TABLE 1.1 Abundances of the stable isotopes from terrestrial sources that have been used to trace ecological change

Element	Isotope	Abundance	Ratio measured	Reference standard
Hydrogen	^{1}H	99.984	$^{2}H/^{1}H$ (D/H)	VSMOW[a]
	^{2}H (D)[b]	0.0156		
Carbon	^{12}C	98.982	$^{13}C/^{12}C$	PDB[c]
	^{13}C	1.108		
Nitrogen	^{14}N	99.630	$^{15}N/^{14}N$	N_2-atm[d]
	^{15}N	0.366		
Oxygen	^{16}O	99.763	$^{18}O/^{16}O$	VSMOW, PDB[e]
	^{17}O	0.0375	$^{18}O/^{17}O$[f]	VSMOW
	^{18}O	0.1995		
Sulfur	^{32}S	95.02	$^{34}S/^{32}S$	CDT[g]
	^{33}S	0.756		
	^{34}S	4.210		
	^{36}S	0.014		
Strontium	^{84}Sr	0.560	$^{87}Sr/^{86}Sr$	NBS-987[h]
	^{86}Sr	9.860		
	^{87}Sr	7.020		
	^{88}Sr	82.56		

[a] The original standard SMOW or standard mean ocean water is no longer available so the International Atomic Energy Agency (IAEA) (http://www.iaea.org/) "builds" an equivalent water sample in Vienna of a similar isotope value now known as VSMOW.
[b] The correct notation for the heavy isotope of hydrogen is ^{2}H though a commonly convention used is "D" standing for the hydrogen isotope with mass 2 called "deuterium."
[c] The original carbon isotope standard, the fossil belemnite from the PeeDee geological formation is no longer available and instead the IAEA "builds" an equivalent carbon standard in Vienna of a similar isotope value (VPDB) though for carbon isotope analyses it is still referred to as PDB.
[d] The IAEA standard is N_2 gas in the atmosphere because N_2 comprises ~78% of the Earth's atmosphere and there is no known additional source of N_2 of significance to dilute this atmospheric source, it is assumed that N_2-atm is not changing enough to warrant developing a different standard.
[e] In the case where investigators desire to know the $\delta^{13}C$ of a carbonate, the standard VPDB is used instead of VSMOW.
[f] The ^{17}O composition of air or water is also referenced to VSMOW; see Chapter 8 for further discussion.
[g] Sulfur isotope values are expressed relative to the FeS in a meteoritic troilite from Meteor Crater in Arizona (US) known as the Cañon Diablo Troilite or CDT.
[h] A widely used standard for strontium isotope analyses is the National Bureau of Standards No. 987 (now called the National Institute of Standards and Technology, NIST; http://www.nist.gov/), a carbonate power. $^{87}Sr/^{86}Sr$ and $^{86}Sr/^{88}Sr$ ratios are determined with a TIMS and unlike the other light isotopes the ratio measured is not expressed as the rare-to-abundant ratio (or heavy-to-light ratio) but as the ratio of the two isotopes that are most easily measured, $^{87}Sr/^{86}Sr$. A common practice is to normalize $^{87}Sr/^{86}Sr$ values with the $^{86}Sr/^{88}Sr$ (a light-to-heavy ratio of 0.1194) present in seawater because of fractionations that occur during thermal ionization; Chapters 21 provides further discussion of this.

By definition, the accepted standard (STD) has a δ value of 0‰. Therefore, any substance with a positive δ value has a ratio of the heavy to light isotope, R_{SA}, that is higher than the standard, R_{STD}. By analogy, a negative δ value has the opposite meaning. Substances with positive δ values are often said to be "heavier" or "enriched" relative to the standard, although this convention can often lead to confusion or errors if not expressed carefully [*e.g.*, heavier or lighter relative to what?—Sharp (2007) provides a more detailed discussion of this issue and the various errors commonly made when using δ notation or expressing isotope language]. As such, a sample of water with a $\delta^{2}H$ of −55‰ means that the ratio of $^{2}H/H$ is 55 per mil or 5.5% lower than that in the standard, V-SMOW. In the case of Sr, expressions of isotope abundance and change are shown as the absolute ratio of $^{87}Sr/^{86}Sr$ (not δ notation); these numbers range in value from a low of near 0.700 to highs near 1.200 (Table 1.1). Differences on the order of a few thousandths can be significant and this will be discussed further in Section IV.D (Chapter 23).