Landscape genetics: key contributions from ENHANCE

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The innovative field of landscape genetics has been promoted in various review articles (Storfer *et al.* 2007; Holderegger and Wagner 2008; Segelbacher *et al.* 2010), international workshops (Balkenhol *et al.* 2009) and (international) teaching activities (ETHZ: Bolliger *et al.* (2010), DGS: Wagner *et al.* (2012)). Landscape genetics amalgamates population genetics and landscape ecology by combining theory, concepts and methods of population genetics with the spatially dynamic framework of landscape ecology, spatial statistics and modelling (Manel *et al.* 2003). Landscape ecology assesses the relationship between spatially dynamic patterns and processes in landscapes by using statistical models including the characterization of landscape structure (e.g., suitable versus unsuitable habitats, barriers, corridors etc.), while population genetics uses a variety of genetic techniques (e.g. AFLPs, microsatellites or SNPs) to describe the genetic structure of populations. Landscape genetics thus provides a powerful tool for explaining genetic structure and gene flow based on spatially dynamic patterns and processes (Fahrig 2003; Cushman 2006; Sander *et al.* 2006) and allows to identify the effects of explicit landscape properties on ecological processes.

Major scientific benefits of landscape genetics are that it provides a powerful conceptual framework for identifying and explaining dispersal, migration, and gene flow based on spatial (and dynamic) landscape patterns (Fahrig 2003; Cushman 2006; Sander *et al.* 2006). The combination of molecular genetic and landscape or environment data with modeling approaches also offers a unique setting to test emerging questions of species behavior land-use change. For example, landscape genetics allows identifying the degree of individual or gene exchange as well as its directionality among populations or individuals, and therefore provides direct tests of functional connectivity in relation to landscape structure. This is in distinct contrast to much ecological research, but also practical management interventions, where simple structural connectivity is used as an indicator of functional connectivity. It is thus possible that entire scientific chapters relying on traditional population biological or ecological approaches (e.g. habitat fragmentation) have to be re-written based on insights emerging from landscape genetics (Epperson 2003). What we learned from landscape genetics so far shows that dispersal, migration and gene flow are often more abundant and occur over larger distances than had hitherto been suggested based on ecological studies (Holderegger and Wagner 2008; Bolliger *et al.* 2011). Thus, landscape genetics provides concepts and methods to contribute significantly to basic and applied research, especially conservation management, the evaluation of connectivity measures and landscape planning.

ENHANCE contributed to the advancement of landscape genetics with the following topics:

1. The role of management intervention in enhancing breeding-habitat networks in the European tree frog (Le Lay *et al.* 2012).

2. The potential genetic consequences of seed mixtures in restoration (Aavik *et al.* 2012).

3. Landscape genetics of seven insect species in intensive agriculture: new ecological insights (Keller *et al.* 2012).

4. Connectivity of river habitats: population genetic survey on the effect of river fragmentation on Swiss brown trout (Araki *et al.* 2012).

5. We initiated a one week Master and PhD winter school on landscape genetics for ETH, conducted at WSL (Bolliger *et al.* 2010; Bolliger *et al.* 2012).

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