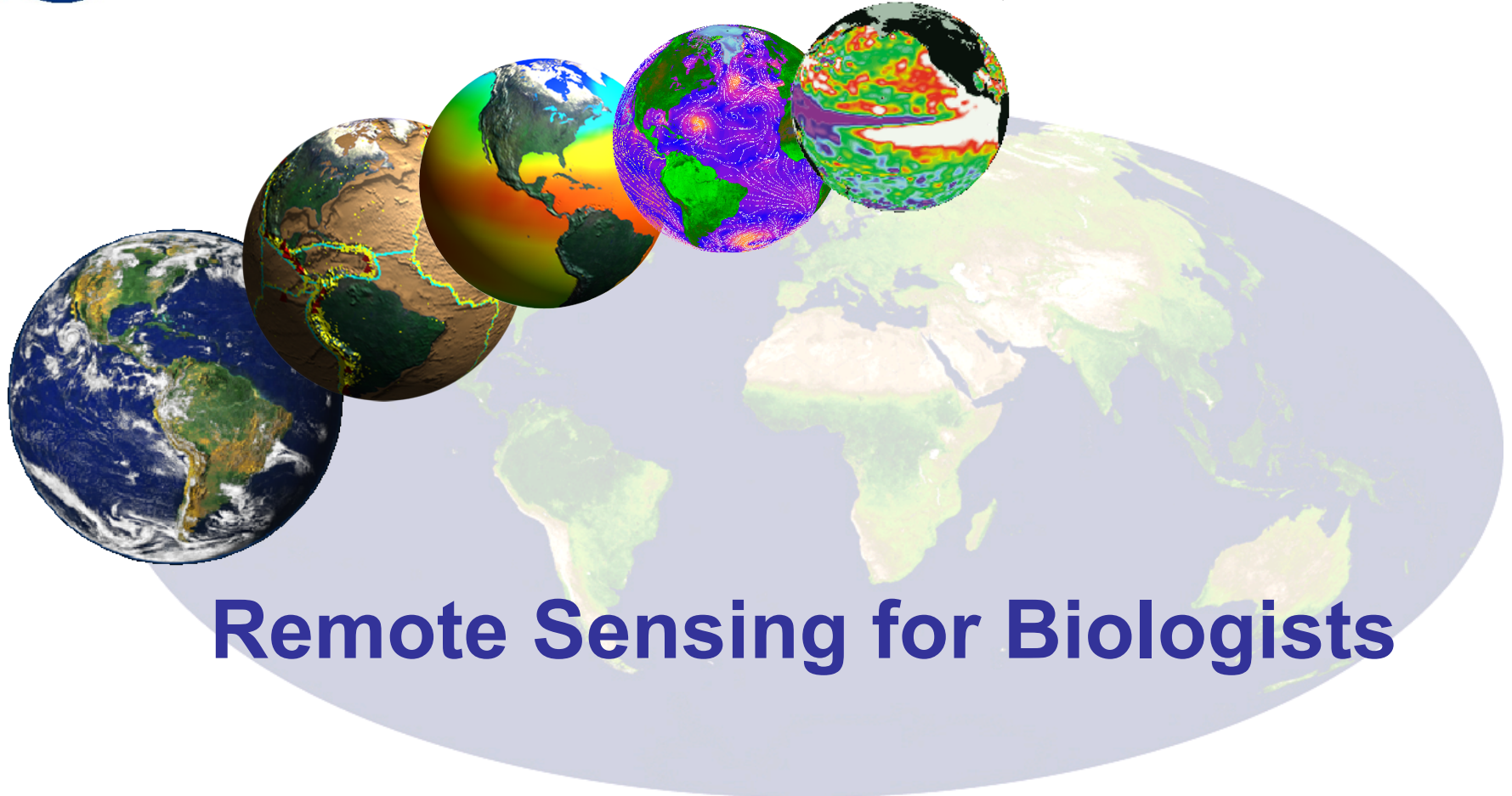




**2016 Biodiversity and Ecological Forecasting Team Meeting
Silver Spring, MD**



Remote Sensing for Biologists

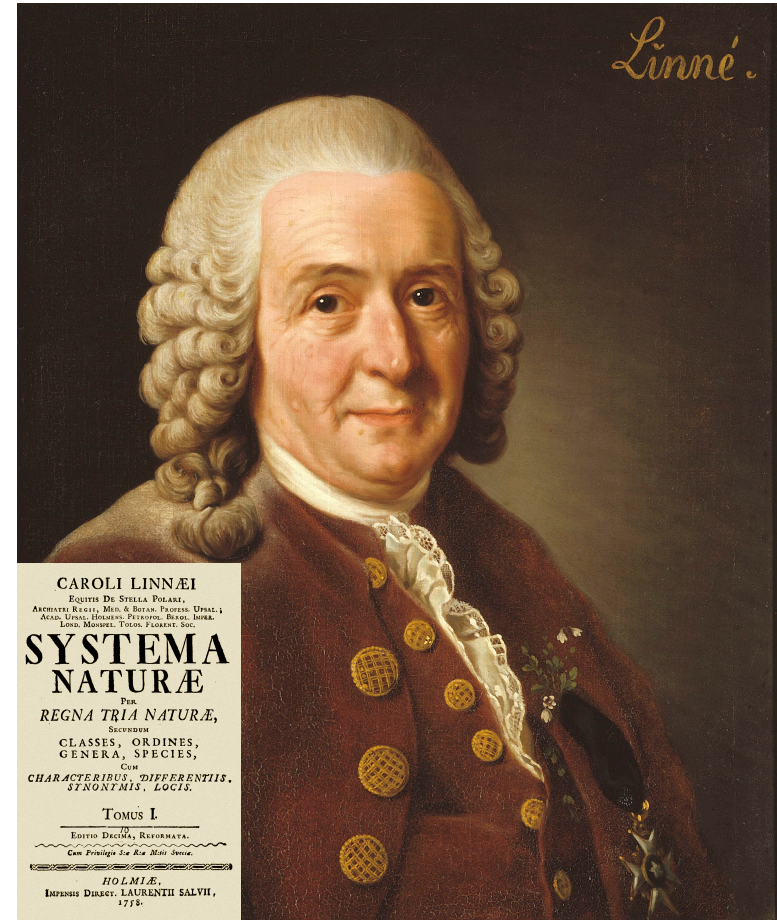
**Woody Turner
Earth Science Division
NASA Headquarters**

May 5, 2016

The Poetry of Science

All biological knowledge begins with names and classification. There is magic in the Linnaean double name....It conjures up what we personally know or think we know. The double name forms the basis of a hierarchy suited to the way the human mind actually works. In repeating it over and over, listening to the sound of it and sensing the unknown, it is the poetry of science.

