

# Why is Genetic Diversity Always Changing?

## Why We Care About Genetics Vol.3

Genetic diversity is always changing — both across space and through time. Typically, the amount and type of genetic diversity within a species vary across its natural range. Additionally, its genetic diversity changes over time — at least in the longterm, and sometimes even over shorter timeframes such as a few generations of the species. These natural changes in the genetic diversity of a species create a dynamic landscape upon which any influences that we exert are superimposed. To better understand our impacts, and to decide if management actions are warranted, it is useful to understand the natural dynamics of genetic diversity.

[ mutation, migration, drift, and selection are ongoing natural processes that affect genetic diversity ]

Genetic diversity is affected by several ongoing natural processes. These processes are: mutation, migration, genetic drift, and selection.

**Mutation** is the origin of all new genetic diversity, occurring when there are occasional errors in the replication of DNA or other elements of the production and packaging of genetic information within the cells. Although it implies something negative, mutations can have positive, neutral, or deleterious impacts. Mutations occur rather slowly but continuously. Mutations at one level, for example, in the nucleotides that are the basis of DNA, may not all be expressed at other levels — such as protein differences or observable changes in the appearance of a plant. The rate of mutation is useful in determining evolutionary relationships.

**Migration** is the movement of genetic diversity, usually within a species. In plants, this occurs through pollen dispersal, seed dispersal, and movement of vegetative propagules, such as suckers or rhizomes, in species that can reproduce asexually. Migration, also called gene flow, occurs both with the advancing front of a population when it is colonizing new areas, and when genes of two or more populations mix through pollen and seed dispersal. The rate of migration is obviously related to the frequency of reproduction and the distances over which pollen and seeds typically disperse.

**Genetic Drift**, or random genetic drift, is simply the change in genetic diversity, or, more specifically, the change in frequencies of different alleles, over generations because of chance. For example, every pollen grain contains a different combination of alleles. Which pollen grains — whether carried by wind, insects, or some other medium — actually succeed in arriving at a compatible flower and producing a seed — are largely determined by chance events. Thus, some genetic diversity is usually lost at every generation through these chance events.

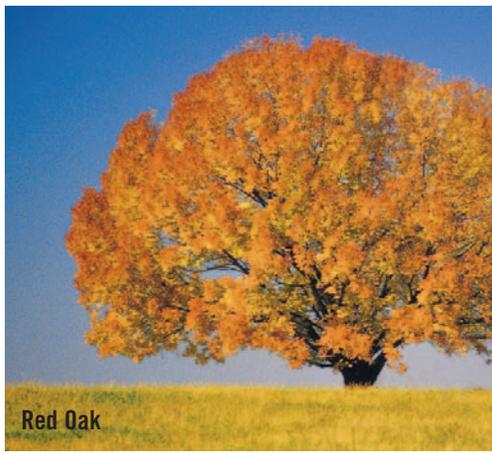
**Selection** is perhaps the best known of the processes affecting genetic diversity and is the only process that directly results in populations becoming better adapted to their environment. For natural selection to occur, there must be differences in fitness and survival among individuals and a genetic basis for those differences. Over time (generations), those individuals that are better suited to the environment live, or live longer, and produce more offspring — those offspring having inherited the more adaptive traits (or rather, have a higher frequency of the alleles that confer better adaptation).



National Forest Genetics Laboratory (NFGEL)  
Pacific Southwest Research Station  
USDA Forest Service  
2480 Carson Road  
Placerville, CA USA 95667  
<http://www.fs.fed.us/psw/programs/nfgel/>



Genetic Resources Conservation Program  
University of California  
One Shields Avenue  
Davis, CA USA 95616  
<http://www.grep.ucdavis.edu>



Red Oak

These processes continue over the lifetimes of individuals, populations, and species. Using estimates of the historic mutation rates for a species, or genetic principles related to the other processes, one can derive clues about the geographic history and past demographic changes. Genetic diversity maintains a footprint of historic influences, allowing one to look back in time and see how the species expanded and contracted its range in response to glacial and other climatic events, whether it was much reduced in size at some time (a bottleneck), and where it commenced to reestablish or radiate when environmental conditions became more favorable (founder effects). For example, from genetic studies it is apparent that the northern

red oak (*Quercus rubra*) had a fairly large and continuous distribution in eastern North America during the last glacial maximum (21,000 to 18,000 years before present). The northern red oaks grew close to the ice sheets as the glaciers retreated, and there is relatively little (compared with many other, including European, oak species) genetic differentiation among populations, and as one goes north in its range the populations become a bit more genetically distinct.

