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Forest management bolsters native snake populations in urban parks

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ABSTRACT

Within a mosaic of agricultural and urbanized landscapes, shrub habitats are important refuges that help maintain biodiversity. Unfortunately, these habitats have been dramatically altered over the past several decades for practical and esthetic reasons. Continued rapid growth of suburban areas has accelerated this shift in habitat quality. Management strategies that promote shrub habitat within developed areas are rarely greeted with public acceptance because bushy thickets (e.g. *Rubus* brambles) shelter undesired species of animals (e.g. snakes, small mammals) and are typically associated with a lack of property maintenance. We conducted an experiment in a heavily impacted suburban habitat (population density of ~2700 humans/km^2). Our study site, containing forest and meadow habitats, was adjacent to a large city (~320,000 inhabitants) and visited by >70,000 people annually. We manipulated the forest habitat by removing trees, and through active maintenance, thereby promoting the growth of brambles. Within six years, we observed that newly-created shrub habitat was rapidly colonized by snakes, notably *Vipera aspis*. The total number of detected individuals increased markedly over time. Numerous advertising and educational activities about snake ecology were conducted in parallel, especially with school children. Complaints from the public were absent which demonstrates that management strategies that favor unpopular organisms are feasible, even in densely populated areas.

1. Introduction

Urbanization is typically viewed as having negative impacts on landscapes, from disrupting the functioning of ecosystems to reducing biodiversity (Gilbert, 1989). Given the rapid pace of landscape alterations, the incorporation of natural elements (e.g. "green spaces," parks) within urbanized developments is essential for wild populations. For example, these elements provide key habitats and improve connectivity across a fragmented urbanized landscape (Fahrig, 2003). Patches of natural habitat that occur within urban settings also serve to enhance human well-being and contribute to public understanding of the importance for conservation efforts when educational materials or signage are present (Miller and Hobbs, 2002; Alvey, 2006). Indeed, green spaces within a mosaic of urban habitat provide the opportunity for inhabitants to experience an encounter with nature.

Not all green spaces are created equal. They can be relatively contrived, populated by a monoculture of tolerant or non-native species, and therefore of limited interest for conservation or environmental education. Furthermore, well-kept, open parks require intensive maintenance, including frequent mowing and pesticide application, making these habitats unsuitable for a variety of wildlife (Fenn et al., 1998; Ma et al., 2000). In contrast, efforts in some inner-city parks have successfully protected the native flora and fauna while promoting public education. These latter examples gained significant international reputation for scientific research and conservation (e.g. http://www.bgpa.wa.gov.au/kings-park). We are unaware of any comparisons of the ecological and educational benefits associated with these two strategies for maintaining green spaces (a surrogate biota representing a few species versus a relatively natural community). Thus, assessing and promoting biodiversity in patches of natural habitat both within and immediately adjacent to urban areas are of paramount importance. We predict, however, that complex and diverse habitats are more valuable for conservation when compared to green spaces that are intensively maintained to comprise a small and artificial community. Green spaces that accommodate populations of threatened species and offer opportunities to observe free ranging animals have a greater conservation and educational impact (Ballouard et al., 2011).

One way to promote the establishment of green spaces that are themselves environmentally friendly (e.g. require minimal maintenance) is to demonstrate the feasibility of the required management operations, and highlight the success of practical outcomes that follow. This study describes a management strategy applied to forest habitats in a suburban landscape that is designed to promote native snake populations. This study faced a number of challenges. Indeed, the study area is not only visited by thousands of people annually, but is inhabited by snakes, species that usually trigger negative reactions from the public. In addition, the most abundant snake species,

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Vipera aspis, is venomous, further complicating the success of the project. Indeed, recent changes (2007) in French legislation now allow for the killing of this previously-protected snake species; without permits, people may now destroy snakes or complain to local authorities to have them removed. Finally, our study design adopted a management approach that promoted, via tree removal, the growth of large brambles. This type of vegetative landscape contrasts with the widely held public opinion that green spaces should be manicured, easily accessible, and contain large trees that offer ample shaded areas (Lindhagen and Hörnsten, 2000; Tyrväinen et al., 2003). For most people, mature forests better represent nature than dense thickets of thorny shrubs, and consequently these esthetic aspects prevail over the ecological value of forests and green spaces (Jim and Chen, 2006; Gundersen and Frivold, 2008).

Although not measured in this study, public acceptance provided the conceptual framework for the project. Indeed, public acceptance can determine the success or failure of conservation landscape management (Clark et al., 2002; Schenk et al., 2007). Several studies have removed canopy cover to create open habitats suitable for reptile communities have been carried out in remote forest areas where possible conflicts with human interests were limited (Greenberg, 2001; Pike et al., 2011a,b). Transferring this experimental approach to an oft-visited urban park is novel, especially with the intent of increasing populations of animals that typically elicit fear responses from humans (Burghardt et al., 2009). Studies report declines in snake populations worldwide (e.g., Reading et al., 2010) including relatively common species, such as the four taxa that occur in this study region. Because alteration and fragmentation of suitable habitat are the leading causes attributed to global losses of biodiversity (Fahrig, 2003; Opdam and Wascher, 2004), generating suitable habitats could help mitigate declines.

