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# Conserving small natural features with large ecological roles: A synthetic overview

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ABSTRACT

Small Natural Features (SNFs) are analogous to keystone species in that they have ecological importance that is disproportionate to their size. Thus the recognition and management of SNFs can be an efficient way to conserve biodiversity and ecosystem services. In particular, while the size of SNFs can engender threats (e.g., they are often overlooked and are relatively vulnerable to complete destruction), small size also leads to special conservation opportunities (e.g., integration with resource uses such as forestry or fisheries). Commonly, SNF conservation begins with education and inventory to form a foundation for appropriate, targeted protection and/or sustainable management. However, in cases of severe degradation or loss, more intensive activities such as restoration or creation may be required. Diverse approaches to conservation action are possible. For example, sometimes SNF conservation is undertaken incidentally to other efforts or on a voluntary basis; sometimes it involves substantial economic incentives or restrictive regulations. In general, the required investment for SNF conservation is likely to be smaller than that for larger areas, with disproportionate benefits given the substantial spatio-temporal influence of these features. In practice, conservation of SNFs should be complementary to traditional, larger-scale, forms of conservation by fostering creative, constructive efforts to conserve some seemingly minor features; features that have previously unknown or unappreciated roles critical to their broader ecosystems and to biodiversity.


## 1. Introduction

As conservation theory and practice have developed in recent decades, much of the attention is focused on extensive ecosystems, especially those that harbor large portions of the Earth's biodiversity (Roberts et al., 2002; Brooks et al., 2006). These systems and the programs to conserve them are often sizable, measured in the hundreds or thousands of square kilometers. Efforts to conserve the Serengeti Ecosystem, Greater Yellowstone Ecosystem, and Great Barrier Reef are prominent examples of this trend.

In this Special Issue, we focus on the other end of the spatial scale, Small Natural Features (SNFs), to offer a complementary approach to large-scale conservation. SNFs have a disproportionate ecological influence analogous to the keystone species concept (Hunter, 2005). As defined in the Introduction section (Hunter, 2017–in this issue), *a small natural feature is a site with ecological importance that is disproportionate to its size; sometimes because it provides resources that limit key*

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*populations or processes that influence a much larger area*; *sometimes because it supports unusual diversity, abundance, or productivity*. Thus, conserving SNFs allows us to protect ecologically important phenomena that may otherwise be overlooked in typical conservation efforts, and to do so with significant efficiency of effort given their small size. Therefore, *the recognition and management of SNFs as distinct entities is primarily a means to facilitate pragmatic conservation of their associated biodiversity and ecosystem services* (conclusion of definition from Hunter, 2017–in this issue).

The nine case studies presented in this Special Issue demonstrate the breadth and importance of the SNF concept across a range of ecological realms: terrestrial, freshwater, marine, and even subterranean and anthropogenic environments. Similarly, the SNF idea spans spatial scales, from square meters (e.g., a single desert spring) to some arbitrary limit probably measured in square kilometers (e.g., the riparian area of a moderate-sized river). The SNF concept also covers a wide range of temporal scales, from daily foraging trips of colonial animals, to seasonal activities such as migration, to long-term processes such as facilitating geographic range shifts and speciation.

For SNFs to be a useful, unifying concept, it is necessary to distill some generalizations that transcend the range of features identified in this Special Issue. The goal of this paper is to articulate these shared attributes and considerations. We first identify key themes that apply to most, if not all, SNFs, as well as some common threats. Then we describe a sample of SNF conservation measures that could be useful to practitioners. These are presented in a specific framework to facilitate communicating about SNF conservation.

## 2. Common themes

### 2.1. Key resources for species

A regular attribute of SNFs, as indicated in the definition, is that they often provide a key resource that is otherwise limiting populations over a wider area of interest (Hunter, 2017–in this issue). In most cases, a SNF provides a resource required by many species. In a few cases, the resource may be important only to a few species, but if one of those is an animal species that travels across a large area performing a major ecological role, then the criterion of large and disproportionate importance is still met. A small island occupied by a large seabird colony or a cave with many roosting bats exemplifies this idea (Sydeman et al., 2001; Medellin et al., 2017–in this issue).

There are at least four kinds of limiting resources for species that are common across different types of SNFs. The first is water. It is clearly a limited but key resource in arid and semi-arid regions, thus making desert springs a prime example of a SNF (Davis et al., 2013, 2017–in this issue). However, even in regions with significant rainfall, physical bodies of standing or flowing water may be uncommon, at least seasonally, thus limiting and shaping the distribution of biota tied to aquatic environments (Douglas et al., 2005).

