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User Guide for the National Forest Inventory and Analysis Lichen Database (Version 1.0)

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Cover: Lichen photo (brown-eyed wolf lichen, *Letharia columbiana*) by Jason Hollinger; all other photos by USDA Forest Service.

Abstract

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Scientists and natural resource managers use bioindicators for overcoming the limitations of instrument-based monitoring networks. Low sampling costs make lichen bioindicators an invaluable tool for detecting finer scaled patterns in air quality than can be detected using instruments. Between 1989 and 2012, three Forest Service programs collected more than 8,300 surveys of epiphytic lichen communities, creating one of the largest systematically sampled lichen datasets in the world. More than 90 studies use these data as a baseline for tracking air quality, climate, and other changes on forest land in the United States. The national Forest Inventory and Analysis (FIA) lichen database (beta) unites, for the first time, all lichen surveys into one set of consistent, linkable tables. We include data for a third of the 5,483 surveys conducted by the national forest inventory programs (Forest Health Monitoring and FIA that are not publically available elsewhere). We also include an additional 2,958 regional surveys collected by the Forest Service's Air Resources Management program in Alaska, Oregon, and Washington. Advances in lichen taxonomy over the 23 years covered by the database led to the description of many new species, name changes, and revisions of species concepts. We provide two reference tables to help users "reconcile" names to maintain continuity within datasets spanning different timespans. We also provide a comprehensive, user-friendly "Atlas" dataset with fully reconciled names according to taxonomic concepts used by the FIA program. We included the most commonly used environmental variables in bioindicator studies, which were gathered across various Forest Service databases and unpublished sources. This user guide documents the content of each database table and provides essential background information for building custom datasets, including linking with external databases that house additional data for lichen survey locations. Although the lichen data are most often used for air quality and climate biomonitoring projects, they are suitable for a wide range of ecological and taxonomic studies.

Keywords: Air pollution, air quality, Air Resource Management program, bioindicators, biomonitoring, climate change, Forest Health Monitoring program, Forest Inventory and Analysis program, lichen, user guide.

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Introduction

Lichens are symbiotic organisms, consisting of a fungus living with one or more photosynthetic partners (an alga, cyanobacterium, or both). The discovery of a third partner in some lichens, a yeast, suggests there is much about these unique symbiotic organisms that we do not yet understand (Spribille et al. 2016). Lichens are widely used as “canaries in the coalmine” for detecting air pollution and monitoring impacts, a practice dating back to 1866 (Nylander 1866). Lichens lack roots, deriving all nutrition and water from the atmosphere, making them especially vulnerable to air pollutants, changes in climate, and shifts in habitat conditions, which further affect light, microclimate, and nutrient availability.

In 1989, the U.S. Forest Service’s (USFS) Air Resource Management (ARM) program began systematically surveying epiphytic (i.e., tree-dwelling) lichen communities in southeast Alaska. The field protocol was adapted in 1992 for use in the national forest inventory by the agency’s Forest Health Monitoring (FHM) program, leading to the creation of the “Lichen Communities Indicator” and the start of large-scale lichen monitoring across the country (Stolte et al. 1993). Around this time, ARM expanded its own lichen surveying efforts to include National Forest System (NFS) lands across the lichen-rich states of Oregon and Washington.

By 2000, FHM had completed 2,311 lichen surveys before the Forest Inventory and Analysis (FIA) program took over national lichen monitoring. By 2012, FIA and ARM conducted another 3,061 and 2,970 surveys, respectively. Altogether, these 8,342 surveys collected by the USFS from more than 6,000 forest locations serve as an invaluable baseline of lichen community data for U.S. forests (figs. 1 and 2). Owing to shifting budgets, the number of repeat surveys per site (0 to 3) and time intervals between them vary. Major funding declines in 2012 prompted FIA to discontinue large-scale lichen sampling, and ARM to also scale back field operations. However, both programs now work closely with partners to revisit sites in areas of interest, as budgets allow.

More than 90 research and monitoring studies across the country use the USFS lichen data for many purposes (app. 1). Examples include developing lichen metrics for detecting nitrogen and sulfur air pollutants, detecting climate change, and establishing regional air quality and climate bioindication models for the Northeastern and Southeastern United States; the states of [southern] Alaska, California, and Colorado; and the northern Rocky Mountains, mid-Atlantic, and Pacific Northwest states. Studies based on the lichen data are increasingly used in policy development, such as in reviews of the national ambient air quality secondary standards for nitrogen and sulfur oxides (USEPA 2008, 2017) and development of pollutant critical loads (e.g., Pardo et al. 2011). The lichen data are commonly used as a tool

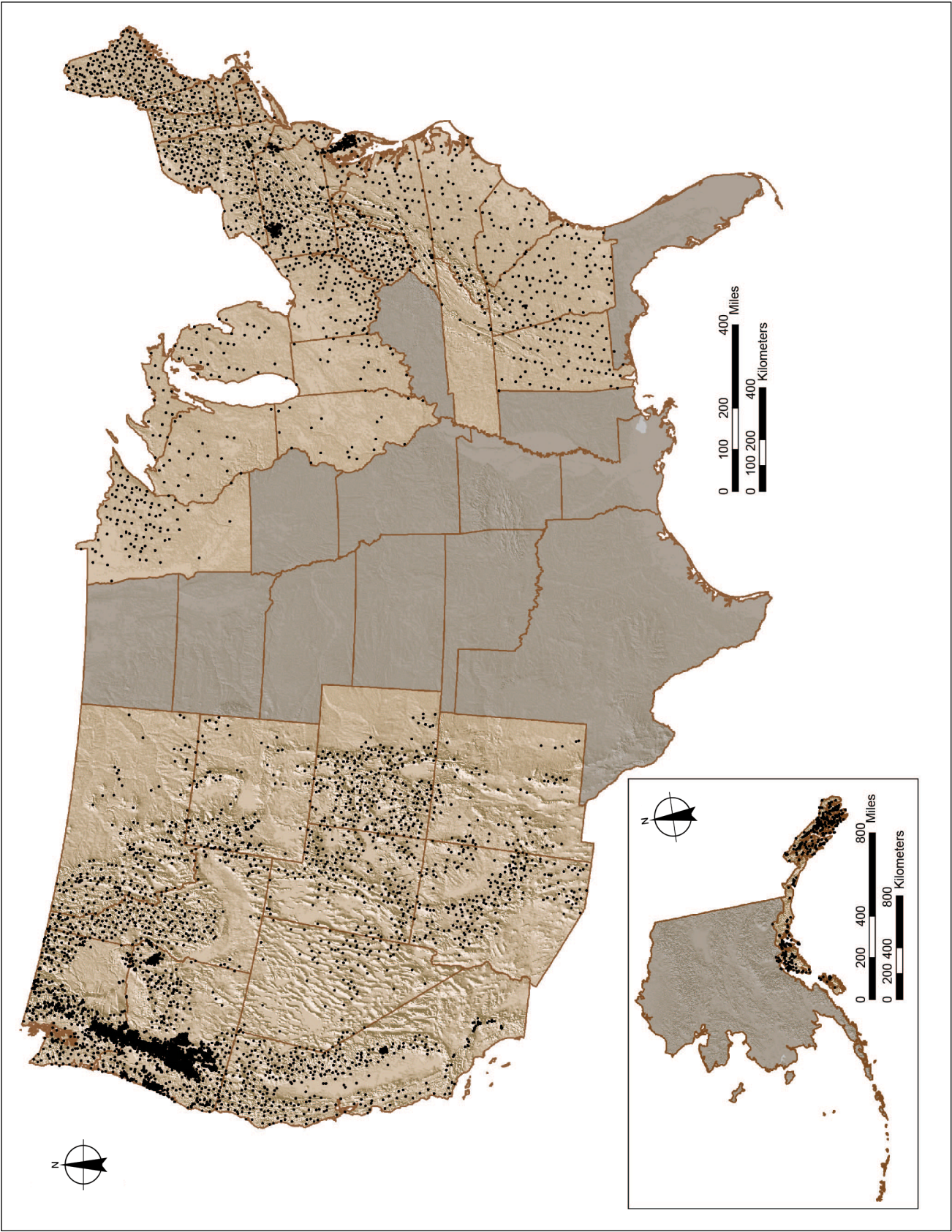


Figure 1—All sites surveyed for lichen communities by the Forest Health Monitoring, Forest Inventory and Analysis, and Air Resource Management programs through 2012.

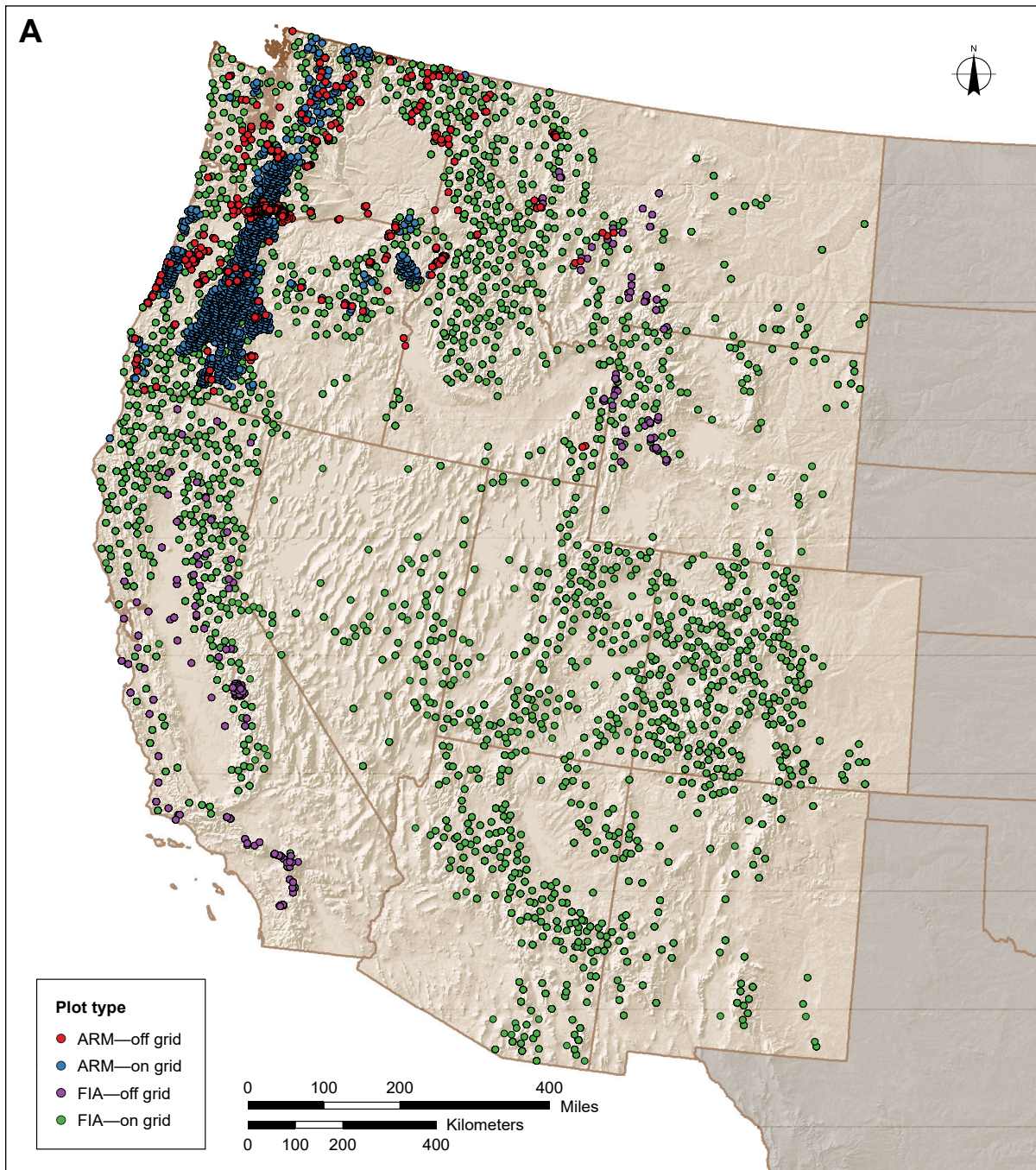


Figure 2—Lichen survey sites shown by geographic region: (A) the West, (B) Alaska, and (C) the East. Sites are coded by administering program and whether they are located on or off the Forest Inventory and Analysis (FIA) grid. FIA sites include historical surveys under the Forest Health Monitoring program. ARM = Air Resource Management.