E.O. Wilson p. 158 *Half-Earth* 2016

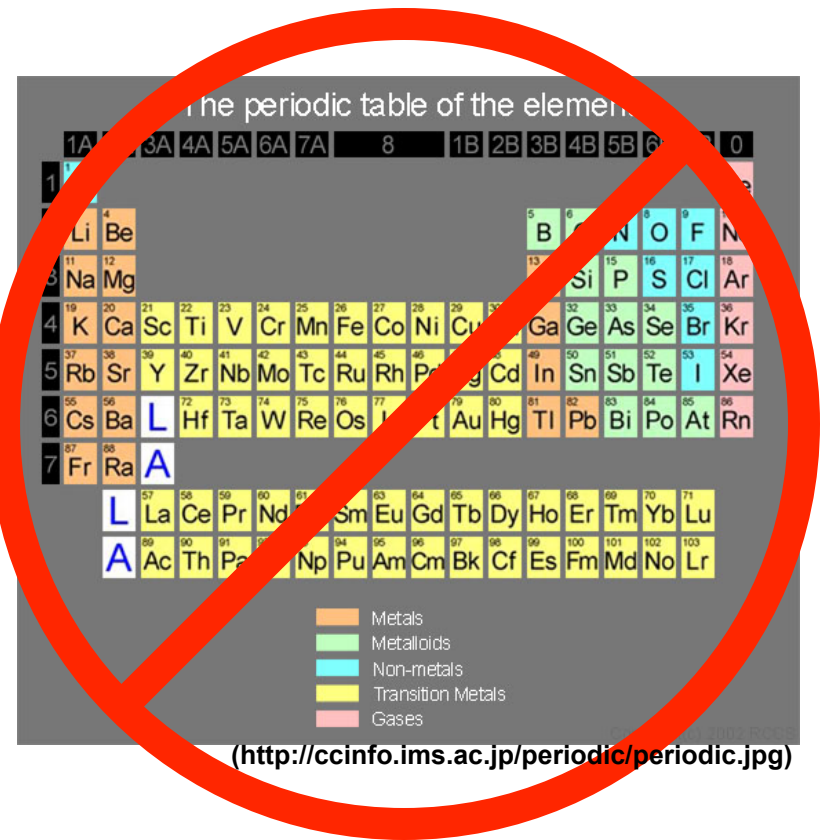


Carl Linnaeus and cover *Systema Naturae*
(Images Source: Wikipedia)

Ecology's Shortfall as Science

The data needed to advance studies of the structure and function of ecosystems do not in most cases exist....Let me put this matter of ecology's shortfall as science another way. Every scientific discipline must go through a natural history period before it can be synthesized into something resembling mature theory. The scientific natural history lacking in most domains of ecology is the identity and biology of the species that compose biodiversity. At least two-thirds of the species on Earth remain unknown and unnamed....It follows that most of the necessary work on ecosystems immediately ahead lies in the study of biodiversity at the level of species. The exploration of biodiversity starts, as it always has, with taxonomy.

