Keys to Lichens of North America, Revised and Expanded. Irwin M. Brodo (photographs by Sylvia Duran Sharnoff and Stephen Sharnoff; drawings by Susan Laurie-Bourque). 2016. Yale University Press, New Haven, Connecticut, USA. 424 pages. $29.95 (paper). ISBN: 9780300195736.

It would be hard to overestimate the importance of the 2001 publication of *Lichens of North America* (hereafter *LNA*) by Irwin Brodo, Silvia Duran Sharnoff, and Stephen Sharnoff (Brodo et al. 2001). Beautifully illustrated, *LNA* included both an excellent overview to lichenology—including such diverse topics as chemistry, ecology, ethnolichenology, and specimen preparation—and descriptions of more than 800 of the common and charismatic lichens of North America. It is the rare book that provides a good introduction to the discipline, while serving as an essential tool for lichenologists. *LNA* is frequently cited in journals as an authoritative source on spot tests (a ch emical spot analysis used to help identify lichens) and biogeography, among other subjects, and remains a go-to reference on many species in the North American lichen flora. By putting lichenology within the reach of the average enthusiast, *LNA* spurred interest among amateurs (this writer included) and created a lichenological renaissance in North America. The *Keys to Lichens of North America*, *Revised and Expanded* (hereafter *Keys*) by Irwin Brodo significantly expands on the taxonomic scope of the original work, with taxonomic keys to 2,028 species in 382 genera, more than double the number of species included in *LNA*. Together, *LNA* and the *Keys* stand as the only generally accessible resources for lichen identification covering the whole of North America. And, as with *LNA*, the new publication will be an essential part of any lichenologist's library, but it also will appeal to the generalist seeking to learn more about identifying these elegant, ecologically important, but often overlooked organisms.

The *Keys* is designed to be a companion to *LNA*. Species treated in full in *LNA* (many with excellent illustrations) are printed in boldface type in the *Keys*, and the beginning user is well advised to purchase copies of both works. The taxonomic keys themselves in the *Keys* are divided into an initial key to major lichen groups, most of which lead to a series of genus-level taxonomic keys to species. The taxonomic keys are easy to follow as paired couplets, and the leads of a couplet appear to be simplified as much as possible, often referring to readily observed characters, substrate, or distributional differences. As might be expected, the *Keys* requires a rudimentary knowledge of lichenological concepts and terminology. However, the author limits use of unfamiliar terms and provides a short, illustrated glossary (with most images reprinted from *LNA*). New users will find that lichenology requires a slightly different set of tools than vascular plant identification. However, many species can be determined with a stereoscope or a compound microscope, a small set of reagents for performing spot tests, and a UV light. Distinguishing with certainty among species within some complexes (e.g., some conspicuous species of *Cladonia*) still requires thin-layer chromatography, but it is a rare occurrence in the *Keys* to find reference to substances that cannot be diagnosed with a spot test.

In addition to expanding the coverage, including thoroughly revising and adding taxa to treatments for species-rich groups (e.g., *Acarospora* and *Lepraria*), the author has adopted many recent nomenclatural changes. In cases in which he opted not to take up new names for old friends (e.g., in *Caloplaca*), Brodo provides these names as synonyms. And, for users trying to track down familiar species under a new name, he provides a complete index. The author cites these synonyms throughout the *Keys*, and provides the occasional note on species circumscriptions. In some cases, generic realignments have led to a bewildering array of morphologically similar genera, which must necessarily be treated together. This occasionally makes it hard to know where you are in the book. For instance, the key to *Melanelia* now includes species referred to seven different genera, and only a few species are still included in *Melanelia*. One can sympathize with the problems this nomenclatural soup creates for authors interested in constructing morphology-based taxonomic keys. However, running headers with the name of the key would be helpful here, as these sorts of problems will only increase with future editions due to the ongoing revolution in molecular systematics.

This work covers less than half of North America's known lichens, so the author has carefully selected the "common or conspicuous species" in the flora. Because of this, some keys that cover larger genera must be used with caution. For instance, the key to *Opegrapha* includes nine of the 32 known North American species, and the key to *Arthonia* (including *Arthothelium*) treats 20 of the 123 lichenized species (and none of the 42 non-lichenized, lichenicolous or saprophytic species). For readers seeking more complete treatments, Brodo provides citations of relevant literature for some groups. If these citations seem somewhat spotty, it is only because most North American lichen genera lack modern monographs. In general, it seems intuitive that one can feel pretty good about determinations made using the *Keys* for small or mid-sized genera but perhaps less confident for very large genera. For the user who may not know the expected diversity within a given genus, having access to a copy of *LNA* helps a bit here, as the generic treatments in that work included estimates of the number of North American species. Unfortunately, an updated estimate of the number of species in each genus is not included in the *Keys*.

Some observations about the current state of lichenology arise from reading the *Keys to Lichens of North America*. One is that the science of lichenology has undergone a dramatic transformation since the publication of *LNA* a mere 15 years ago. Many generic circumscriptions taken up in the *Keys* are new and based on surprising discoveries facilitated by mo-

lecular phylogenetics. While it tends to make for a dizzying taxonomic array, the inclusion of species in as many as eight different genera in one taxonomic key demonstrates what an exciting and dynamic science lichenology has become today—in many cases, those segregates were still considered congeneric when *LNA* was published in 2001. Despite this activity and these recent discoveries, it also is clear from the *Keys* how many lichen groups remain poorly known in North America. The paucity of cited monographs is in part a testament to the fact that much remains to be done. It is encouraging, therefore, that many of the nomenclatural combinations in the *Keys* have been published by living taxonomists, because even some of our most well-known elements lack names—for instance, the common species that North American lichenologists have long called "*Lecania perproxima.*" That this and other taxonomic problems may one day be resolved is in no small part due to the lasting contributions that Brodo has made to North American lichenology with *LNA* and *Keys*.—*Caleb A. Morse, Collection Manager, R. L. McGregor Herbarium, Biodiversity Institute, University of Kansas, 2045 Constant Avenue, Lawrence, Kansas 66047, USA.*

LITERATURE CITED

Brodo, I. M., S. D. Sharnoff, and S. Sharnoff. 2001. Lichens of North America. Yale University Press, New Haven, Connecticut, USA.