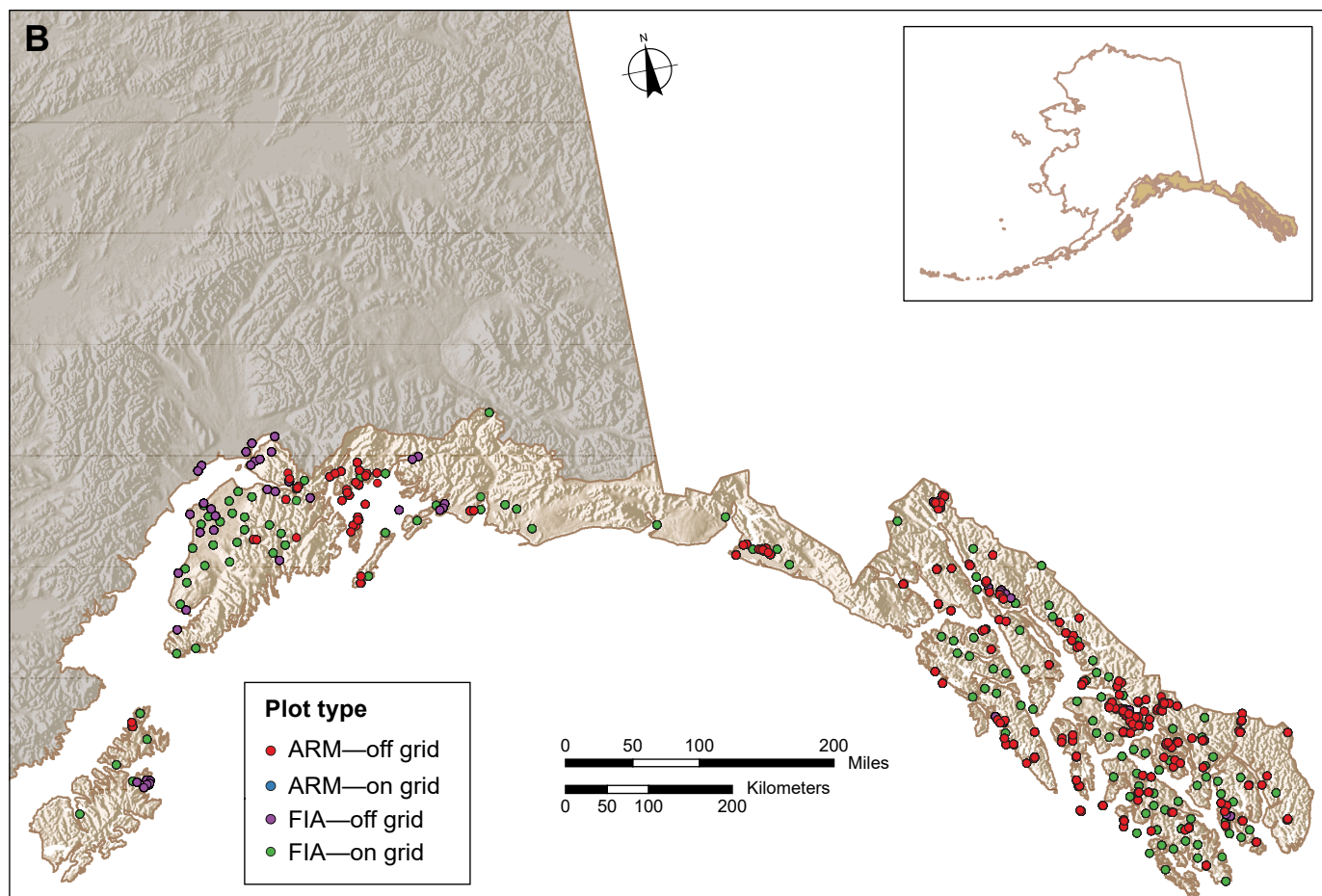


Figure 2—continued.

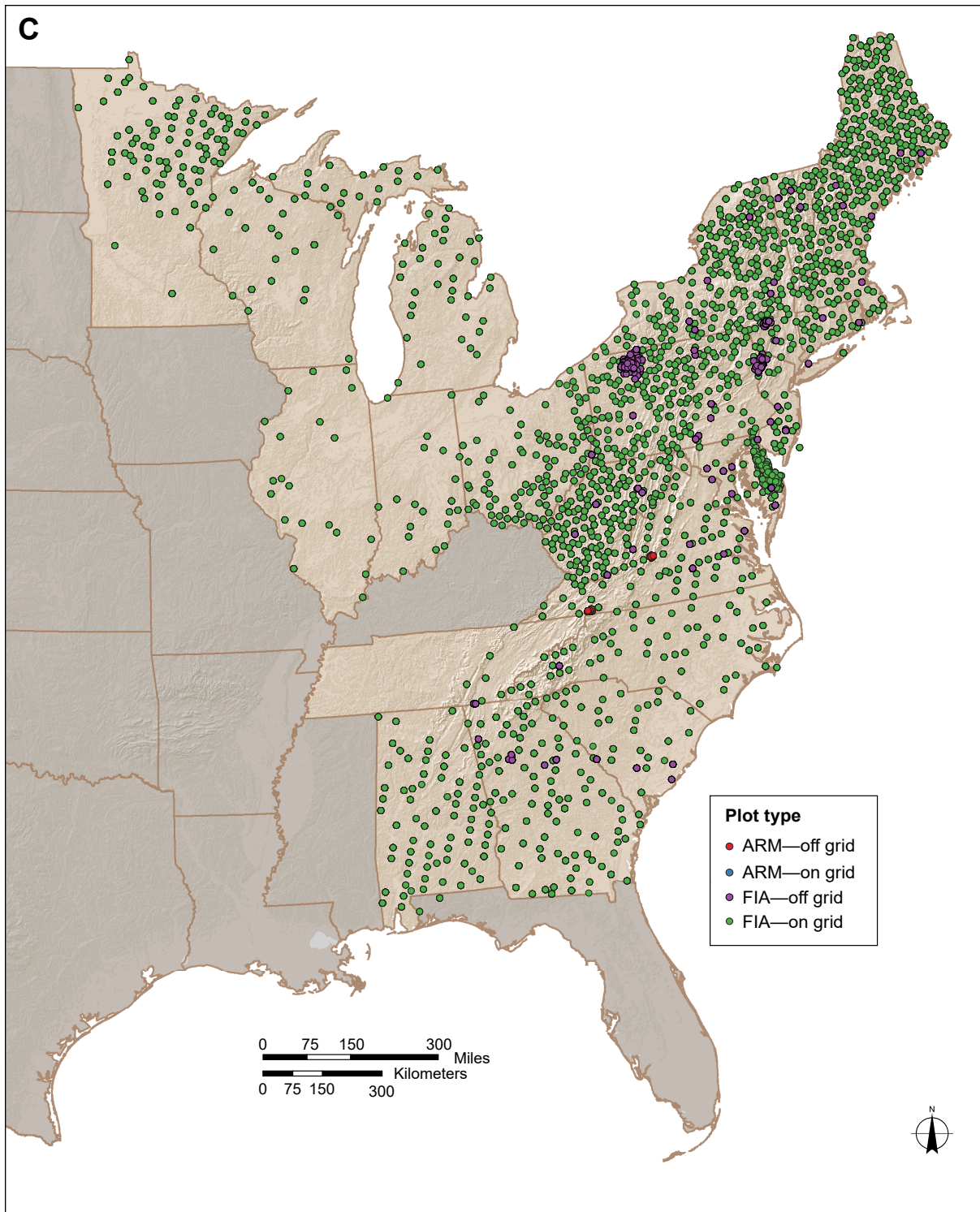


Figure 2—continued.

for meeting federal land monitoring mandates such as the Wilderness Stewardship Challenge¹ and the Climate Scorecard.²

Although air quality and climate have typically been the focus, the lichen data are suitable for a wide range of ecological studies. Our main goal in uniting the first 23 years' worth of data in the national FIA lichen database (NFLD) is to make it easier to access and use them in new ways. The core data tables of the NFLD compile all FHM and FIA lichen data, making much of the historical FHM data available to the public for the first time. The NFLD also has a specialty "Atlas" dataset compiling all lichen surveys collected through 2012 by all three parent programs (FHM, FIA, and ARM) into a consistent, user-friendly format; this dataset has been used to produce a companion volume to this user guide, the *National Atlas of Epiphytic Lichens in Forested Habitats of the United States* (hereafter, the Atlas) (Jovan et al. 2020), which displays the geographic distributions of more than 400 lichen taxa. The FIA and ARM programs have since collected additional lichen data as part of special projects. Users of the NFLD are encouraged to check in with both programs for availability of new data relevant to their studies. As the NFLD is in beta mode, users are also encouraged to report errors and provide feedback.³

Lichen Survey Method

The FHM/FIA survey protocol (app. 2), developed in collaboration with the U.S. Environmental Protection Agency's (EPA's) Environmental Monitoring and Assessment Program (Stolte et al. 1993), was designed to use nonexpert crews for fieldwork. The ARM survey method is similar and generates comparable data (see Geiser 2004). Professional lichenologists train and certify crews, identify lichens, conduct most of the field quality assurance (QA), and quality assure the resulting data (apps. 3 and 4). Crews are trained to observe diagnostic characteristics that differentiate species but are not required to know their names. Crews collect a voucher of each "species" they think is different, which is later identified by a lichen expert.

The surveys aim to capture all epiphytic macrolichen (i.e., foliose and fruticose) species present within a 0.94-ac circular area (see fig. 3 in app. 2). Alaska sites surveyed by ARM are smaller (0.12 ac), which does affect diversity studies when these plots are mixed with the standard full-size plots (Smith et al. 2017). Surveys are timed to last a minimum of 30 minutes and a maximum of 2 hours.

¹ <https://www.wilderness.net/NWPS/documents/FS/10YWSC%20Brochure.pdf>.

² <https://www.fs.fed.us/climatechange/advisor/scorecard.html>.

³ Please send comments and questions to Sarah Jovan (sarah.jovan@usda.gov), National Lichen Indicator Advisor.

The surveyor collects a voucher specimen of each species occurring above 1.5 ft on natural woody substrates or from recent litterfall and assigns a broad abundance code (table 1). Voucher specimens are sent to lichen experts for identification (app. 4) and ultimately are deposited in herbaria to be available for further study.

Table 1—Abundance codes assigned to each lichen species encountered during a survey

Code	Description
1	Rare (1 to 3 individuals)
2	Uncommon (4 to 10 individuals)
3	Common (>10 individuals but less than 50 percent of boles and branches have species present)
4	Abundant (species is present on >50 percent of boles and branches)

Crew expertise ranges widely from novice to professional lichenologist, except for all ARM surveys in Alaska, which are conducted by professional lichenologists. Field crews undergo an annual training and certification exam. McCune et al. (1997a, 1997b) found that crews must capture >65 percent of the species diversity found by experts in order to get repeatable results in ordination-based climate and air quality models, which are core research products generated from the USFS lichen data. The 65 percent criterion is used in both the certification exam and in field QA; if someone fails, he/she receives more training and evaluation through additional field QA checks. If multiple checks are failed, he/she abstains from further data collection but may attempt to recertify in future years. Depending on geographic region and program, 5 to 10 percent of lichen surveys are chosen for blind checks to ensure that the 65 percent diversity criterion is met (app. 3).

Specimens collected from across the United States by FHM/FIA and from Oregon and Washington by ARM reside at the Oregon State University Herbarium (OSC). Specimens collected by ARM from the Tongass National Forest before 2005 and Chugach National Forest before 2011 reside at the University of Alaska Fairbanks Herbarium. Specimens collected by ARM after these dates are at the University of Alaska Anchorage Herbarium.