E.O. Wilson pp. 103-104 *Half-Earth* 2016

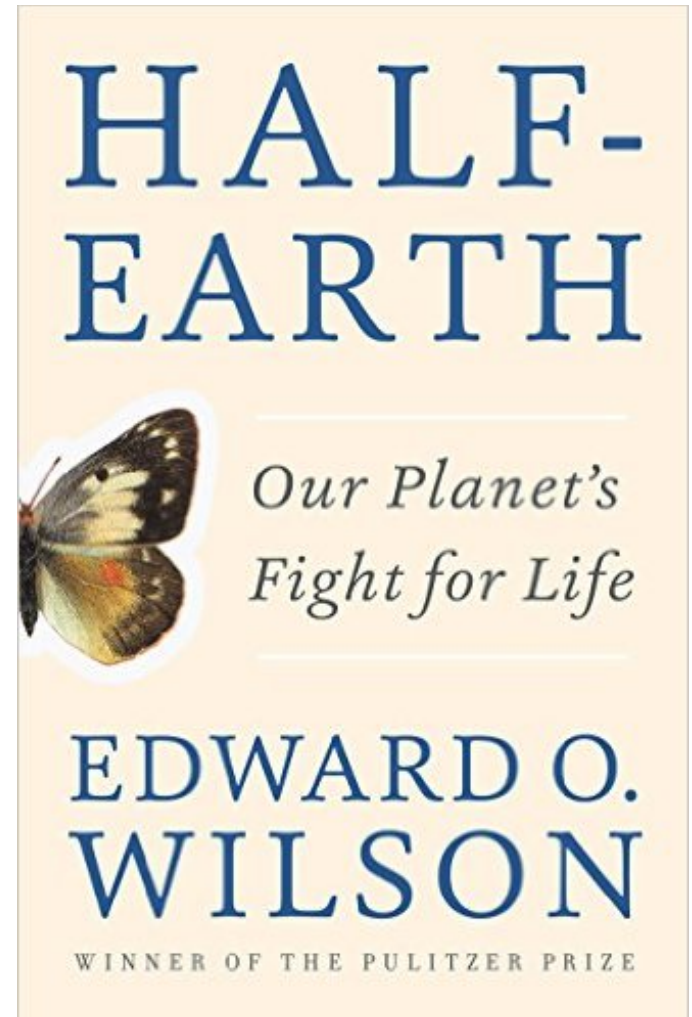


**Still A Long Way to Go in Finalizing
Biology's Periodic Table**

A Challenge

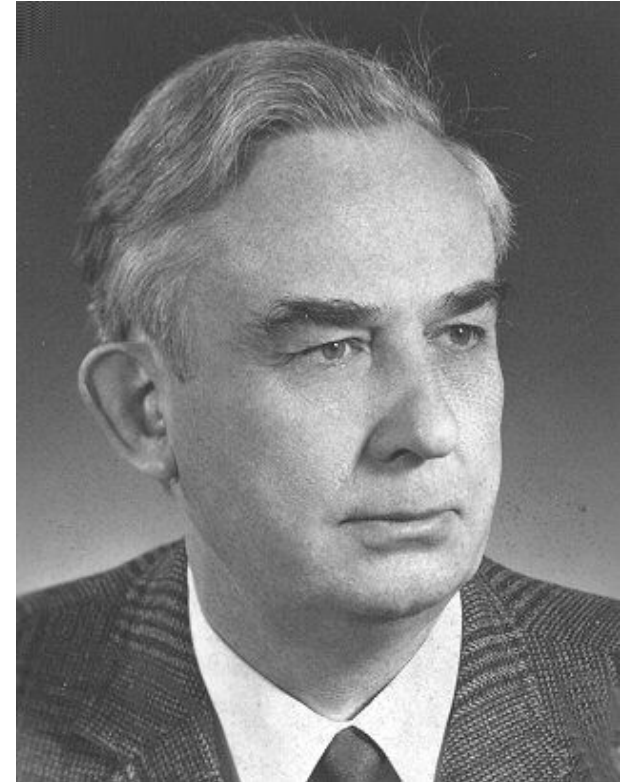
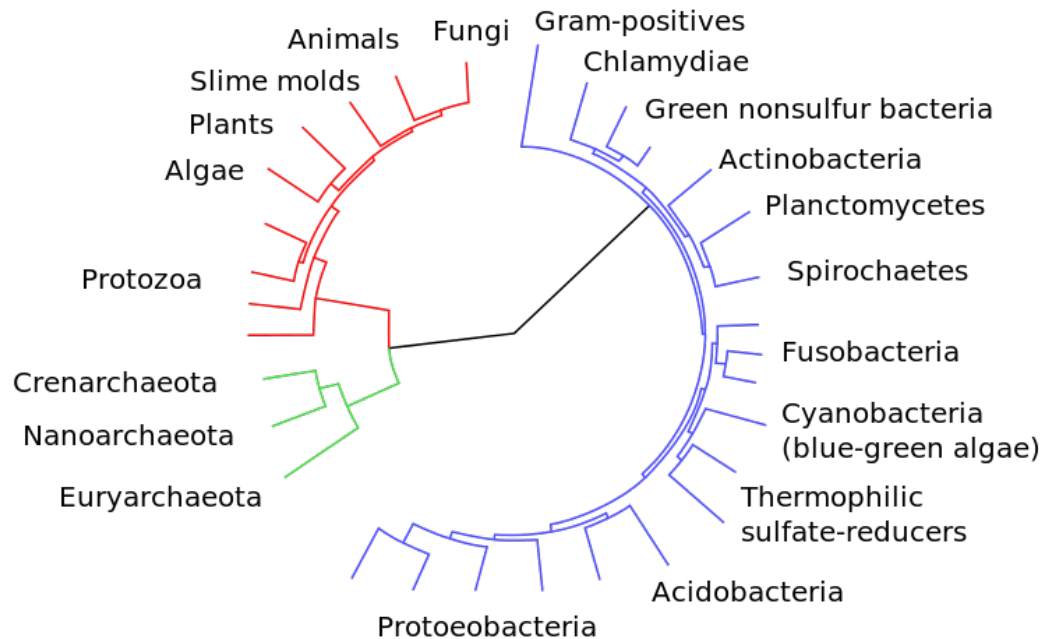
To those who believe they can fathom the working of ecosystems with mathematical models of a handful of species, I say you live in a dream world. And to those who believe that a damaged ecosystem will heal itself or can be safely restored by replacing original native species with functional alien equivalents, I say think again before you cause damage. Just as successful medicine depends upon a knowledge of anatomy and physiology, conservation science depends upon a knowledge of taxonomy and natural history.