New techniques for extracting DNA from ancient trees (fossilized wood or cones) allows another type of insight — a direct comparison of the genetic diversity of historic plant populations with current plant populations.

The timeframes over which these processes show significant impacts can vary widely. Because changes in genetic diversity happen over generations, the length of a generation for the species will greatly influence the absolute time over which genetic changes occur. Typically, for example, natural selection

may take a long time to show noticeable changes in genetic diversity of a population. Furthermore, the processes generally do not act with the same force or in the same direction. Typically, mutations increase genetic diversity; the other three processes reduce it. Natural selection and genetic drift tend to enhance genetic differences among populations; migration tends to homogenize genetic difference, decreasing the differences among populations.

[ genetic diversity changes over time and has important implications for species management ]

The slippery, dynamic nature of genetic diversity has important implications for species management and for questions concerning the 'normal' or 'healthy' status of genetic diversity. Because taking a diversity measurement at different times, places, or generations of a species would naturally give different values, this context must be carefully considered when designing a genetic study and interpreting such values. For example, differences in genetic diversity between the parent plants and their seeds, between samples taken ten years apart, or between plants in wildland and more managed areas, could indicate problems that might be addressed with appropriate management practices or might lie within a normal range of variation. The ability to distinguish these two interpretations lies in appropriately designed studies. (See Volume 8 for more information.) ■

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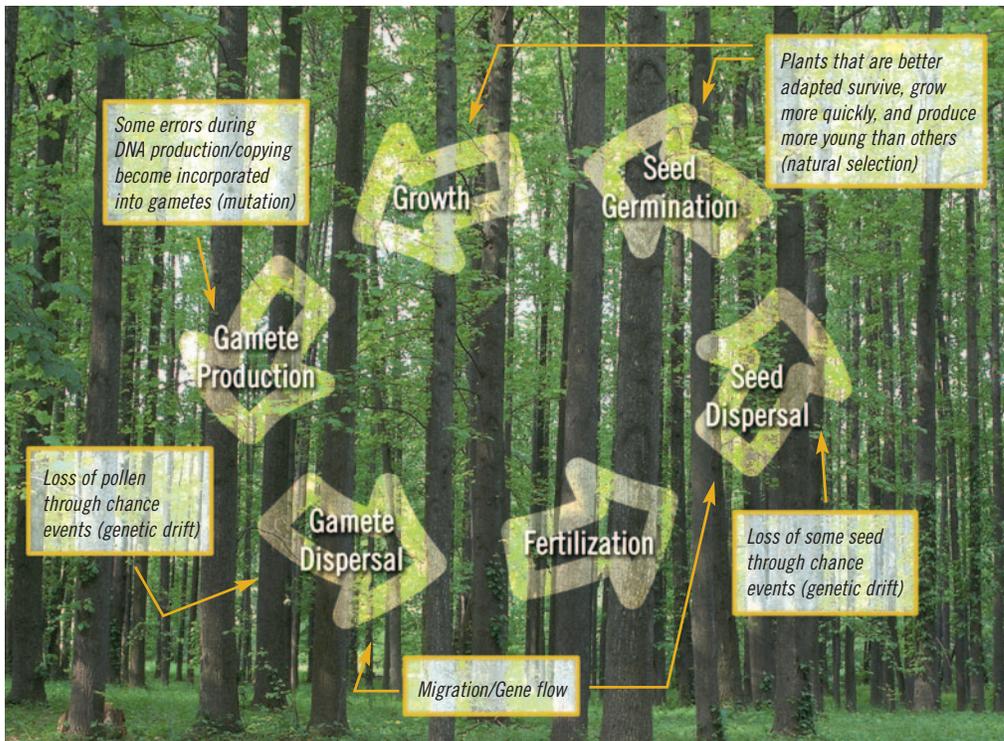


Figure. Various processes that effect genetic diversity.