Inventory Design

Although the parent lichen programs use a consistent survey method,⁴ there are some differences in sampling grids, lichen taxonomy, and availability of additional data for survey sites that may be relevant to some users' studies. The Atlas dataset in the NFLD accounts for many of these differences, applying a consistent taxonomic treatment across programs and time, and bringing together consistent environmental measurements from different databases. However, users may want to build their own datasets, which can be done with the NFLD. Datasets spanning shorter timeframes (the Atlas covers 23 years) would have greater taxonomic resolution (i.e., require less "lumping" of newer taxa; this is discussed more in "Taxonomy and Identification"). Likewise, using lichen surveys from only one parent program greatly increases the variety of environmental data available for the entirety of the dataset (see "Plot Sampling Grids" and "Other Plot Data").

Plot Sampling Grids

The FIA program collects detailed data on forest structure across the United States using a standardized sampling grid, formerly known as the "Phase 2 grid." The grid spans all land ownerships and has 1 plot per 6,000 ac in which plots are about 3.2 to 3.3 mi apart (Bechtold and Patterson 2005). Field crews visit all plots located on forest land, defined as having at least 10 percent tree canopy cover. Lichen surveys conducted under FIA and older surveys under FHM were typically done on 1 out of every 16 plots, equivalent to 1 plot per 96,000 ac (formerly, the "Phase 3 grid"), although plots were occasionally sampled elsewhere on the Phase 2 grid or off the grid entirely for special projects (fig. 2). A major benefit of analyzing lichen surveys on the FIA grid is that they provide a representative, statistically unbiased sample of lichen communities across the forested landscape. Unlike distribution maps created from herbaria collections, the absence of species at a particular survey site is also informative about the species' biogeography.

Most ARM surveys from Oregon and Washington are collected on Phase 2 plots that fall on NFS land. A separate sampling grid focusing on NFS land and wilderness areas is used by ARM in Alaska (Geiser et al. 1994). As part of special projects, ARM also surveys lichens at many off-grid locations that include a variety of land ownerships.

⁴ The exception being the smaller lichen search area used in Alaska because of difficult terrain.

Other Plot Data

Lichen surveys on the FIA grid can be linked to hundreds of other Phase 2 inventory measurements⁵ on trees, understory vegetation, soils, down woody debris, disturbance, and land ownership through the public FIA database (FIADB) posted to the FIA DataMart.⁶ FIA lichen surveys are themselves classified as Phase 3 measurements, linking to both Phase 2 measurements and an additional suite of “forest health” measurements collected only on the Phase 3 subset of plots (Woodall et al. 2010).⁷ Phase 2 and 3 measurements associated with older (2002 and prior) lichen surveys conducted by FHM and ARM are stored at FIA’s “Other Data” page.⁸ We included basic inventory measurements in the NFLD database that are most commonly used in lichen studies although most data from the older plot visits are not publicly accessible at this time. In these cases, the best option may be to use more recent Phase 2 or 3 measurements from the FIADB or contact the lichen indicator advisor for help. Parts of the lichen survey data included in the NFLD can also be found at both FIA websites. However, we recommend using only the NFLD, which has undergone additional error checking and pulls together the various pieces of both published and unpublished lichen data into a consistent format.

Most ARM sites also include “elemental” data, measurements of heavy metals, nitrogen, and sulfur accumulated in lichen or moss samples.⁹ These data can be accessed from the U.S. Forest Service Lichens and Air Quality website,¹⁰ which offers tools such as on-the-fly mapping and easy-to-use queries. The website displays data from “megadatabase,” a work in progress that will integrate all lichen surveys in the NFLD with more recent surveys from both ARM and FIA, and more than 4,000 additional surveys conducted by the USFS and cooperators using different lichen survey protocols.

The FHM/FIA programs have not routinely collected lichen elemental data, although researchers sometimes collect small datasets to inform air quality projects. Owing to the growing use of elemental data in air studies, the FIA lichen program

⁵ Phase 2 Database Documentation: https://www.fia.fs.fed.us/library/database-documentation/current/ver611/FIADB_User_Guide_P2_6-1-1_final.pdf.

⁶ DataMart Web page: <https://apps.fs.usda.gov/fia/datamart/datamart.html>.

⁷ Phase 3 Database Documentation: https://www.fia.fs.fed.us/library/database-documentation/current/ver60/FIADB%20User%20Guide%20P3_6-0-1_final.pdf.

⁸ Other data Web page: <https://www.fia.fs.fed.us/program-features/indicators/lichen/>. or by contacting the National Lichen Indicator Advisor (sarah.jovan@usda.gov).

⁹ Elemental Analysis Methods: <http://gis.nacse.org/lichenair/doc/AQBPMthds.pdf>.

¹⁰ USFS Lichens and Air Quality website: <http://gis.nacse.org/lichenair/>.

recently developed a field collection protocol specifically for FIA crews to use on the FIA sampling grid (Will-Wolf et al. 2017a, 2017b, 2020). This protocol is compatible with ARM's approach so elemental data are comparable across programs. Future versions of the NFLD will include elemental data accumulated by FIA and be archived in the megadatabase and the USFS Lichens and Air Quality website.

Sampling Schedule

Owing to continuously fluctuating budgets, the schedule of plot visits for all lichen programs varied widely by region, state, and over time (app. 5). Originally, a 5-year cycle was intended for FHM/FIA on-grid surveys, later, a 10-year cycle. But the actual number of site revisits ranges from zero to three. In general, FHM/FIA plots surveyed for lichens in a given year had a wide geographic spread, aiming to sample 10 percent of plots on the grid in a region each year. This goal was inconsistently achieved, and the sampling schedule became increasingly erratic in later years. All large-scale lichen sampling ceased in 2012 because of funding shortfalls, although FIA retains the capacity for additional data collection and storage and still takes part in many special studies to revisit plots or survey lichens at new sites on a project-to-project basis.

The ARM program aimed to revisit sites every 10 years. Decreased funding led the program to prioritize revisits to plots in wilderness areas, which are afforded special protections under the Clean Air Act's 1977 Prevention of Significant Deterioration amendment. Like FIA, however, ARM continues to participate in special monitoring projects and accumulates additional lichen data as budgets allow.

Taxonomy and Identification

Taxonomy and protocols for specimen identification are largely compatible between the ARM and FIA programs. A key difference is that ARM typically confirms identifications for cryptic taxa with the use of thin-layer chromatography and compound microscopes. The FIA program does not consistently use these tools and instead lumps certain taxa for analysis (app. 4). However, both programs use chemical spot tests as appropriate.

The NFLD includes a list of past and present scientific names used by the FIA program that experts periodically review to reflect changes in lichen taxonomy. This list largely agrees with the North American lichen checklist (version 22) (Esslinger 2018),¹¹ which ARM also follows. A potentially controversial exception to the checklist is our acceptance of a new phylogeny for cetrarioid species (Divakar et al. 2017), a group that has been in flux for some time. FIA sometimes lags a couple years in

¹¹ http://sweetgum.nybg.org/images3/2671/370/op17p2_29January2018.pdf.

adopting new taxonomic revisions to ensure that name changes have gained wide acceptance. Conservatism in dealing with the latest discourse on nomenclature is critical because each name change creates discontinuity in the lichen data that users must then “reconcile” before analysis (see “Taxonomic Reconciliation”). Lichen vouchers are not consistently revisited by FIA or ARM researchers, although lichenologists are making considerable effort to update specimens housed at OSC. Most annotations made once the specimens left their USFS storage facility are not reflected in the current NFLD, the exception being when the USFS provided specimens directly to a taxonomic study or expert for further investigation. New annotations can be searched out using the Consortium of North American Lichen Herbaria website¹² using the prefix “OSC-M-” or by visiting the herbarium where the specimens of interest were deposited. When possible, future versions of the NFLD will include annotations.

Database Overview

The NFLD is composed of seven tables (table 2). Species data [LICHEN_SPP] and environmental plot data [LICHEN_PLOT] for FHM/FIA surveys are in separate tables to be consistent with prior releases of FIA lichen data. The Atlas dataset [LICHEN_ATLAS] adopts a new format, combining species and environmental data into a single table for ease of use. Variables that link NFLD tables to each other or to external data sources (see “Other Plot Data”) are indicated in each table’s respective section. An extensive search was conducted to bring together environmental data in [LICHEN_PLOT] and [LICHEN_ATLAS] from across several Forest Service databases. Any missing records for these variables in the NFLD are considered unrecoverable. For missing ARM data, check the megadatabase for updates at the USFS Lichens and Air Quality website.

¹² <http://lichenportal.org/portal/>.

Table 2—Names and descriptions of tables in the lichen database

Name	Description
[LICHEN_SPP]	Species occurrence data from FHM/FIA surveys
[LICHEN_PLOT]	FHM/FIA plot data (1992–2012) and identifiers for linking to other databases
[REF_LICHEN_SPECIES]	Scientific names used in the FIA program
[REF_LICHEN_SPP_COMMENTS]	Instructions for reconciling lichen taxonomy
[REF_FIPS_STATE]	Crosswalk for state numeric codes
[REF_FIPS_COUNTY]	Crosswalk for county numeric codes
[LICHEN_ATLAS]	Dataset combining species occurrence and plot data from FHM, FIA, and ARM (1989–2012), including plot identifiers for linking to other databases

FHM = Forest Health Monitoring; FIA = Forest Inventory and Analysis; ARM = Air Resource Management Program.

Taxonomic Reconciliation

All data users should consult the [REF_LICHEN_SPECIES] and [REF_LICHEN_SPP_COMMENTS] tables before beginning analysis. Many taxa have been split, lumped, or renamed over the 23 years covered by the NFLD. Therefore, users need to reconcile names in their dataset unless they are using [LICHEN_ATLAS], which has already been reconciled (but see “Atlas User Tips”).

The [REF_LICHEN_SPECIES] table tracks all past and present names used in the FIA/FHM program. Note that sometimes a name is not updated until that taxon was encountered in the field, so several “old” names still exist in the list. Also, hundreds of older lichen records were reexamined for the Atlas project, prompting many recent updates to [REF_LICHEN_SPECIES]. Both circumstances lead to some long-seeming lags (3+ years) between taxonomic revisions and acceptance of new names. But this should not be of concern as current taxonomic concepts are used at the time of specimen identification, and part of that process is proposing updates to [REF_LICHEN_SPECIES]. The [REF_LICHEN_SPECIES] table provided with the NFLD beta version was current in 2019 and will be updated periodically (see “NFLD Future Updates”).

Detailed recommendations for reconciling datasets across different timespans and geographic regions are provided in [REF_LICHEN_SPP_COMMENTS]. This table can also guide users combining NFLD datasets with new ARM surveys from the megadatabase. However, program differences in lichen names, identification approach (see “Taxonomy and Identification”), abundance codes (see Geiser 2004), and data storage conventions (see “Atlas User Tips”) will need to be addressed. The “Atlas_notes” column in [LICHEN_ATLAS] is also a valuable reference for combining ARM and FHM/FIA data because it highlights program differences for all taxa included in the Atlas dataset.

Atlas User Tips

Names in [LICHEN_ATLAS] are already reconciled for consistency across programs and over time using [REF_LICHEN_SPP_COMMENTS] and [REF_LICHEN_SPECIES] with exceptions noted in the Atlas_notes column. The taxonomic concepts we use will be updated with each new version of the NFLD. Because of the long timespan covered by the Atlas, many taxa had to be lumped. However, [LICHEN_ATLAS] includes the original determinations for each record so users may decide for themselves when and how to lump taxa. Or users may opt to create datasets covering shorter timespans, which allows the retention of additional distinct lichen taxa for analysis.

Depending on analysis goals, the following preparation steps may need to be taken before using [LICHEN_ATLAS]:

- Multiple collections of the same lichen species are often made during a survey, and the parent programs store these data differently. ARM records in [LICHEN_ATLAS] and the ARM parent database track individual lichen collections. In this case, abundance codes are simply the codes surveyors assign to each individual collected in the field. By contrast, FHM/FIA records are aggregated to the species level; each plot has one record per species reporting a “final” abundance based on aggregating codes across all collections of that species (table 3). Thus for studies using abundances, the final abundances should be calculated for ARM surveys using the rules in table 3.
- Additionally, only records within restricted timeframes are included for a few species in [LICHEN_ATLAS], as noted in the Atlas_notes column, and thus do not reflect the full dataset available for these species. To more accurately map the ranges of some species in the Atlas, we removed records for specimens we could not access at the time. The four species most affected include *Parmeligga barrenoae*, split from *P. sulcata*, and *Platismatia wheeleri*, split from *P. glauca*. Also, old records preceding major taxonomic reorganization were removed. This includes records for *Xanthomendoza* (before 1997), *Physconia* (*P. isidiigera*, *perisidiosa*, and *leucoleiptes*; before 1998 in the Western United States), *Usnea. subfloridana* (before 1998), *U. esperantiana* (before 2000), and *U. glabrata* (before 2000). All FHM/FIA records missing from [LICHEN_ATLAS] can be easily gathered using [LICHEN_SPP]. Missing ARM data can be downloaded from the USFS Lichens and Air Quality website. Instructions for when and how to lump taxa are provided in [REF_LICHEN_SPP_COMMENTS].

