Figure 16.1. Nitrogen transformations and processes affecting $\delta^{15}N$ values in forest ecosystems. Modified from Nadelhoffer and Fry (1994).

Figure 16.2. Reaction progress vs. the $\delta^{15}N$ values of residual reactant ($\text{NO}_3^-$) and cumulative product ($\text{N}_2$) resulting from denitrification; calculated using the Rayleigh equation for fractionation factors (β) of 1.005, 1.010, and 1.020. The higher the β value, the higher the $\delta^{15}N$ of the NO$_3^-$ and the lower the $\delta^{15}N$ of the N$_2$. 
Figure 16.3. The conversion of NH₄ to NO₃ and changes in their δ¹⁵N values resulting from application of anhydrous NH₄ fertilizer to an agricultural field, volatilization of ammonia, and nitrification of the ammonium. Modified from Feigin et. al (1974).

Figure 16.4. Summary of the range of δ¹⁵N values for the major sources of nitrogen in the hydrosphere. The labels on the x-axis are for the high-end of the range plotted within the cell. Precipitation data from: Hoering (1957), Moore (1977), Heaton (1986, 1987), Freyer (1978, 1991), Garten (1992, 1995), Paerl and Fogel (1994), Heaton et al. (1997), and the other sources listed in caption of Figure 16.8. Soil nitrate data from the compilation of Fogg et al. (1998) from the following sources: Brenner and Tabatabai (1973), Kreitler (1975, 1979), Rennie et al. (1976), Black and Waring (1977), Shearer et al. (1978), Gormly and Spalding (1979), and Wolterink et al. (1979). Fertilizer data are from: Kohl et al. (1971), Aly et al. (1981), Shearer et al. (1974b), and Rennie et al. (1976).
Figure 16.5. Schematic cross-section through an agricultural catchment in the Delmarva Peninsula, Maryland (USA) showing the increase in age of waters (solid lines, based on CFC data) and decrease in nitrate concentration with depth (shaded zones). Flowlines (dashed) to stream A are more shallow than the flowlines to stream B, intersect the riparian zone, and many flowlines are within the anoxic bedrock unit; hence, enhanced denitrification along the flowlines contributing to stream A results in lower nitrate concentrations and higher δ¹⁵N values than in stream B. Modified from Böhlke and Denver (1995).
Figure 16.6. Compilation of nitrate $\delta^{18}O$ and $\delta^{15}N$ data from the following sources: Amberger and Schmidt (1987), Voerkelius (1990), Böttcher et al. (1990), Aravena et al. (1993), Durka et al. (1994), Wassenaar (1995), Kendall et al. (1995b), Bing et al. (1996), Böhke et al. (1997), Aravena and Robertson (1998), Kendall et al. (in review), Bollwerk et al., (in preparation), unpublished data from S. Schiff (per. comm., 1998), unpublished data B. Mayer (pers. comm., 1998), and unpublished U.S. Geological Survey data. A colored version of this and other plots in this chapter are located at URL http://wwwrcamnl.wr.usgs.gov/isoig/ISOPubs/.

Figure 16.7. The $\delta^{18}O$ of nitrate in precipitation samples (rain, throughfall, snow, and snowmelt) collected over various time intervals. Separate histograms show all available nitrate-$\delta^{18}O$ data, and just data from sites in North America. North American data were compiled from: Kendall et al. (1996), Kendall et al. (in review), unpublished data from S. Schiff (pers. comm., 1998), and unpublished USGS data from collaborations with J. Sueker, M. Williams, L. Pardo, and J. Sickman. German data were compiled from: Voerkelius (1990), Durka et al. (1994), and unpublished data from B. Mayer (pers. comm., 1998). The labels on the x-axis are for the high-end of the range plotted within the cell.
Figure 16.9. Schematic of typical ranges of $\delta^{18}$O and $\delta^{15}$N values of nitrate from various sources, simplified from data presented in Figure 16.6. Nitrification of ammonium and/or organic-N in fertilizer, precipitation, and organic waste can produce a large range of $\delta$ values, as shown. Soil waters tend to have higher NO$_3$-$\delta^{18}$O values, and a larger range of NO$_3$-$\delta^{15}$N values, than groundwaters because of the higher $\delta^{18}$O values of O$_2$ and/or H$_2$O in soils.

Figure 16.10. (a) Theoretical evolution of the $\delta^{15}$N and the nitrate-N concentration during mixing (solid line) of two waters X and Y, and during an isotope fractionating process (e.g., denitrification of water X with a NO$_3$ concentration of 10 ppm). Denitrification for $\varepsilon = -4.1\%$ results in a curve (dashed line) that ends at Y, one of the mixing endmembers. Two different enrichment factors are compared: $\varepsilon = -4.1\%$ and $\varepsilon = -8.1\%$. The data points represent successive 0.1 increments of mixing or denitrification progress. (b) Plotting the natural log of NO$_3$ concentration for a fractionation process yields a straight line. Modified from Mariotti et al. (1988).
Figure 16.11. $\delta^{15}\text{N}$ values and gas contents of dissolved air in oxic and suboxic waters. Data for oxic waters are consistent with atmospheric equilibration at 9 ± 3 °C, and data for suboxic waters indicate the presence of excess N$_2$ in concentrations up to 135µM, which is equivalent to 270 µM of reduced NO$_3$ (a). $\delta^{15}\text{N}$ values for oxic waters are consistent with equilibration at 9±3°C, and values for suboxic waters indicate that the excess N$_2$ has a $\delta^{15}\text{N}$ value between 2 and 5‰ (b). Modified from Böhlke and Denver (1995).