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Research Paper

Potential of restoration of gravel-sand pits for Bats

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ABSTRACT

Restoration management of quarries is one of the major tasks in global restoration ecology due to the magnitude of impacts link with extraction activities and the potential conservation value of these post-industrial sites. However, identifying a target to reach can be challenging as ecological issues can be numerous and post-exploitation state can differ from the original due to ecosystems removal or topography alterations caused by exploitation.

Here, we assess the restoration potential of gravel-sand pits for Bats, a targeted group for conservation, using data from 21 gravel-sand pits monitored by the ROSELIERE scheme and we selected external data from 76 sites of the French Bat Monitoring. We analysed the relative attractiveness of 17 habitats and 5 gravel-sand pit operating statuses (before quarrying, during quarrying, rehabilitation post-quarrying younger than 5 years, rehabilitation post-quarrying between 5 and 10 years and, finally, rehabilitation post-quarrying older than 10 years). We paid close attention to comparison between gravel-sand pits states and aquatic habitats, because the restoration process in the gravel-sand pits studied often leads to bodies of water and these habitats are among the most favorable for numerous bats species. In addition, we focus our comparisons on arable land because new gravel-sand pit settlements are usually planned on such agricultural land and furthermore because it represents the major land-use pressure for bats.

We found that bat activity in gravel-sand pit displays a range comparable to what is observed in numerous habitats, though it does appear both slightly lower than in bodies of water and greater than arable land. Bat activity appears increasing during the gravel-sand pit life's cycle. However, only quarries which had been rehabilitated for more than 10 years exhibited significantly greater bat activity than observed in the four other gravel-sand pit states. Our results, highlight the length of time required to detect obvious changes in the attractiveness of site being rehabilitated and the magnitude of the gap between the current state and the target (i.e. aquatic habitat). Such results should be take into account when sizing offsetting measures of quarries.

1. Introduction

Mining activities (steel industries, coal mining, rock or gravel sand extraction) have affected about 1% of the land worldwide (Walker, 1999). These post-industrial sites represent an increasing component of many landscapes and regions (Tropek et al., 2010) and there is currently an urgent need to solve problems related to ecological restoration of affected regions (Šálek, 2012). After closing, most of these mining sites and quarries became neglected due to their decrease in economic value (Dekoninck et al., 2010). The original ecosystems have been removed, the original topography has been significantly changed and the previous ecological function has been irreversibly disrupted (Milgrom, 2008). Spontaneous succession in those abandoned quarries resulted in a biodiversity pool that is significantly different from the original and surrounding habitats due to the dissimilarity between the physical and chemical substrate properties of the original and new soils (Dekoninck et al., 2010; Tischew and Kirmer, 2007). However, the opinion on these post-mining sites has changed among conservationists as natural recovery occurring in these sites may sometime result in the creation of biodiversity refuges, particularly in human-exploited regions (Tropek et al., 2010). Quarries are periodically disturbed and offer early successional stage, with extreme abiotic conditions leading to xerophilous open or oligotrophic habitats (Krauss et al., 2009; Novák and Prach, 2003). However similar conditions have become rare in human-exploited regions, because agriculture intensification processes contribute to increase the use of fertilizers, that in turn lead to eutrophication of soil and water and indirectly contribute to abandonment of marginal unproductive lands. This, in turn, promotes middle

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phase of succession, which is also favored by intensive forestry (i.e. fuelwood and shortening of cycle Bouget et al., 2012). In addition, many human actions induce control of natural perturbations (i.e. channeling of rivers, fire regime…etc.) in such a way that specialized species dependent on early successional stage and sparsely vegetated habitats are among the most threatened in many regions (Morris et al., 1994; Hoekstra et al., 2005; Wenzel et al., 2006). Literature is, therefore, quite abundant on the conservation potential of quarry sites for vascular plants (Bizoux et al., 2004; Shu et al., 2005; Tropek et al., 2010; Wheater and Cullen, 1997), spiders (Tropek and Konvicka, 2008; Tropek et al., 2010), odonata (Harabis, 2016; Tichanek and Tropek, 2015), orthoptera (Tropek et al., 2010), coleoptera (Brändle et al., 2000), butterflies (Benes et al., 2003; Tropek et al., 2010), wild bees (Krauss et al., 2009), ants (Dekoninck et al., 2010), amphibians (Dolezalova et al., 2012; Vojar et al., 2016) and birds (Šálek, 2012). In addition to conservation policies focused on creating protected areas, it is increasingly argued that restoration of degraded areas must be undertaken in order to achieve worldwide ambitious targets (Aichi Biodiversity Targets) such as bringing close to zero the rate of loss of natural habitats. Based on the potential conservation value of these post-industrial sites, restoration management of quarries is now one of the major tasks in global restoration ecology (Tischew and Kirmer, 2007). One particularly important issue is the quantification of the roles of the various intrinsic, environmental and management factors on restoration success. In this context, several studies focus on the benefits of active restoration achieved by human intervention through reclamation works versus passive restoration where environmental stressors are removed and secondary succession takes place naturally. (see Brändle et al., 2000; Prach et al., 2011; Šálek 2012; Tropek and Konvicka, 2008).