Table 3—Forest Health Monitoring/Forest Inventory and Analysis rules for calculating the final abundance for each species encountered in the lichen survey^a

Recorded abundances	Final abundance
1 + 1	2
1 + 1 + 1 + 1 + 1	2
More than five 1s	3
1 + 2	2
2 + 2	2
1+1+2	2
1 + 1 + 1 + 2	3
1 + 2 + 2	3
3 + any others	3
4 + any others	4

^a See table 1 for abundance code definitions.

NFLD Future Updates

Revisions and updates to the NFLD will be periodically posted to the FIA lichen website (<https://www.fia.fs.fed.us/program-features/indicators/lichen/>) depending on user needs, error discovery, and the number of new FIA lichen surveys collected. Feedback is appreciated and will inform the content included in future data releases. Each NFLD release will include updated versions of both [REF_LICHEN_SPECIES] and [REF_LICHEN_SPP_COMMENTS]. Future NFLD versions will include annotations to specimens that we were aware of at the time.

Database Tables

Table 4 contains the seven NFLD database tables (tables 4a through 4g).

Table 4a—National Forest Lichen Database (NFLD) [LICHEN_SPP]

Subsection	Column name	Descriptive name	Table links
1.1	ID	Record ID	
1.2	NFLD_ID	National Lichen Database ID	[LICHEN_PLOT], [LICHEN_ATLAS]
1.3	LICH_SPPCD	Lichen species code	[REF_LICHEN_SPP_COMMENTS], [REF_LICHEN_SPECIES],
1.4	SPP_ACRONYM	Species acronym	[REF_LICHEN_SPECIES], [REF_LICHEN_SPP_COMMENTS],
1.5	GENUS	Genus	[REF_LICHEN_SPECIES]
1.6	SPECIES	Species	[REF_LICHEN_SPECIES]
1.7	ABUNDANCE_CODE	Abundance code	

1.1 ID

Record ID. A unique identifier for each record in this table.

1.2 NFLD_ID

National Lichen Database plot ID. A unique identifier for each lichen survey.

1.3 LICH_SPPCD

Lichen species code. A unique numerical code for each lichen species name used in the FHM/FIA program. Only one particular combination of LICH_SPPCD and SPP_ACRONYM with a GENUS and SPECIES is in use in the program at any one time. A taxon is tracked through time with LICH_SPPCD and SPP_ACRONYM; GENUS and SPECIES may change without interfering with tracking the taxon through time. LICH_SPPCD links this table with table REF_LICHEN_SPP_COMMENTS, which includes important notes about taxonomic usage and changes over time in the program.

1.4 SPP_ACRONYM

Species acronym. A unique three- to six-letter acronym for each lichen species used in the program. Only one particular combination of LICH_SPPCD and SPP_ACRONYM with a GENUS and SPECIES is in use in the program at any one time. A taxon is tracked through time with LICH_SPPCD and SPP_ACRONYM; GENUS and SPECIES may change without interfering with tracking the taxon through time. See table REF_LICHEN_SPP_COMMENTS for a history of taxonomic usage in the program.

1.5 GENUS

The lichen genus name.

1.6 SPECIES

The lichen species name (including subspecies, variety, or form if needed).

1.7 ABUNDANCE_CODE

A code indicating the abundance code assigned to SPP_ACRONYM for a given survey. The abundance code is assigned in the field.

Code	Description
1	Rare (1 to 3 individuals)
2	Uncommon (4 to 10 individuals)
3	Common (>10 individuals but less than 50 percent of boles and branches have species present)
4	Percentage (species is present on >50 percent of boles and branches)

Table 4b—National Forest Lichen Database (NFLD) [LICHEN_PLOT]

Subsection	Column name	Descriptive name	[Table]/external links
2.1	NFLD_ID	National Lichen Database ID	[LICHEN_SPP], [LICHEN_ATLAS]
2.2	MEGADB_ID	Megadatabase ID	USFS Lichens and Air
2.3	PLOT_FIADB	FIADB plot number	FIADB
2.4	OFFGRID_ID	Off-grid ID	
2.5	P3ID	Phase 3 ID	FIA “Other Data”
2.6	MEASYEAR	Measurement year	
2.7	STATECD	State code	[REF_FIPS_STATE]
2.8	COUNTYCD	County code	[REF_FIPS_COUNTY]
2.9	LICHEN_STATCD	Lichen status code	
2.10	LAT	Latitude	
2.11	LONG	Longitude	
2.12	DATUM	datum	
2.13	ELEV	Elevation	
2.14	MEASYEAR_TREE	Tree measurement year	
2.15	SLOPE	Slope	
2.16	ASPECT	Aspect	
2.17	BA_CONIF	Conifer basal area	
2.18	BA_HARDW	Hardwood basal area	
2.19	BA_CONIF_PCT	Percentage conifer basal area	
2.20	BA_HARDW_PCT	Percentage hardwood basal area	

2.1 NFLD_ID

National Lichen Database plot ID. A unique identifier for each lichen survey. Links to [LICHEN_SPP], [LICHEN_ATLAS].

2.2 MEGADB_ID

Megadatabase ID. A unique identifier for each lichen survey. Links to lichen data on the U.S. Forest Service Lichens and Air Quality website: <http://gis.nacse.org/lichenair/>.

2.3 PLOT_FIADB

FIADB plot number. Plot identifier linking plots on the FIA sampling grid to the FIADB database on the FIA DataMart Web page: <https://apps.fs.usda.gov/fia/datamart/datamart.html>. Along with STATECD and COUNTYCD, FIADB_PLOT may be used to uniquely identify a plot.

2.4 OFFGRID_ID

Off-grid ID. An alternate identifier for plots located off the FIA sampling grid.

2.5 P3ID

Phase 3 ID. A historical plot identifier linking older FHM plots to additional plot data on FIA's "Other Data" Web page: <https://www.fia.fs.fed.us/program-features/indicators/lichen/index.php>.

2.6 MEASYEAR

Measurement year. The year the lichen survey was conducted.

2.7 STATECD

State code. Bureau of the Census Federal Information Processing Standards (FIPS) two-digit code for each state. Refer to table [REF_FIPS_STATES] for code definitions.

2.8 COUNTYCD

County code. Bureau of the Census Federal Information Processing Standards (FIPS) numeric code for each county. Refer to table [REF_FIPS_COUNTY] for code definitions.

2.9 LICHEN_STATCD

Lichen status code. A code indicating whether or not lichens were collected and, if not collected, why not.

Code	Description
1	Lichens collected
2	Plot searched, no lichens found
3	Not collected—no measurements taken, plot harvested
4	Not collected—no measurements taken, plot dangerous
5	Not collected—ran out of time
6	Not collected—rain/storm
7	Not collected—left plot for emergency
8	Lichens not scheduled for collection on the plot
9	Not collected for other reason
10	Lichens collected—plot later defined as nonforest. Tree data not available in FIADB

2.10 LAT

Latitude. The approximate latitude of the plot in decimal degrees. Actual plot coordinates cannot be released because of a privacy provision enacted by Congress in the Food Security Act of 1985. Therefore, this attribute is approximately ± 1 mi although most plots are within ± 0.5 mi. The latitude given for off-grid plots is the actual coordinate.

2.11 LONG

Longitude. The approximate longitude of the plot in decimal degrees. Actual plot coordinates cannot be released because of a privacy provision enacted by Congress in the Food Security Act of 1985. Therefore, this attribute is approximately ± 1 mi although most plots are within ± 0.5 mi. The longitude given for off-grid plots is the actual coordinate.

2.12 DATUM

Datum of geographic coordinates.

2.13 ELEV

Elevation in feet. The distance the plot is located above sea level. On-grid plots may be rounded to the nearest 10-ft or 100-ft category depending on FIA work unit.

2.14 MEASYEAR_TREE

Tree measurement year. The year trees were measured for basal area calculations.

2.15 SLOPE

The angle of slope, in percentage, determined by sighting along the average incline or decline of the subplot. Measurement taken from the center of the lichen search area.

2.16 ASPECT

The direction of slope, to the nearest degree, determined along the direction of slope. If the aspect changes gradually, an average aspect is recorded. When slope is <5 percent, there is no aspect and it is recorded as zero. North is recorded as 360. Measurement taken from the center of the lichen search area.

2.17 BA_CONIF

Conifer basal area (ft²/ac). For off-grid, plots basal area was obtained using the wedge prism method. For on-grid plots, basal area was calculated from the FIADB TREE table.

2.18 BA_HARDW

Hardwood basal area (ft²/ac). For off-grid plots, basal area was obtained using the wedge prism method. For on-grid plots, basal area was calculated from the FIADB TREE table.

2.19 BA_CONIF_PCT

Percentage basal area in conifers.

2.20 BA_HARDW_PCT

Percentage basal area in hardwoods.

Table 4c—National Forest Lichen Database (NFLD) [REF_LICHEN_SPECIES]

Subsection	Column name	Descriptive name	Table links
3.1	ID	Record ID	
3.2	LICH_SPPCD	Lichen species code	[REF_LICHEN_SPP_COMMENTS], [LICHEN_SPP]
3.3	YEARSTART	Year start	[REF_LICHEN_SPP_COMMENTS]
3.4	YEAREND	Year end	[REF_LICHEN_SPP_COMMENTS]
3.5	SPP_ACRONYM	Species acronym	[LICHEN_SPP], [LICHEN_ATLAS] via 6.21 SPP_ACRONYM_ORIGINAL
3.6	GENUS	Genus	[LICHEN_SPP]
3.7	SPECIES	Species	[LICHEN_SPP]

3.1 ID

Record ID. A unique identifier for each record in this table.

3.2 LICH_SPPCD

Lichen species code. A unique numerical code for each lichen species name used in the FHM/FIA program. Only one particular combination of LICH_SPPCD and SPP_ACRONYM with a GENUS and SPECIES is in use in the program at any given time. A taxon is tracked through time with LICH_SPPCD and SPP_ACRONYM; GENUS and SPECIES may change without interfering with tracking the taxon through time. LICH_SPPCD links this table with table REF_LICHEN_SPP_COMMENTS, which includes important notes about taxonomic usage and changes over time in the program.

3.3 YEARSTART

Year start. The year a particular combination of LICH_SPPCD, SPP_ACRONYM, GENUS, and SPECIES was put into use. LICHEN_SPP entries with MEASYEAR = YEARSTART use that particular combination of LICH_SPPCD, SPP_ACRONYM, GENUS, and SPECIES.

3.4 YEAREND

Year end. The year a particular combination of LICH_SPPCD, SPP_ACRONYM, GENUS, and SPECIES was retired from use. LICHEN_SPP entries with MEASYEAR = YEAREND no longer use that particular combination of LICH_SPPCD, SPP_ACRONYM, GENUS, and SPECIES.

3.5 SPP_ACRONYM

Species acronym. A unique three- to six-letter acronym for each lichen species used in the program. Only one particular combination of LICH_SPPCD and SPP_ACRONYM with a GENUS and SPECIES is in use in the program at any one time. A taxon is tracked through time with LICH_SPPCD and SPP_ACRONYM; GENUS and SPECIES may change without interfering with tracking the taxon through time. See table REF_LICHEN_SPP_COMMENTS for a history of taxonomic usage in the program.

3.6 GENUS

The lichen genus name. Note that this table contains many old names for taxa that were never encountered in the lichen program. Typically, a name is updated once the affected taxon is collected.

3.7 SPECIES

The species epithet (including subspecies, variety, or form, as applicable). Note that this table contains many old names for taxa that were never encountered in the lichen program. Typically a name is updated once the affected taxon is collected.

