Photo by Tony Downs, Imago

# Nutrient Export from the Land

by Matt Hagny

SCIENCE

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Farmers and ranchers generally think of production in terms of pounds or bushels to be sold, derived from a specified land area. Very few think of it as nutrient export from the land: to put it more bluntly, the 'mining' of the soil's nutrient resources.

## Plant & Animal Nutrition

Because of the deep kinship of multi-cellular life, both plants and animals use certain elements as building blocks for the organism: hydrogen, (H), oxygen (O), carbon (C), nitrogen (N), phosphorus (P), sulfur (S), potassium (K), calcium (Ca), magnesium (Mg), chlorine (Cl), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B), nickel (Ni), and silicon (Si). A few additional elements, such as sodium (Na), selenium (Se), iodine (I), fluorine (F), tin (Sn), vanadium (V), chromium (Cr), and cobalt (Co) are essential for animals but do not appear to be essential for plants, even though plants readily take up these minerals and certain plant species grow more vigorously in the presence of some of these elements.[1]

**Secondary and micronutrient deficits will continue to worsen with each harvest until something is done to correct them.**

Photo by Matt Hagny.

Severely sulfur-deficient no-till wheat in central Kansas. Many other nutrient deficits can also cause crops to be paler than a healthy crop would be, although sometimes the color differences are subtle and easily overlooked. Nutritional deficits are more likely in no-till due to increasing soil organic matter sequestering nutrients, increased cropping intensity, and cooler & wetter soils during some parts of the growing season.

Apart from radioactive decay (which proceeds extremely slowly anyway), elements do not convert from one to another at the pressures and temperatures found on Earth. While hydrogen, oxygen, carbon, and (for some organisms) N and S are available from the atmosphere, all land-dwelling organisms must obtain the other essential elements from the soil, directly or indirectly. The terrestrial distribution of these elements is non-uniform, finite, and the availability (in forms suitable for uptake) often imposes substantial constraints on the viability and robustness of organisms in many environments, as well as their reproductive success.

Bio-available forms of the essential elements tend to be conserved ('recycled') in ecosystems. This was likely an adaptation. Plants assimilated elements from the soil, and eventually the plant biomass was consumed by other

[1] N.C. Brady & R.R. Weil, 2002, *The Nature and Properties of Soils*, 13th ed., Prentice Hall; A.V. Barker & D.J. Pilbeam, 2007, Introduction, in *Handbook of Plant Nutrition*, ed. A.V. Barker & D.J. Pilbeam, CRC Press: Taylor & Francis; W.F. Bennett, 1993, Plant Nutrient Utilization and Diagnostic Plant Symptoms, in *Nutrient Deficiencies & Toxicities In Crop Plants*, ed. W.F. Bennett, Am. Phytopath. Soc. (St. Paul, MN). See generally: various authors, 2005, Essential trace elements for plants, animals, and humans, in Proceedings of NJF Seminar No. 370, Reykjavik, Iceland (15-17 Aug. 2005), Nordic Assoc. Agric. Scientists. See also F.C. Nielsen, 2000, Evolutionary events culminating in specific minerals becoming essential for life, *Eur. J. Nutr.* 39: 62-66. (Vanadium may be necessary for some plant species, but its essentiality for the entire plant kingdom hasn't been adequately proven. A number of other elements are tentatively included in the list as essential for animals, but studies have been few and/or the issue lurks as to whether they are essential for only a few species or broadly across the animal kingdom; these include lead, arsenic, aluminum, bromine, lithium, germanium, rubidium, tungsten, and strontium. Lead and arsenic are often thought of as toxins due to the high exposure resulting from some industrial processes and consumer products, but these elements are essential in trace amounts. These lists of essential elements for plants [and animals and fungi] are likely incomplete: "[With improved technology] it is quite likely that additional elements will be shown to have irreplaceable functions in discrete biochemical processes that are important for plant life." —P.H. Brown, 2007, 'Nickel,' in *Handbook of Plant Nutrition*, ed. A.V. Barker & D.J. Pilbeam, CRC Press: Taylor & Francis.)