A second resource is hard substrates, which are scarce in many settings, notably in the vast sediment beds of many aquatic environments or their terrestrial analogues (e.g., many grasslands and agricultural landscapes). In particular, a number of marine SNFs are associated with rocky substrates (e.g., deep-sea coral communities on seamounts, and kelp forests) and biogenic hard substrates (e.g. oyster and mussel reefs) (Lundquist et al., 2017–in this issue). Many species need hard substrates to which they can attach, or cracks in which they can hide from predators or shelter against extreme weather (Fitzsimons and Michael, 2017–in this issue).

Third, benign microclimates are the key resource provided by a number of SNFs. For example, the aforementioned cracks in rocks have an analogue in the bark cracks and bole hollows of large, old trees (Lindenmayer and Laurance, in press; Lindenmayer, 2017–in this issue). The most extreme examples of benign (and stable) microclimates are found in caves, albeit tied to the unusual aspect of permanent darkness (Medellin et al., 2017–in this issue). Riparian zones, especially in arid regions, also represent a distinct microclimate, able to buffer extreme temperatures and maintain moisture (Felipe-Lucia et al., 2014; González et al., 2017–in this issue).

Fourth, protection from predation is another resource provided by many SNFs. Hiding in cracks or caves, or being attached to a substrate that predators cannot climb (e.g. cliff-dwelling plants and birds) are obvious examples. A less obvious example is provided by temporary wetlands, which are often free of the fish that would prey on amphibian and invertebrate species that have limited defenses against predation (Calhoun et al., 2014, 2017–in this issue). In the marine realm, many SNFs such as coral reefs, seagrass meadows, and mangrove forests have three-dimensional biogenic structures that provide refugia from predation (Diaz et al., 2003; Berkström et al., 2012).

Finally, many SNFs provide multiple resources that are scarce in the larger environment. Perhaps the most obvious examples of this are the remnant patches of semi-natural vegetation found in landscapes dominated by agriculture (Poschlod and Braun-Reichert, 2017–in this issue). In these patches, many species can find the resources they need to persist, although some animal species may also exploit the agricultural matrix. Riparian areas are another example of a multiple resource feature, given that their biotic richness is based on providing both water for terrestrial species and land for aquatic species (González et al., 2017–in this issue). When multiple resources are involved, SNFs are likely to be sites of high diversity and productivity.

### 2.2. Key roles for ecological processes

SNFs also play an important role in a number of ecological processes, and a sizable portion of those processes are important to human welfare. Here we describe some common processes; Bauer et al. (2017–in this issue) address SNFs from the perspective of ecosystem services.

Many types of SNF help shape the movement of surface and ground freshwater and concomitantly they influence water quality, particularly sediment loads. Some of these hydrological roles are obvious (e.g., in riparian areas and temporary waterways (González et al., 2017–in this issue)); some less so (e.g., temporary wetlands (Rains et al., 2016) and caves). Marine SNFs composed of saltmarsh and mangrove forests filter sediments and nutrients, enhance sediment deposition, and buffer against erosion (Alongi, 2008; Friess et al., 2012).

A recurrent theme is the role of some SNFs as essential habitat for animals that travel widely and play critical ecological roles. Some of these animals are predators (e.g., bats that leave caves to forage for insects, or seabirds leaving nesting islands to fish [Sydeman et al., 2001]); others are pollinators (e.g., the insects that spread-out over farmlands from remnant patches of native vegetation [Arthur et al., 2010]).

SNFs can also play a pivotal role in the manner in which water, wind, and animals move materials, notably key macro and micronutrients, across areas far larger than the SNF occupies. In other words, SNFs can be biogeochemical hotspots. For example, temporary wetlands play a disproportionate role in leaf-litter decomposition and denitrification (Marton et al., 2015). Riparian zones in arid and semi-arid regions produce much more biomass than the upland ecosystems, and can make groundwater available to riparian animals via primary consumption (Sabo et al., 2008). Large old trees store disproportionate amounts of carbon relative to smaller, younger trees (Lindenmayer and Laurance, in press). In agricultural landscapes, linear SNFs such as hedges provide shelter from the wind, thereby inhibiting soil erosion and reducing desiccation of adjacent fields (Forman and Baudry, 1984). The highly localized spawning reaches used by anadromous fishes can serve as marine derived nutrient sources promoting primary production in downstream food webs (Schindler et al., 2005). Collectively, these processes often mean that SNFs are characterized by unusually high productivity, abundance, or diversity.