Table 4d—National Forest Lichen Database (NFLD) [REF_LICHEN_SPP_COMMENTS]

Subsection	Column name	Descriptive name	Table links
4.1	ID	Record ID	
4.2	LICH_SPPCD	Lichen species code	[REF_LICHEN_SPECIES]
4.3	SPP_ACRONYM	Species acronym	[REF_LICHEN_SPECIES]
4.4	SPP_NAME	Species name	
4.5	YEARSTART	Year start	[REF_LICHEN_SPECIES]
4.6	YEAREND	Year end	[REF_LICHEN_SPECIES]
4.7	SPP_COMMENTS	Species comments	

4.1 ID

Record ID. A unique identifier for each record in this table.

4.2 LICH_SPPCD

Lichen species code. A unique numerical code for each lichen species name used in the program. Only one particular combination of LICH_SPPCD and REF_LICHEN_SPECIES.SPP_ACRONYM with a REF_LICHEN_SPECIES.GENUS and REF_LICHEN_SPECIES.SPECIES is in use in the program at any given time. A taxon is tracked through time with LICH_SPPCD and REF_LICHEN_SPECIES.SPP_ACRONYM; GENUS and SPECIES may change without interfering with tracking the taxon through time. LICH_SPPCD links this table with table REF_LICHEN_SPECIES, a master list of all species codes and names used in the program.

4.3 SPP_ACRONYM

Species acronym. A unique three- to six-letter acronym for each lichen species used in the program.

4.4 SPP_NAME

This field includes the full species name corresponding to LICH_SPPCD; it includes both REF_LICHEN_SPECIES.GENUS and REF_LICHEN_SPECIES.SPECIES. Only one particular combination of LICH_SPPCD and REF_LICHEN_SPECIES.SPP_ACRONYM with a REF_LICHEN_SPECIES.GENUS and REF_LICHEN_SPECIES.SPECIES is in use in the program at any one time.

4.5 YEARSTART

The year a particular combination of LICH_SPPCD, REF_LICHEN_SPECIES.SPP_ACRONYM, REF_LICHEN_SPECIES.GENUS, and REF_LICHEN_SPECIES.SPECIES (the latter two represented in this table by SPP_NAME) was put into use. Default start year for most species is 1993. LICHEN_spp entries with MEASYEAR = YEARSTART use that particular combination of LICH_SPPCD, REF_LICHEN_SPECIES.SPP_ACRONYM, REF_LICHEN_SPECIES.GENUS, and REF_LICHEN_SPECIES.SPECIES as needed.

4.6 YEAREND

The year a particular combination of LICH_SPPCD, REF_LICHEN_SPECIES.SPP_ACRONYM, REF_LICHEN_SPECIES.GENUS, and REF_LICHEN_SPECIES.SPECIES (the latter two represented in this table by SPP_NAME) was retired from use. LICHEN_SPP entries with MEASYEAR = YEAREND use the updated combination of LICH_SPPCD, REF_LICHEN_SPECIES.SPP_ACRONYM, REF_LICHEN_SPECIES.GENUS, and REF_LICHEN_SPECIES.SPECIES.

4.7 SPP_COMMENTS

This field includes informational comments, explanations of changes in taxonomic nomenclature between years, and actions to perform before analyzing data. For most changes (even those with action code 0 = no action), there are individual records for each unique combination of LICH_SPPCD, REF_LICHEN_SPECIES.SPP_ACRONYM, REF_LICHEN_SPECIES.GENUS, and REF_LICHEN_SPECIES.SPECIES (the latter two represented in this table by SPP_NAME) involved in the change or action. FIA does not use thin layer chromatography (TLC) or examinations of thin sections for identification of lichen specimens. Lichen species whose identification requires these techniques are noted and then grouped under the name of a look-alike species identifiable from morphology visible with a dissecting microscope, chemical spot tests, or long-wave UV (ultraviolet) lamp. If data from a single LICHEN_SPP.MEASYEAR are to be analyzed, action codes 1 and 2 apply, action codes 3 and 4 do not apply, and action codes 5, 6, and 7 should be checked to see if parts apply.

Table 4e—National Forest Lichen Database (NFLD) [REF_FIPS_STATE]

Subsection	Column name	Descriptive name	Table links
5.1	ID	Record ID	
5.2	STATECD	State code	[LICHEN_PLOT], [LICHEN_ATLAS], [REF_FIPS_COUNTY]
5.3	STATE	State name	

5.1 ID

Record ID. A unique identifier for each record in this table.

5.2 STATECD

State code. Bureau of the Census Federal Information Processing Standards (FIPS) code for each state.

5.3 STATE

State name.

Table 4f—National Forest Lichen Database (NFLD) [REF_FIPS_COUNTY]

Subsection	Column name	Descriptive name	Table links
6.1	ID	Record ID	
6.2	STATECD	State code	[LICHEN_PLOT], [LICHEN_ATLAS], [REF_FIPS_STATE]
6.3	COUNTYCD	County code	[LICHEN_PLOT], [LICHEN_ATLAS]
6.4	COUNTY	County name	

6.1 ID

Record ID. A unique identifier for each record in this table.

6.2 STATECD

State code. Bureau of the Census Federal Information Processing Standards (FIPS) code for each state.

6.3 COUNTYCD

County code. Bureau of the Census Federal Information Processing Standards (FIPS) numeric code for each county.

6.4 COUNTY

County name.

Table 4g—National Forest Lichen Database (NFLD) [LICHEN_ATLAS]

Subsection	Column name	Descriptive name	Table links
7.1	ID	Record ID	
7.2	MEGADB_ID	Megadatabase ID	USFS Lichens and Air
7.3	NFLD_ID	National Lichen Database ID	[LICHEN_SPP], [LICHEN_PLOT]
7.4	PLOT_FIADB	FIADB plot number	FIADB
7.5	OFFGRID_ID	Off-grid ID	
7.6	P3ID	Phase 3 ID	FIA “Other Data”
7.7	PLOT_TYPE	Program	
7.8	MEASYEAR	Measurement year	
7.9	STATECD	State code	
7.10	COUNTYCD	County code	
7.11	LAT	Latitude	
7.12	LONG	Longitude	
7.13	DATUM	Datum	
7.14	ELEV	Elevation	
7.15	SLOPE	Slope	
7.16	ASPECT	Aspect	
7.17	BA_CONIF	Conifer basal area	
7.18	BA_HARDW	Hardwood basal area	
7.19	BA_CONIF_PCT	Percentage conifer basal area	
7.20	BA_HARDW_PCT	Percentage hardwood basal area	
7.21	SPP_ACRONYM_ORIGINAL	Original species acronym	[LICHEN_SPP], [REF_LICHEN_SPECIES], [REF_LICHEN_SPP_COMMENTS]
7.22	DATA_EDITS	Data edits	
7.23	ATLAS_NOTES	Atlas notes	
7.24	GENUS	Genus	
7.25	SPECIES	Species	
7.26	ABUNDANCE_CLASS	Abundance class	

7.1 ID

Record ID. A unique identifier for each record in this table.

7.2 MEGADB_ID

Megadatabase ID. A unique identifier for each lichen survey. Links to lichen data on the USFS Lichens and Air Quality website: <http://gis.nacse.org/lichenair/>.

7.3 NFLD_ID

National Lichen Database plot ID. A unique identifier for each lichen survey. Links to [LICHEN_SPP] and [LICHEN_PLOT].

7.4 PLOT_FIADB

FIADB plot number. Plot identifier linking plots on the FIA sampling grid to the FIADB database on the FIA DataMart Web page: <https://apps.fs.usda.gov/fia/datamart/datamart.html>. Along with STATECD and COUNTYCD, FIADB_PLOT may be used to uniquely identify a plot.

7.5 OFFGRID_ID

Off-grid ID. An alternate identifier for plots located off the FIA sampling grid.

7.6 P3ID

Phase 3 ID. A historical plot identifier linking older FHM plots to additional plot data on FIA's "Other Data" Web page: <https://www.fia.fs.fed.us/program-features/indicators/lichen/index.php>.

7.7 PLOT_TYPE

Administering program and plot type for lichen survey.

Code	Description
ARM	ARM plot on FIA grid
ARM—off grid	ARM plot off FIA grid
FIA	FIA plot on FIA grid
FIA—off grid	FIA plot off FIA grid

7.8 MEASYEAR

Measurement year. The year in which the lichen survey was conducted.

7.9 STATECD

State code. Bureau of the Census Federal Information Processing Standards (FIPS) two-digit code for each state. Refer to table [REF_FIPS_STATES] for code definitions.

7.10 COUNTYCD

County code. Bureau of the Census Federal Information Processing Standards (FIPS) numeric code for each county. Refer to table [REF_FIPS_COUNTY] for code definitions.

7.11 LAT

Latitude. Latitude accuracy varies. For on-grid plots (see PLOT_TYPE), the approximate latitude of the plot is given in decimal degrees. Actual plot coordinates cannot be released because of a privacy provision enacted by Congress in the Food Security Act of 1985. Therefore, this attribute is approximately ± 1 mi although most plots are within ± 0.5 mi. The latitude given for off-grid plots

is the actual coordinate.

7.12 LONG

Longitude. Longitude accuracy varies. For on-grid plots (see PLOT_TYPE), the approximate longitude of the plot is given in decimal degrees. Actual plot coordinates cannot be released because of a privacy provision enacted by Congress in the Food Security Act of 1985. Therefore, this attribute is approximately ± 1 mi, although most plots are within ± 0.5 mi. The longitude given for off-grid plots is the actual coordinate.

7.13 DATUM

Datum of geographic coordinates.

7.14 ELEV

Elevation in feet. The distance the plot is located above sea level. For on-grid plots (see PLOT_TYPE), elevation is rounded to the nearest 10-ft or 100-ft category depending on FIA work unit. For off-grid plots, actual elevation is given.

7.15 SLOPE

The angle of slope, in percentage, determined by sighting along the average incline or decline of subplot. Measurement is taken from the center of the lichen search area.

7.16 ASPECT

The direction of slope, to the nearest degree, determined along the direction of slope. If the aspect changes gradually, an average aspect is recorded. When slope is < 5 percent, there is no aspect and it is recorded as zero. Measurement is taken from the center of the lichen search area.

7.17 BA_CONIF

Conifer basal area (ft²/ac). For off-grid plots, basal area was obtained using the wedge prism method. For on-grid plots, basal area was calculated from the FIADB TREE table.

7.18 BA_HARDW

Hardwood basal area (ft²/ac). For off-grid plots, basal area was obtained using the wedge prism method. For on-grid plots, basal area was calculated from the FIADB TREE table.

7.19 BA_CONIF_PCT

Percentage of basal area in conifers.

7.20 BA_HARDW_PCT

Percentage of basal area in hardwoods.

7.21 SPP_ACRONYM_ORIGINAL

Original species acronym. A unique three- to six-letter acronym for each lichen species used in the FIA program. These acronyms are original species names as they occur in parent databases ([LICHEN_SPP], the FIADB, and the USFS Lichens and Air Quality website) before taxonomic reconciliation. Note that ARM tracks individual lichen collections, resulting in multiple records per species in a plot, whereas FHM/FIA data have only one record per species and plot (see 7.25).

7.22 DATA_EDITS

Short description of lichen name changes, if any. Names were reconciled using [REF_LICHEN_SPP_COMMENTS] unless noted otherwise in 7.23 Atlas_notes. Specimens were reexamined where indicated.

7.23 ATLAS_NOTES

Notes on data handling for the Atlas dataset that differ from ordinary procedures or reconciliation rules in [REF_LICHEN_SPP_COMMENTS]. This field highlights taxonomic differences between the FIA and ARM programs.

7.23 GENUS

The reconciled lichen genus name.

7.24 SPECIES

The reconciled lichen species name (including subspecies, variety, or form if needed).

7.25 ABUNDANCE_CLASS

A code indicating the abundance class assigned to each lichen species in a given survey. Abundance class is assigned in the field. Note that ARM reports abundance for individual collections whereas FIA reports “plot-level” abundance calculated from all instances of that species on a plot. See “Atlas User Tips.”