Proper evaluation of restoration success requires first a standardized definition of success, though. Despite this pressing need, there still are no general and broadly accepted success criteria for restoration of quarries. This stems from several reasons: (i) original ecosystems have often been totally removed and newly hydrographic, physical and chemical conditions are so different that biodiversity pool can hardly return to a state close to the initial one, (ii) ecosystems before gravel sand extraction are rarely described and pristine ecosystems references are not easy to identify in some countries with long history of human footprint, (iii) quarries under restoration process are in a very dynamic state, (iv) there are rarely clearly defined biodiversity targets for quarries in conservation policies-strategies (i.e. which state or taxa to reach and promote). Therefore, restoration attempts may set goals that are too idealistic or based on incorrect assumptions of the state before human impacts (Nilsson et al., 2007). Indeed, as expected, the majority of studies dealing with biodiversity restoration within quarries did not clearly identify a target to reach. In addition, strong feedbacks between biotic factors and the physical environment can alter the efficacy of restoration management (Suding et al., 2004). Studies indicates that some degraded systems are resilient to traditional restoration efforts owing to constraints such as drastic changes of biogeochemical processes, changes in landscape connectivity, loss of native species pools, shifts in species dominance, invasion by exotics (Suding et al., 2004). Here, we focus on gravel-sand pits, a type of mining activities, which impact the original topography. After end of operating such quarries are colonized by body of water due to the massive extraction of sand and gravel of old riverbed and the water table. While a return to the original topography is thus not an option, the target state identified is aquatic habitat. Such spaces are then dedicated for public recreation facilities or for nature conservation but never return to some original land uses such as agriculture land.

Moreover, the great majority of studies that monitored biodiversity along successional stages in quarries rarely used external standardized references to assess comparisons between the biodiversity present within quarries and other habitats (see Bonifazi et al., 2003; Brändle et al., 2000; Dekoninck et al., 2010; Dolezalova et al., 2012; Krauss et al., 2009; Milgrom 2008; Novák and Konvička, 2006; Novák and Prach, 2010; Prach et al., 2013; Tropek et al., 2010; Tichanek and Tropek, 2015; Vojar et al., 2016; Yuan et al., 2006; Zhang et al., 2013), for the few studies that used explicit external references see: Benes et al., 2003; Khater et al., 2003; Tropek and Konvicka, 2008. External references (i.e. biodiversity states assessments on sites without quarry activity or outside of restoration process) usage allows, however, unbiased evaluation of the conservation value of quarries for biodiversity. What's more, it enables the definition of objective goals and thus impartial assessment of restoration success. In this way, we mobilize biodiversity data in quarries, using ROSELIERE scheme and we use independent dataset provide by VIGIE NATURE a national biodiversity monitoring scheme based on citizen science for provide an external reference. ROSELIERE (http://programme-roseliere.fr/node/21), is a biodiversity monitoring scheme focused on evaluating biodiversity dynamics in French gravel-sand pits, implemented since 2006. The main goals of the ROSELIERE program are (i) to assess the level of biodiversity in a large number of quarries nationwide (ii) assess the success of restoration programs of gravel-sand pits (iii) understand the basic processes that promote or reduce the conservation effectiveness of these restoration programs. ROSELIERE currently aims, thus, to monitor 12 taxonomic groups (birds, bats, amphibians, aquatic macroinvertebrates, butterfly, plants….) and is based on protocols consistent with national monitoring.

Measuring restoration at the community level is particularly tough, due to the great variability inherent in most natural communities and may require a focus on restoration of community function (e.g., trophic structure) rather than a focus on the restoration of a particular species (Palmer et al., 1997). Here we propose to focus on bat taxa, because this group and microchiropterans particularly are long live species and act as important biodiversity indicators as their population trends reflect those of lower trophic level species thus tracking the biodiversity response to anthropogenic pressures (Jones et al., 2009). Furthermore, several studies have highlighted their value in terms of providing ecosystem services (Kunz et al., 2011), such as pest control (Cleveland et al., 2006) seed dispersal (Medellin and Gaona, 1999; Kelm and Wiesner, 2008) and pollination (Fleming et al., 2009). We measure bat activity using acoustic recorder, this metric based on bat echolocation is a diversity index, which directly include trophic function, because bats that hunt for flying insect, use echolocation to detect, identify, and localize prey (Schnitzler and Kalko 2001). Indeed bat activity is used by academics researchers to investigate differential use of habitat by bats (Sherwin et al., 2000). Additionally, from a conservationist point of view, bats are a group of interest, because they are increasingly threatened worldwide (Mickleburgh et al., 2002). An important part of European bat species (40%) have a poor conservation status much of their range (Barova and Streit, 2014) because of various pressures, such as the loss of suitable foraging habitats (Walsh and Harris, 1996), agricultural practices that use toxic pesticides (Swanepoel et al., 1999, Wickramasinghe et al., 2004), emerging infectious diseases (Frick et al., 2010), urbanisation (Loeb et al., 2009), forest management (O'Donnell, 2000) and roost destruction and disturbance (Mitchell-Jones et al., 2007). In response to these pressures, answers in terms of protection have been implemented: all Europeans bats are legally protected in European countries through national or European laws (Council Directive 1992, Convention on Migratory Species (CMS 1985–2008), and Agreement on the conservation of Populations of European Bats). In addition to species protection, 31% of European bat species are target species for the designation of Natura 2000 conservation areas (Barova and Streit, 2014). To our knowledge, however, and despite this established role as valuable indicator, this particular group has never been studied in the context of quarry restoration.

Considering that relative abundance, diversity or success of restoration are relative states, we compared bat activity measures on gravel-sand pits sites (before operating, during quarrying or in rehabilitated sites) to bat activity measures on the main habitats present