E.O. Wilson p.111 *Half-Earth* 2016



(Image Source: Amazon.com)₄

Phylogeny: Taxonomy + Evolutionary History



Willi Hennig: Father of Cladistics or Phylogenetic Systematics

The Language We Need to Speak

In practicing remote sensing, we cannot redefine biological classification along lines more suitable to us—or to the climate and biogeochemical cycling modeling communities—and expect the vast majority of biologists and ecologists to follow along. We must speak the language of the community observing the variations we seek to measure. In doing so, we need to align our tools and products with accepted systems of biological classification to make progress in biodiversity understanding and conservation—if we want to understand biodiversity change.

Spectroscopy Is Leading the Way



remote sensing



Article

Associations of Leaf Spectra with Genetic and Phylogenetic Variation in Oaks: Prospects for Remote Detection of Biodiversity

Jeannine Cavender-Bares ^{1,*}, Jose Eduardo Meireles ^{1,*}, John J. Couture ², Matthew A. Kaproth ¹, Clayton C. Kingdon ², Aditya Singh ², Shawn P. Serbin ^{2,3}, Alyson Center ^{1,4}, Esau Zuniga ⁵, George Pilz ⁵ and Philip A. Townsend ²

(*Remote Sens.* 2016, 8, 221; doi:10.3390/rs8030221)

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Imaging spectroscopy links aspen genotype with below-ground processes at landscape scales

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²Department of Forest and Wildlife Ecology, and ³Department of Entomology, University of Wisconsin, Madison, WI 53706, USA

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Research



CrossMark

(*Phil. Trans. R. Soc. B* 369: 20130194. <http://dx.doi.org/10.1098/rstb.2013.0194>)

A Symphony of Observations to Capture Nature's Chorus

Global-regional coverage



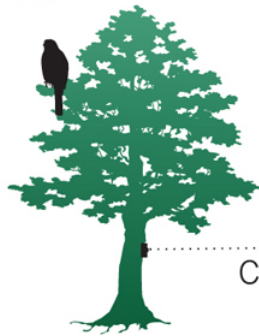
Regional-local coverage



Citizen scientist with cell phone



Drone



Camera trap



Sound recorder

Wildlife officer with receiving antenna



Transmitting collar



Collecting environmental DNA

(*Science* 346:301-302, 10/17/14)

Issues

- We must define what we want to measure and why.
- If it's biodiversity, we have new spectroscopic tools that allow us to detect elements of biodiversity (spectral expressions of phenotypes and genotypes) that align with approaches to biological systematics.
- Our ability to capture these taxonomic/phylogenetic observations and the taxonomic/phylogenetic levels at which we can capture them will vary based on the observational tools available and the ecosystems, species, and genes observed.
- Canopy structure will obscure leaf-level variation. We need to observe structure as well as spectra.
- Environmental and phenological variation will challenge us. There will always likely be a need for contextual environmental data to refine the spectroscopic and structural observations.
- Does evolutionary convergence in structure for a particular function lead to convergence in the optical spectra or does deeper evolutionary history predominate in spectral signatures enabling discrimination?
- We must try. It will not always be pretty and our accuracies may be low at times—but we will get better and better.

Thank You