Code	Description
1	RARE (1 to 3 individuals)
2	UNCOMMON (4 to 10 individuals)
3	COMMON (>10 individuals but less than 50 percent of boles and branches have species present)
4	ABUNDANT (species is present on >50 percent of boles and branches)

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Metric Equivalents

When you know:	Multiply by:	To get:
Inches	2.54	Centimeters
Feet (ft)	.305	Meters
Miles (mi)	1.609	Kilometers

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Appendix 2: Forest Inventory and Analysis Lichen Survey Field Protocol

Protocol Excerpt From the Most Recent (2011) Revision¹

Method summary—

The objectives are to determine the presence and abundance of macrolichen species on woody plants in each plot and to collect samples to be mailed to lichen specialists. Note that the crew member responsible for this task is not required to accurately assign species names to the lichens (that is done later by a specialist) but must be able to make distinctions among species.

The field method has two parts that are performed at the same time:

1. Collect a specimen of each macrolichen species on the plot (fig. 3) for identification by a specialist. The population being sampled consists of all

¹ https://www.fia.fs.fed.us/library/field-guides-methods-proc/docs/2012/field_guide_p3_5-1_sec21_10_2011.pdf.

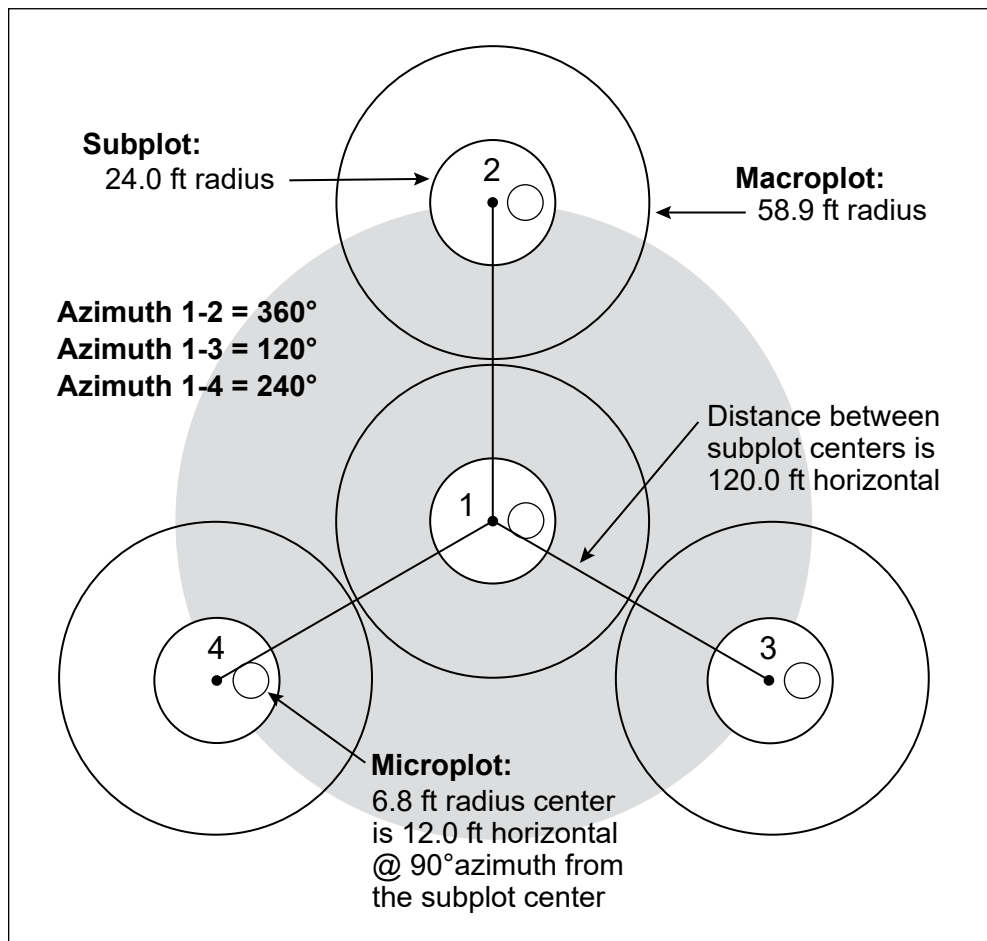


Figure 3—Layout of Forest Inventory and Analysis plot. The area in gray is searched for lichens.

macrolichens occurring on live or standing dead woody plants, excluding the 19.7-inch (0.5-m) basal portions of trees, snags, saplings, and shrubs. Include in your sampling recently fallen branches on which the canopy lichens still look healthy (usually down for no more than a few months). Branches and logs left from recent harvests are okay to sample. Older down woody debris and any sawed or human-treated wood surfaces are not okay to sample.

2. Estimate the abundance of each species. Possible species that you are not sure are different from those already collected should be collected as many times as needed with abundance rated separately for each sample.

Equipment and supplies—

1. Specimen packets folded from 8.5- by 11-inch paper, averaging 30 per plot (fig. 4). Regions may differ in how packets are provided. It is convenient to type/print your name and state into a master template file, then print your customized template as a master to make copies. This file is available from your regional crew supervisor. Before you print the template, be sure the page margins in your word processing software are set so that the packet label prints on the bottom one-third of a 8.5- by 11-inch piece of paper. You can also type your name and state on a paper template to use as a duplicating master. Take 30 to 50 #1 or #2 paper bags as backup “packets” on very wet days.
2. Permanent ink pen for recording data on packets.
3. Plot data cards (fig. 5).
4. Large rubber bands to keep packets together. Medium size paper bags (#3

FOREST INVENTORY & ANALYSIS PROGRAM – P3 lichens of _____		
P3HEX (old FHM) No: FIA Plot No: County:	Date:	Coll. No:
Scientific Name:	ID Notes:	Abundance:
Crew number:	Remarks:	

Figure 4—Label used on specimen field packets.

Lichen Communities Indicator	PLOT DATA CARD	FIA
This will be part of the permanent record for this plot. PLEASE COMPLETE IT FULLY! If using the PDR, complete BOLD fields only. If not using the PDR, complete all fields.		
P3 FHM Hexid #: _____	FIA Plot # _____	State: _____ County: _____
Date: _____	Lichen Project _____	Crew Number: _____
QA Status _____	LICHENS COLLECTED Y N	
Time lichen sampling began: _____		Time lichen sampling ended: _____ Elevation (ft): _____
% Cover (on lichen plot): Conifers _____		Hardwoods _____ Tall Shrubs _____
Dominant Tree/Shrub Species(w/% cover) _____		

Important substrate species not on subplots _____		

% gap _____	Recent(<5 yr)? Y N	w/ Tall Shrubs? Y N
Size class(es) of 3 largest trees (in DBH) <10 _____ 10-20 _____ 21-30 _____ 31-40 _____ >40 _____		
Features important for high/low lichen diversity (if any) _____		

Sampling issues/problems (weather, etc) _____		
Other comments _____		
REMEMBER:		
• Record the abundance code on each packet! • Remember to look for the common species. • Try to put only one species in each packet.		

Figure 5—Lichen plot data card.

- and #4) or similar size, one per plot as alternates, or a few for plots with many packets.
5. Backpack or similar bag to keep lichen packets and equipment together.
 6. Locking-blade or fixed-blade knife with sheath.
 7. 10× hand lens—Hastings triplet optics is preferred to avoid headaches.
String hand lens on a neck cord to avoid losing it.
 8. Hand pruners that are useful for collecting small branch segments.
 9. Wood chisel at least 0.75-inch wide that is useful for collecting samples from tough-barked hardwoods. Chisel should have a sheath.
 10. Timepiece.
 11. Regional guides for lichen identification. Different guides will be needed for different areas.
 12. Portable data recorder (PDR), if used.

Survey method—

1. Record **time lichen sampling began** and **time lichen sampling ended** on the plot data card or PDR. Sampling continues for a maximum of 2 hours or until 10 minutes elapse with no additional species recorded. At least 45 minutes in the Northeast, North Central, South, and West Coast including Alaska, and 30 minutes in the Intermountain West, must be spent searching the plot, even if very few lichens are present.
2. Take a reconnaissance walk through the lichen plot (fig. 3), locating lichen epiphytes on woody plants, collecting lichen samples, and assigning **abundance** scores. The following method is suggested. Begin at approximately 100 ft due north from plot center, estimating to the limiting boundary of 120 ft, and continue to the right in a sinuous manner until reaching the perimeter of subplot 3. The same procedure is followed between subplots 3 and 4 and 4 and 2. The idea behind this approach is that the crew can scan the whole area but intensely scrutinize selected areas to best represent the diversity on the plot (see item 4 for more details). If time allows, make additional circuits of the plot, searching for substrates or spots that were not visited on the first pass. Collect on the entire lichen plot regardless of forest vs. nonforest condition. Do not collect from any portion of the lichen plot that is denied access or inaccessible. If only part of the plot is sampled for one of these reasons, note under **sampling issues/problems**.
3. Lichen species with the following growth forms will be collected: fruticose and foliose (i.e., macrolichens). Even minute fruticose and lobate forms should be included. Squamulose species and *Cladonia* squamules lacking fruit bodies or upright stalks should not be included.
4. Inspect woody plants (trees, saplings, and shrubs >19.7 inches tall (>0.5 m tall)) within the lichen plot for lichen species. This includes dead trees. Be careful to inspect the full range of substrates and microhabitats available:
 - Shaded and exposed
 - Both live and standing dead trees
 - Conifers and hardwoods
 - Branches and twigs on trees
 - **Recently fallen** (judged to be from more than 19.6 inches (0.5 m) healthy lichens plus branches and twigs on which the canopy lichens still look healthy (usually down for no more than a few months). This includes branches and logs left from **recent** harvests.
 - Shrubs

- Trees in particular topographic positions (e.g., check in a draw or ravine on an otherwise uniform slope, so long as it occurs within the lichen plot).
 - Older down woody debris, decayed stumps, and any sawed or human-treated wood surfaces are not substrates that are okay to sample.
5. Collect a large (ideally palm-sized) sample of each possible species and place it in a packet. Optimally each sample has at least 20 lobes or branches and has abundant morphological characters—aim for a sample about 3 to 4 inches in diameter for larger species.
 6. Care should be used when removing lichens specimens with a knife or chisel. The knife must have a locking blade or fixed blade. Trees should not be climbed to procure specimens.
 7. Label the packet with the **state**, **county**, **plot number**, and **current date**, packet number (sequentially as collected), and record relative **abundance** code. Revise the abundance rating as collection proceeds. Also record any comments on the outside of the packet.
 8. Place each specimen in a separate packet and fill in the label (fig. 4) as follows:
 - Number packets sequentially as collected.
 - Record relative **abundance** on the packet using the codes listed in table 5, and revise this rating as collection proceeds:

Table 5—Forest Inventory and Analysis lichen abundance codes

Code	Abundance
1	Rare (one to three individuals in lichen plot)
2	Uncommon (four to ten individuals in lichen plot)
3	Common (> ten individuals in lichen plot but less than half of the boles and branches have that species present)
4	Abundant (more than half of all allowed substrate in lichen plot has the subject species present) Note: this code is not frequently assigned but is valid. Make sure that more than one out of every two pieces of allowed substrate, which includes boles, branches, twigs, and shrubs, has this species.

Often there will be more than one species on a given bark sample. If there is any chance of ambiguity about which species in the packet corresponds with the **abundance** code, write a descriptive clarifying phrase, such as “the white one” or “the sorediate one,” on the packet in the **remarks** box.

9. The field crew may have uncertainties about the classification of an organism. The following rules for the field crew are designed to put the burden of the responsibility for classification on the specialist, not the field crew.
 - When in doubt, assume it is a lichen.
 - When the growth form is in doubt, assume it is a macrolichen.
 - When species distinctions are in doubt, assume that two different forms are different species.

The purpose of these rules is to encourage the field crew to make as many distinctions in the field as possible. The specialist can later adjust the data by excluding specimens that are not macrolichens and by combining forms that were considered separate by the field crew but are actually the same species. A crew member not certified in lichens may assist by labeling lichen packets for the “lichen” crew member as the latter collects. Crew members not certified in lichens should not collect specimens, nor should they help assign **abundance** codes for lichens.

10. Place all the specimen packets from a given plot with the Plot Data Card (fig. 5). Either bundle with two crossed rubber bands, or place into a single or several paper bags **only if** there are too many samples for rubber bands.
11. Be sure the electronic documentation and the Plot Data Card (fig. 5) are complete and comparable where necessary.
12. Dry packets as needed, store them in a dry place, and mail them to the designated lichen specialist using package tracking.