During the past 50 years, the abandonment of traditional farming practices has altered previously-open habitats that were characterized by mosaics of meadows and dense networks of hedgerows (Woodhouse, 2010). Therefore, the management employed in our study partly represents restoration to a historic condition. Our primary objective was to replace closed-canopy forest with shrub habitat in order to bolster snake populations. In temperate climates, removal of closed-canopy forest increases opportunities for thermoregulation in ectothermic reptiles like snakes, and thus enhances physiological processes such as digestion or reproduction (Huey, 1982). Consequently, this management approach is expected to favor colonization of the open patches (Edgar et al., 2010). Here we focus on the dynamics of snake occurrence within four experimentally modified habitats in an urban park used intensively for recreational purposes.

2. Material and methods

2.1. Study site

The study site is situated in western France (47°59′25″N, 0°14′47″E; 50–75 m above sea level; 450 ha) and includes a suburban public forest (350 ha) interspersed with several small meadows and orchards (100 ha). The study site borders the city of Le Mans (~320,000 people), and is fully surrounded by an urban mosaic composed of smaller cities and transportation infrastructure (Fig. 1). The forest is managed for wood production, and is transected by many paths that connect various recreational areas (e.g. jogging and cycling trails, large lawns, playgrounds, an educational farm, and an archery range) that are all part of a major city project led by the local authorities of Le Mans Métropole (www.lemans.fr/). This project, named the Ark of Nature (www.arche-nature.fr/), offers free services to approximately 70,000 visitors annually that participate in the educational activities at the park (e.g. registered schoolchildren), and an additional 500,000 non-registered visitors (e.g. joggers).

Most of the study site comprised a mature closed-canopy forest, and several patches are managed for timber production (~10% of the area is cleared annually). The canopy is nearly continuous and its average height ranges from 15 to 25 m; solar radiation does not easily reach the substrate. The dominant tree species include pines (*Pinus pinaster*; 60% of the forest area), chestnuts (*Castanea sativa*), oaks (*Quercus robur*), with additional species (e.g. *Salix caprea*) more sparsely distributed.

2.2. Experimental treatment of the habitat

We conducted this study from 2006 to 2012 and the habitat manipulation aspect of the project involved two separate phases. First, we removed canopy cover adjacent to several paths, orchards and meadows to create transects of recently opened habitat. Then, we applied different treatment regimes within the transects. Four species of spiny shrubs colonized the open habitats: mostly berry brambles (*Rubus fruticosus*; >80% of occurrence), but also gorse (*Ulex europaeus*), hawthorn (*Crataegus monogyna*), and dog-rose (*Rosa canina*). For simplicity, these bush species are collectively labeled bramble bushes hereafter. All forestry operations were completed in winter months when snakes were not active.

From 2006 to 2008 we established four replicate transects simultaneously in different locations (Fig. 1) in the park via the removal of canopy cover along preexisting paths frequented by park visitors. These transects consisted of open habitat extending 5–10 m in width beyond each path edge. Henceforth, we refer to these four transects created in 2006 as "initial transects." The total length of all transects (i.e., sum of replicates) increased over time, from ~400 m in 2006, ~2500 m in 2007, to ~3700 m in 2008. Thus, a substantial increase of canopy removal occurred from 2006 to 2007 (6.3×), then a proportionally modest increase occurred from 2007 to 2008 (1.5×). The rate of increase in the length of the transects during 2006–2008 was comparable among transects. We adopted this gradual approach both for logistical reasons, and to increase acceptance by the public. Bramble bushes colonized the opened transects and developed rapidly (annual growth of 1–2 m).

From 2008 to 2012 we initiated phase two of the project where we actively managed segments within each initial transect to evaluate the effect of time on vegetative growth and snake colonization over four years. Based on this approach, we established 16 different experimental areas within the study site:

1) Stable unfavorable habitat (SU): we designated four transects of mature forest not managed during the study to serve as unfavorable habitat controls (total length = 555 m; 15% of total transect length). We never removed canopy in these SU areas.
2) Stable favorable habitat (SF): to prevent closure by fast-growing pioneer trees (e.g. *S. caprea*) in segments of the initial transects, we actively managed bramble bush height to remain below 2 m. We selected and maintained segments (total length = 1665 m; 45%) to remain open over the duration of the study in each of the four initial transects to serve as favorable habitat controls.
3) Transitional habitat from favorable to unfavorable conditions (FU): we selected segments (total length = 555 m; 15%) in each of the four initial transects where we did not actively maintain bramble bushes, thereby allowing for the establishment of pioneer trees and a gradually closing canopy.
4) Transitional habitat from unfavorable to favorable conditions (UF): we selected segments within each of the four initial transects where we removed additional tracts of mature forest (total length = 925 m; 25%) to create newly established areas of open habitat. These segments allowed us to evaluate if snakes rapidly used these newly opened areas. Note that we did not remove a few isolated large trees for esthetic reasons.

2.3. Snake monitoring

We conducted several initial surveys in 2006, and then instituted continual efforts for the duration of the project. Preliminary surveys