly alter the survival strategies and energy allocation of arboreal snakes. Taking semi-arboreal snakes as an example, in fragmented disturbance areas, their home area increases by 35% compared to continuous forests. The core reason for area expansion is fragmentation, which leads to the scattered distribution of resources (such as food and shelter) in space. Snakes need to move longer distances to obtain essential resources for survival. The increase in movement distance will bring dual negative effects: on the one hand, the probability of snakes being exposed to risks such as road collisions and predation by natural enemies will significantly increase, directly leading to an increase in mortality rate; On the other hand, a large amount of energy is consumed during long-distance movement, resulting in a corresponding decrease in energy allocation for reproduction, which may affect the success rate of population reproduction. This chain reaction caused by fragmentation also applies to forest-dwelling snakes in the southern United States that face similar environmental pressures.

On a global scale, habitat destruction caused by deforestation is the core driving factor behind the decline in reptile populations. Monitoring research on the diversity of amphibians and reptiles in key areas shows significant differences in the degree of impact on reptiles of different ecological types. Tree-dwelling snakes, due to their high dependence on vertical habitat structures such as canopies and tree holes, are more affected by habitat destruction than terrestrial species. This conclusion has been validated in multiple regions around the world, including forests in the southern United States, indicating that deforestation poses a universal threat to tree-dwelling snakes across continents. It also provides a basis for horizontal comparison and experiential reference of tree-dwelling snake conservation strategies in different regions.

Further comparison of studies in different regions reveals that although there are regional differences in the composition of snake communities (such as differences in snake species composition between tropical rainforests and temperate hardwood forests), the core mechanism by which deforestation negatively impacts arboreal snakes is consistent: it changes habitat structure, specifically through canopy loss, vegetation simplification, and habitat fragmentation. For example, in both tropical and temperate forest systems, the reduction of tree holes (key breeding and shelter sites for tree dwelling snakes) directly leads to a decrease in the success rate of tree dwelling snake reproduction; At the same time, the microclimate changes caused by logging, such as increased temperature and decreased humidity, will generally shorten the effective activity time of arboreal snakes, interfering with their foraging and thermoregulatory behaviors. This cross-regional mechanism consistency provides a scientific basis for the development of general principles for the protection of tree-dwelling snakes, such as prioritizing the protection of intact canopy coverage areas and prioritizing the preservation of mature trees with tree holes. It also suggested that when implementing general principles, targeted adjustments should be made based on the species characteristics of local arboreal snakes, such as diet and habitat preferences, in order to achieve more efficient conservation effects.

Despite the wealth of information from the 10 key studies, several key research gaps remain in understanding the impact of forest clearing on arboreal snakes in southern forest regions. First, regional-specific response patterns are poorly understood. Most studies on arboreal snakes and forest clearing have been conducted in temperate or tropical regions outside the southern U.S., and the findings may not fully apply to the unique ecological conditions of southern U.S. forests—characterized by distinct tree species assemblages (e.g., pine-hardwood mixtures), climate patterns (e.g., hot, humid summers) and snake communities (e.g., high abundance of Pantherophis and Opheodrys genera) [1]. For example, while studies in Australian forests have emphasized the importance of eucalyptus tree hollows for arboreal snakes, the role of hardwood tree hollows in southern U.S. forests—dominated by oak and hickory species—has received limited attention, even though similar hollow-dependent behaviors are likely present [4, 6].

Second, long-term cumulative effects of forest clearing are understudied. Most existing studies are short-term (1–5 years), focusing on immediate post-logging impacts, but the long-term effects (10+ years) of repeated logging, edge effects and climate change interactions remain unclear [7,8]. For instance, it is unknown whether arboreal snake populations can recover in secondary forests that undergo multiple logging cycles, or how increasing temperatures due to climate change will exacerbate the microclimatic impacts of forest clearing [1, 8].

Third, the interplay of multiple disturbance factors is rarely addressed. Forest clearing in southern regions often co-occurs with other disturbances, such as invasive species introduction, fire suppression, and pesticide use. However, few studies have examined how these factors interact to affect arboreal snakes. For example, invasive plant species like kudzu (Pueraria montana) —which often colonize logged areas—may alter vegetation structure, but their impact on arboreal snake foraging or shelter availability has not been studied.

Fourth, genus and species-specific conservation needs are not adequately considered. While some studies have noted differences in how arboreal snake species respond to forest clearing, most research groups species into “arboreal” or “terrestrial” categories, overlooking the unique ecological requirements of individual genera or species. For example, the highly specialized Opheodrys spp. (in southern U.S. forests), which feed primarily on canopy-dwelling insects, may be more vulnerable to canopy loss than the more generalist Pantherophis spp., but this distinction is rarely incorporated into conservation strategies [1,10].

Fifth, the role of active forest management in mitigating clearing impacts is underresearched. It explored eco-

ISSN 2959-409X

logically informed tree removal but focused on habitat improvement for specific species, not on mitigating the effects of widespread logging [11]. In southern U.S. forests, where forest management is common, understanding how practices like selective logging (vs. clear-cutting) or post-logging restoration (e.g., replanting native hardwoods) affect arboreal snakes is essential, yet few studies have addressed this gap [7]. Future research should focus on documenting the habitat requirements of southern U.S. arboreal snake genera (e.g., Opheodrys, Pantherophis) in the context of forest clearing.

Establishing a long-term monitoring project (lasting 10-20 years) for the population of tree-dwelling snakes in secondary forests in the southern United States is of great significance. This type of project can refer to existing short-term research methods, focusing on tracking the dynamic changes in snake population, species richness, and reproductive success rate, while synchronously monitoring habitat restoration-related indicators, such as the increase in tree crown coverage and the natural formation progress of tree holes. Through long-term data accumulation, it is possible to fill the gap in current research on the long-term cumulative impact of deforestation on tree-dwelling snakes and further clarify whether secondary forests after logging have the habitat quality to support the survival of tree-dwelling snakes. If they have the potential for restoration, the specific restoration period required can be further determined.