Appendix 3: Training and Quality Assurance Procedures

Sarah Jovan and Susan Will-Wolf

April 2019

Introduction

This document is revised periodically as needed, to update and clarify language. The lichen indicator field protocols have remained stable since 1994 (McCune and others 1997a, 1997b). Recommended training time and the basic components of training have also remained stable since 1994; improvements, updates, and new approaches to training are tried each year. Successful modifications of training approach and details are incorporated into this document. Quality assurance (QA) blind checks were added to the program starting in the late 1990s. This document is substantially revised from Will-Wolf (2007). The contents of this document evolved from earlier documents authored by Bruce McCune, Peter Neitlich, and Susan Will-Wolf, and from critiques and contributions to training and QA by the many contractor lichen specialists and Forest Health Monitoring and Forest Inventory and Analysis field crews who have contributed evaluations and feedback.

McCune, B.; Dey, J.P.; Peck, J.E.; Cassell, D.; Heiman, K.; Will-Wolf, S.;

Neitlich, P. 1997a. Repeatability of community data: species richness versus gradient scores in large-scale lichen studies. *Bryologist*. 100(1): 40–46.

McCune, B.; Dey, J.; Peck, J.; Heiman, K.; Will-Wolf, S. 1997b. Regional gradients in lichen communities of the southeast United States. *Bryologist*. 100(2): 145–158.

Neitlich, P.; Will-Wolf, S. 1999. Lichen indicator training plan. Forest Health Monitoring program: lichen communities indicator. Internal U.S. Forest Service document. On file with: Sarah Jovan, Pacific Northwest Research Station, 620 SW Main Street, Suite 400, Portland, OR 97205.

Will-Wolf, S. 2007. Forest Inventory and Analysis program: lichen specialist training and QA procedures. FIA lichen communities indicator. Internal U.S. Forest Service document. On file with: Sarah Jovan, Pacific Northwest Research Station, 620 SW Main Street, Suite 400, Portland, OR 97205.

Part 1: Training Preparation and Setup

1. Training site requirements:

- **Lichen diversity:** The two primary field requirements for a good lichen training site are high lichen diversity and access to diverse forested stands. In practice, this means holding the training in an area with relatively clean air with good access to a variety of forest stands. The lichen indicator advisor (IA) should coordinate as needed with other IAs and regional FIA staff to assure that the prospective training site is appropriate.
- **Workspace:** A large, unshared classroom or lab is needed that will be available all day and evening for the entire length of the training (including setup and post-training). The room needs to have ample electrical outlets for microscope lamps and water nearby for dealing with laboratory chemicals. Space must be able to accommodate about 4 linear ft of table space per trainee for interactive lichen teaching stations and other microscope work, seating for talks and slide presentations, and enough extra room for display of a collection of local specimens.
- **Equipment:** At least one dissecting microscope per lichen trainer is needed, and, at most, one dissecting microscope per trainee is desirable. Several power strips and extension cords are needed.
- **Other logistical needs:** Access to a photocopier and a computer with printer if possible.

2. Time requirements:

Length of the training should vary according to the skill level of the crews. Training time is counted in multiples of half-day blocks and includes at least one block for certification testing. The duration of each teaching block should be at least 3 hours, but 4 hours is preferable. For beginning crew with no previous lichen experience, 2.5 days are needed. Most 1-year returning crew need 1.5 days of training unless there is a demonstrated problem with lichen collection skills (previous season QA, for example), and for 2+ year returning veteran crews, 1 day is required. An alternative for a 2+ year veteran crew with a good QA record is for a lichen specialist to meet the crew on the first standard plot of the season for a 2-hour refresher and on-plot certification.

2+ year returning veteran crew members who are candidates to perform QA blind checks (they regularly score around 90+ percent on certification and blind checks) should receive extra training in addition to standard 1-day veteran recertification. This can be accomplished via these crew serving as training

assistants for one-half day, or via an extra review session with a trainer, or some other method arranged with the lead lichen trainer.

3. Number and sequence of time blocks and days for each component of training:

In general, it is best to program taxonomic activities for the mornings, as this is the time of maximum concentration and good outdoor light. If the training is held concurrently with other indicators, all attempts should be made to give lichens the morning sessions, and certainly for the first 2 days of new crew training.

4. Training staff:

- In general, one trainer per three to four crew members is needed for a full new-crew training (see above for training requirements), and one trainer is needed per five to six veteran crew members.
- One lead trainer is needed; (s)he must have more skills and may be paid at a higher rate than the assistant trainer. The lead trainer plans the training, scouts field sites, and sets up the indoor workshop, and directs the training. Assistant trainers as needed help with last-minute setup and to help conduct training. A worthy, highly skilled veteran crew member (see instructor requirements below) is qualified to assist with training.
- An identification specialist participates during the last 2 days of training specifically to help identify certification samples.

5. Instructor requirements:

- **Lead trainers:** Lead trainers need to have specialist-level skills in lichen taxonomy, be good teachers, and be well-versed in Forest Inventory and Analysis (FIA) methods and typical crew questions and problems. Lead trainers should have been an assistant regional trainer or auditor, preferably for 2 or more years, and must have a demonstrated ability to identify most macrolichen species in the region. If possible, that individual should have been an assistant trainer **in that region**. This person would plan to attend a lichen pretraining if there is one, or would be instructed by the lichen IA, as a requirement to be a trainer. In the lichen indicator, specialists perform the identification of field samples, relying on established microscopic and chemical tests. They often have several peer-reviewed publications on lichens and have worked with the FIA program or have used the method for related activities. It is the responsibility of the lichen IA to select and train lead trainers. They then are contracted directly by the lichen IA or by the region after the lichen IA has agreed to their role.

- **Assistant trainers:** Assistant trainers are a critical part of the training program and tend to be as helpful as the lead trainer in teaching basic lichen discrimination to crews. They may be selected by the lichen IA or by the lead trainer as delegated. In addition to potential lead trainers, assistant trainers may include people in the following categories:
 - A good lichen ecologist or lichenologist without FIA-specific experience, but with a demonstrated ability to identify the macrolichen species common in the region and with teaching experience.
 - An experienced lichen crew veteran (2+ years) who has demonstrated an ability to identify macrolichen species common in the region and has either had teaching experience or has previously assisted with field training.
 - Assistant trainers need to attend a lichen pretraining or would be instructed and certified by the lead regional trainer early in training, as a requirement to be a trainer.

Note: Formal lichen pretraining sessions should be held every third or fourth year. In other years, trainers will be trained and certified by the lead regional trainer just before crew training at that site.

- **Identification specialists:** An identification (ID) specialist may attend a portion of a smaller training to assist the lead trainer with identification of lichens from practice and certification plots as well as other activities. The ID specialist needs to be very skilled at identification of macrolichens in the region but needs no teaching experience.
- **Veteran crew assistants:** Worthy veteran crew members (2+ years) can at the discretion of the lead trainer assist with classroom and field teaching for the indicator. Those who regularly find 90 percent or more of the species a lichen specialist finds are candidates to conduct QA blind checks; assisting at training prepares them for this.

6. Work expectations:

Lichen training is very intense, both for lead and assistant trainers. Hours tend to be long and grueling. Trainers should be aware that their jobs involve 10-hour days during the setup phase, and 14- to 16-hour days during the training itself. Much of the additional time required comes in identifying trainee samples in the evenings.

7. Certification and practice plot requirements:

The certification and practice plots should be chosen to represent as much of the potential forest lichen diversity in the region as is available at the

training site. Plots should be located to reflect, **at a minimum**, the average species richness of the state or region, and should strive in all cases to reflect species richness much higher than this. Attention to this requirement will ensure that crews are exposed to the lichen diversity of their region and have mastered this diversity by the end of training. Because this is a prime concern, training location must be chosen with this requirement in mind.

Part 2: Training Plan

1. Lichen indicator training/field manual:

The basic training module is designed to explain and elaborate on the several-hundred-page lichen training/field manual, which contains the following sections:

- The lichens methods chapter of the FIA P3 field manual
- Basics (What is a lichen? Lichen morphology, illustrated glossaries, where to collect lichens, etc.)
- QA (The latest official version of our QA plan, including crew measurement quality objectives, certification requirements, and QA methods)
- Mailings (plot data cards and specialist mailing forms)
- Rationale for the lichen communities indicator
- Reprints 1: Lichens and Air Pollution
- Reprints 2: Regional Species Lists and Publications
- Lichen 911 and contact information

2. Outline of training plan:

The lichen training consists of the following basic components:

- Introduction to FIA lichen communities indicator—purpose, rationale, methods, examples, and basic lichen ecology. This is normally a slide or PowerPoint™ presentation. Lead trainers are furnished with an FIA image set and are free to supplement or substitute (time: 20 minutes to 1 hour). Examples should be from the region as possible.
- Lead trainer presents objectives of the training session, schedule, and explanation of testing activities including practice, certification, and scoring (10 to 15 minutes)
- Introduction to lichen identification—basic lichen morphology, structures, and how to use them to discriminate among species (0.5 hour)
- Learning lichen characters, species discrimination, and lichen genera in the classroom and field through any appropriate combination of the items below (4 to 8 hours)
- Tutorial workstations (2 to 4 hours).

- Examining demonstration material in conjunction with regional species lists (1 to 2 hours) making and examining personal collections (2+ hours)
- Field work (2 hours)
- Genus workstations (1 hour)
- Informal evening activities (e.g., keying, study, etc.); any other activities
- Lichen indicator methods and detailed explanation of field crew responsibilities (1 hour)
- Field outings to practice field discrimination of species and lichen indicator methods (2 hours)
- At least one practice plot for new crew (4 hours each)
- Certification plot (4 hours)
- Retesting if needed (4 hours)
- Additional field outings to other regional subclimates as appropriate (1 day; can be held concurrently with recertification)

Total time: 20 hours (2.5 days) minimum daytime scheduling for new crew, less for returning crew (see “Time Requirements” on p. 47). Informal evening practice with trainers present is strongly encouraged, but it should never substitute for scheduled day time when crew must be alert and not fatigued. Additional time can be scheduled as arranged with the region coordinator.

3. Training objectives:

By the end of the training, crew members should be able to:

- Collect the majority of lichen species present on a plot and assign proper abundance codes
- Describe the basic lichen structures and features of a lichen
- Describe the three basic growth forms of lichens and how to discriminate among them
- Apply basic principles of lichen morphology to discriminate among as many as possible of the epiphytic species in the region
- Describe the concept of substrate specificity and give several examples using local species
- Recognize many of the most common genera in the region—by name is desirable, but not required.
- Conduct FIA lichen plot surveys according to standard field methods
- Follow protocols on plot time and collection locations and substrates on the plot

- Describe the range of microhabitats to examine
- Recite the cardinal FIA lichen rule: “When in doubt, it’s a lichen”
- Collect appropriate sizes of specimens
- Know how to deal with uncertainties relating to species identity and abundances
- Describe the steps needed to complete the lichen specimen requirements after the field survey
- Understand procedures for drying and storing specimens
- Understand packet labeling requirements
- Practice filling out plot data cards
- Have knowledge of how to use forms in the mailings section
- Understand the basic goals and objectives of the lichen indicator and how individual lichen plots will be used in regional and national context, including:
 - The basic concept of lichen decline in areas of poor air quality and the purpose of the indicator in general
 - The importance of lichens in the ecosystem
- Pass the certification (achieve a species collection score of 65 percent or higher of the trainer’s score)

4. Certification requirements:

A crew member is certified if they have found at least 65 percent of the lichen species that a trainer has found on the certification plot. Failing crews may take the recertification test.

- **Preliminary testing exercise:** The lichen indicator will informally score the results of the practice plots as if they were a certification plot, as time permits. This is generally accomplished by having crew spread out their practice plot samples for the training staff to examine. Each training staffer will have made an informal list of what they saw on the practice plot, for comparison with crew samples.
- **Field test:** Lichen certification (see above) is based completely on a field test that includes performing the lichen survey with higher than 65 percent species capture compared to the lead trainer, filling in proper abundance coding, and packaging and labeling plot samples for mailing to the specialist, in this case the lead trainer.
- **Retesting materials:** Another certification field test, as above.