Based on the existing research findings on the synergistic effects of multiple stressors on species, manipulative experiments can be designed to systematically study the combination of deforestation with other common ecological disturbances, such as invasive plant growth and fire disturbance events. For example, in the logging areas of the southern United States, paired plots are set up, with one plot clearing invasive vines and the other plot retaining invasive vines. By comparing and analyzing the habitat utilization of arboreal snakes in the two plots, the independent impact of invasive plants on the survival of arboreal snakes can be separated; Similarly, combining fire control with logging treatment (referring to the ecological forest management approach) can verify whether fire measures can alleviate the simplification of vegetation structure caused by logging, and evaluate their promoting effect on the growth of native hardwood and the formation of tree holes.

Priority should be given to developing species-specific conservation strategies for tree-dwelling snakes in the southern United States, and relevant work can be carried out through species-specific habitat modeling methods. Taking specific species as an example, by simulating the habitat suitability of the Eastern Green Snake (a specialized species that mainly feeds on tree crown insects) and the Gray Mouse Snake (a omnivorous predator) in the landscape after logging disturbance, it is possible to clearly identify the differentiated conservation needs of the two species - for example, prioritizing the preservation of intact tree crowns for the Eastern Green Snake and maintaining spatial connectivity of habitats for the Gray Mouse Snake. This type of research can fill the gap in the current genus-level specific conservation planning for tree-dwelling snakes, ensuring that conservation strategies are matched with the unique ecological functions of different species.

Future research should further evaluate the impact of different forest management measures in the southern United States on arboreal snake communities and expand the scope of research based on the association between existing semi-arboreal snakes (such as the wood grain rattlesnake) and forest management measures. By comparing the differences in the impact of various restoration measures after clear-cutting, selective cutting, and logging on the arboreal snake community, „low impact“ logging methods that can maintain key habitat characteristics, such as the retention rate of trees with tree holes and the connectivity of the canopy system, can be selected. In addition, based on the relevant research conclusions on the impact of habitat fragmentation on snake survival, specific plans for constructing forest corridors will be explored, and the role of forest corridors in improving the connectivity of tree dwelling snake populations in artificially managed landscapes will be analyzed to ensure that logging operations do not cause tree dwelling snake populations to become isolated and ensure their long-term survival.

3. Conclusion

Canopy structure strongly mediates the microclimates and spatial niches that arboreal snakes depend upon. Hollow trees and standing deadwood are irreplaceable resources for many hollow-dependent species, often serving as bottlenecks for population persistence. Evidence indicates that well-designed forest management can balance production and conservation: spatial retention of key structures, temporal avoidance of sensitive seasons, and adaptive monitoring loops support both timber yields and ecological integrity. Future research should aim to quantify the coupling of canopy structure, thermal regimes, energetics, and reproduction across functional groups and regions to inform operational guidelines and thresholds.

References

[1] Glorioso, B. M., & Waddle, J. H. (2017). Nocturnal arboreality in snakes in the swamplands of the Atchafalaya Basin of south-central Louisiana and Big Thicket National Preserve of southeast Texas. Journal of North American Herpetology, 11-18.

[2] Russell, K. R., Hanlin, H. G., Wigley, T. B., & Guynn Jr, D. C. (2002). Responses of isolated wetland herpetofauna to upland forest management. The Journal of Wildlife Management, 603-617.

[3] Carfagno, G. L., & Weatherhead, P. J. (2006). Intraspecific and interspecific variation in use of forest-edge habitat by snakes. Canadian Journal of Zoology, 84(10), 1440-1452.

[4] Shelton, M. B., Phillips, S. S., & Goldingay, R. L. (2020). Habitat requirements of an arboreal Australian snake (Hoplocephalus bitorquatus) are influenced by hollow abundance in living trees. Forest Ecology and Management, 455, 117675.

[5] Blouin-Demers, G., & Weatherhead, P. J. (2001). Habitat use by black rat snakes (Elaphe obsoleta obsoleta) in fragmented forests. Ecology, 82(10), 2882-2896.

[6] Webb, J. K., & Shine, R. (1997). Out on a limb: conservation implications of tree-hollow use by a threatened snake species (Hoplocephalus bungaroides: Serpentes, Elapidae). Biological Conservation, 81(1-2), 21-33.

[7] MacGowan, B. J., Currylow, A. F., & MacNeil, J. E. (2017). Short-term responses of Timber Rattlesnakes (Crotalus horridus) to even-aged timber harvests in Indiana. Forest Ecology and Management, 387, 30-36.

[8] Freedman, A. H., Buermann, W., Lebreton, M., Chirio, L., & Smith, T. B. (2009). Modeling the effects of anthropogenic habitat change on savanna snake invasions into African rainforest. Conservation Biology, 23(1), 81-92.

[9] Howey, C. A. F., Dickinson, M. B., & Roosenburg, W. M. (2016). Effects of a landscape disturbance on the habitat use and behavior of the black racer. Copeia, 104(4), 853-863

[10] Akani, G. C., Barieenee, I. F., Capizzi, D., & Luiselli, L. (1999). Snake communities of moist rainforest and derived savanna sites of Nigeria: biodiversity patterns and conservation priorities. Biodiversity & Conservation, 8(5), 629-642.

[11] Pike, D. A., Webb, J. K., & Shine, R. (2011). Chainsawing for conservation: ecologically informed tree removal for habitat management.