5. Reporting requirements for trainers:

- **Off-frame stand data sheet:** This data sheet (fig. 6) should be filled out completely for each training certification plot.
- **Lichen identification data sheet:** A lichen identification data sheet (fig. 7) appropriate to the region should be completed for trainers and all crew certified for each test plot and submitted to the lichen IA. The lichen IA will prepare electronic data files.
- **Data quality evaluation form:** Either this form (fig. 8) should be filled out and provided to the crew, or some other equivalent written notification of certification results should be provided to the crew. Copies should be submitted to the region coordinator and to the lichen IA.
- **Voucher set:** A complete voucher set for each training site should be prepared and sent to the lichen IA. If a trainer uses a site over multiple years, they may add any new species found at a training to the set. This set documents the training site and the training staff as a whole, not individual trainers or ID specialists. The lichen IA will maintain a voucher list for each site and update it after each training.
- **Report:** A brief written report (1 to 2 pages) outlining the training schedule, certification scores, site notes, recommendations, etc., should be prepared and submitted to the lichen IA with the lichen identification data sheets, vouchers, and off-frame stand data sheet within 2 weeks after the training. The summary report should be submitted electronically, All other written products may be submitted electronically, but hard copy is equally acceptable.

FIA Lichen Indicator - Off-frame Plot Data Sheet

Selection criteria: minimum stand area >1.5 acres, semi-natural or natural understory

Set up standard FHM/FIA Plot for Training

(area 40828 ft² = 0.937 acres = 3783m² = 0.378 ha)

can be 34.7 m = 114 ft radius circle for other off-frame uses

Observers _____

Date: _____ 20____
Plot Number: _____

Contact Name: _____

1. Standard lichen community data plus plot data card (see lichen field methods manual).

2. Stand location

a. State _____ b. County _____ c. elevation (units) _____
d. latitude/longitude _____ N _____ W
e. location in words (attach maps if applicable)

3. Stand tree basal area: Take five wedge-prism counts, 1 at plot center and the rest on N, S, E, W radii about 2/3 out from plot center.

_____ BA factor of prism	Tree counts conif. hardw.
	_____ 1 Center
	_____ 2 North
	_____ 3 East
	_____ 4 South
	_____ 5 West
	_____ averages
Basal area (ft ² /acre or m ² /ha):	_____ = average * BA factor
Total basal area	_____ (circle units)

4. Proportion of BA in conifers _____ %

5. Topographic position

6. Slope _____ degrees or % 7. Aspect _____ degrees E of N

8. % gap _____ Recent? (<5 yr) Y N w/ Tall Shrubs? Y N

9. Dominant tree species (name, %cover)

10. Major shrub species (name, %cover)

Figure 6—Off-frame plot data sheet.

Lichen Identification Data Sheet — *SAMPLE*Plot No. 15NVplotAField Collection Date July 29, 2015Lichen specialist StoneCounty, State Casino, NVCollector W. FiastaffID Date 10/05/15

= Coll. No. A = Abundance on packet. Abun = Final Abundance (see rules). Sp. Code – See Epiphyte Master List

Species Name		FINAL DATA		DATA FROM PACKETS								Comments
		Sp. Code	Abun.	#	A	#	A	#	A	#	A	
1	<i>Flavopunctelia soredica</i>	2704	3	1	3	7	2	5	0			
2	<i>Melanohalea subolivacea</i>	4017	3	3	2	8	2	9	3			Not sectioned
3	<i>Phycia adscendens</i>	5701	1	6	1							
4	<i>Phycia biziana</i>	5705	3	2	1	5	2	11	2			
5	<i>Usnea hirta</i>	8041	2	10	2							
6	<i>Xanthomendoza fallax</i>	8203	2	4	1	12	1					
7	<i>Phaeophyscia hirsuta</i>	5605	0.01	11	0							
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

3/2003

Abundance codes used by field crews: 1 = Rare (1-3 individuals seen), 2 = Occasional (4-10 individuals seen), 3 = Common (> 10 individuals seen), 4 = Abundant (more than half of the allowed substrates have this species).
Species codes: Refer to Lichen Species Master List for lichen species code numbers.

Figure 7—Lichen identification sheet with data.

Data Quality Evaluation—Lichen Communities

Name _____ Region/study _____

Date _____

Plot _____

Trainer/auditor _____

Trainer # spp____ Crew # spp____ Percent of species detected _____ Evaluation:

Comments:

<65% = Practice! You didn't pass.

65%–75% = Congratulations! You passed!

75%–85% = Good eye!

>85% = You could be a trainer!

Figure 8—Data quality evaluation sheet used to report certification and hot check results.

Part 3: QA Activities—Preparation and Setup

1. Auditor requirements:

Only certified lead and assistant trainers may conduct hot audits, which include recertification of crew members. Blind checks may be conducted by certified lead and assistant trainers as well as by qualified crew who have been trained and certified to perform blind checks. These crew typically have collected for more than 2 years and have consistently performed around 90 percent of a trainer's score on plots. They are identified before a training and given extra instruction by the lead trainer.

2. Planning:

The region communicates with the lichen IA and the auditors about the number and location of plots to sample for audits and blind checks, and collaborates on organization of field visits performed by contract lichen specialists. The FIA region pays all costs for contract lichen specialists to perform field hot audits or blind checks, while typically the national lichen indicator budget pays costs for identification, data entry, and reporting of audit and blind check samples

3. Hot checks:

Hot checks (i.e., audits) serve two primary purposes: (1) check in with the field crew to see if they are having any difficulties with the method, and (2) documenting the data quality. The first objective is achieved by talking with the crew, observing the method in progress, and providing immediate feedback. The second objective is met by calculating numerical scores (comparing results to those of the lichen specialist) based on the field crew sampling a plot without interference from the auditor. One or more plots will be examined per audit. Note that the early steps provide immediate feedback to the crew, but the later steps quantify the data quality with increasing rigor.

- The auditor asks the crew member if they have questions concerning the method before the sampling begins, then discusses those problems with the crew member. (If time allows the auditor to be present for two plots, the first plot should be done more interactively, with the specialist helping the crew).
- The auditor then allows the crew member to sample on their own, but observing at a distance the manner in which the crew member covers the plot. At the completion of the plot, the lichen specialist quickly assesses the number and quality of specimens and provides immediate

feedback on the specimens and other aspects of technique (e.g., coverage of plot and substrate, assignment of abundance values, completion of paperwork). Normally, it is fairly easy for a specialist to judge how well someone is doing, even before the final scores are in. The specialist then samples the plot independently.

- The specialist identifies the lichens, then evaluates the number of species obtained by the crew member as a percentage of the specialist's species count. These field scores are reported by the specialist to the lichen IA and crew member as soon as possible: occasionally the same day, but usually within a week.
- If the crew member appears to have passed the hot audit with >70 percent, the remaining steps are followed with no urgency.
- If the crew member's passing score is <70 percent, the next step should be completed as soon as possible, while the crew member continues to collect lichens. If the crew member passed, the season proceeds as planned. If the crew member failed, corrective actions as outlined in the next step need to be taken.
- The specialist sends (with tracking) the specimens to the lichen identification specialist for the state for final identification, and lab scores are calculated. If the crew member failed the hot audit, the crew member is no longer certified to collect lichens. The region coordinator is notified as soon as possible. Corrective actions, as appropriate and feasible, are initiated via communications between field crew, regional coordinator, lichen specialist, and lichen IA. The original crew member may not collect lichens until retrained and recertified, which can be done on the next scheduled plot if feasible.
- After the data are delivered from the specialist to the lichen IA, the species scores for both the crews and the specialists are entered into data files.
- Results of the audit are communicated to the region and QA specialist in a summary QA report prepared at the end of the field season, or earlier if requested by program managers.

4. Blind checks:

Blind checks document data quality, although they do not affect in-season crew performance. Crew remeasurement by crew or others who are not lichen specialists can document between-crew consistency of performance, but they do not document achievement of the field measurement quality objectives (MQO) for adequate species capture to place the plot on a

regional gradient within the desired range of measurement error. Only crew who have been specifically trained and certified may perform blind checks.

Documentation of achievement of the field MQO is met by calculating numerical scores comparing crew results to those of a lichen specialist (or someone with documented lichen specialist level of skill in field species capture) based on the lichen specialist sampling a field crew plot without the crew's knowledge.

- The field crew samples a plot during their regular schedule.
- The regional lichen ID specialist identifies the lichen species from this plot according to normal procedures.
- A trainer/auditor specialist resamples the plot independently, usually in the same field season. In special circumstances, this may occur in a year or two following the crew sampling.
- That specialist submits the lichens from his/her plot to the regional lichen ID specialist.
- After the data are delivered from the specialists to the lichen IA, the species scores for both the crews and the specialists are compared, and data are entered into data files. In the past, we have found that if trainees obtain 65 percent or better of the number of species obtained by the specialist, the plot index scores (below) will mostly fall within 10 percent of the specialist's.
- Results of blind checks are communicated to the QA specialist in a summary QA report prepared at the end of the field season, or earlier if available. They are used to assess quality of data collection in a region, and do not affect in-season crew performance. They may affect crew training intensity in a subsequent season.

Appendix 4: Lichen Specialist Identification Procedures

Sarah Jovan and Susan Will-Wolf

Revised from documents co-authored by Bruce McCune, John Dey, Peter Neitlich, and Susan Will-Wolf

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Introduction and Acknowledgments

The lichen identification specialist has three primary tasks: (1) assign names to lichen specimens collected by the Forest Inventory and Analysis (FIA) field crew and record the data; (2) maintain an official “chain of custody” log for receipt of all FIA lichen samples and for sending on to the lichen indicator advisor (IA) all lichen samples and lichen data; (3) assist the FIA lichen IA to update the FIA REF_LICHEN_SPECIES and FIA REF_LICHEN_SPECIES_COMMENTS tables by recommending additions and revisions.

In some cases, the identification specialist also acts as trainer (see “Lichen Specialist Training and QA Procedures,” app. 2), whose roles are:

1. Conduct or assist with training of field crews, and
2. Conduct or assist with field audits.

This document is revised as needed to update and clarify language. The lichen indicator field protocols have remained stable since 1994 (McCune and others 1997). The goals and basic lichen specialist protocols for specimen identification and data management have also remained stable since 1994; improvements and updates in data management and documentation of protocols have been made as the program matured. All taxonomic changes made have preserved full backward compatibility since the indicator was first implemented. This document is revised from a 2009 version authored by Susan Will-Wolf that evolved from earlier specialist chapters in training manuals authored by Bruce McCune, Peter Neitlich, and Susan Will-Wolf (e.g., Will-Wolf and Neitlich 2006), and from critiques and contributions by the many contracted lichen specialists and office assistants to FIA lichen IAs.

McCune, B.; Dey, J.; Peck, J.; Heiman, K.; Will-Wolf, S. 1997. Regional gradients in lichen communities of the southeast United States. *Bryologist*. 100(2): 145–158.

Will-Wolf, S.; Neitlich, P. 2006. Specialist chapter in training manual: the lichen community indicator in FIA and FHM. Washington, DC:U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program. Internal document. Updated from similar chapters 1995–2005. On file with: Sarah Jovan, Pacific Northwest Research Station, 620 SW Main Street, Suite 400, Portland, OR 97205.

General Instructions

Lichen specimens arrive in one of two ways:

1. Specimens are sent directly by field crew members or auditors, or
2. Specimens are sent by the lichen IA. If received from the field crew, first follow the instructions in part A below, then follow the processing procedures in part B.

Maintaining an official “chain of custody” log: In recent years, FIA data have been used in court cases related to forest management, a reminder that official documentation of chain of custody for FIA samples and data, while they are out of FIA custody, is a necessary part of standard FIA practice. Copies of e-mails acknowledging receipt of samples with a list of plots received from the field or elsewhere, and e-mails accompanying submission of data files and notifying the lichen IA that plot samples are being sent on (with tracking) are acceptable documentation. The lichen specialist copies all e-mails to the lichen IA so the lichen IA can assume the responsibility for maintaining the official documentation of chain of custody. The plot tracking file with dates of receipt for plot samples is another piece of chain of custody documentation.

A. For specimens received directly from field crews

1. Open boxes immediately and check for damp lichens. If any are damp, thoroughly air dry them. Contact the regional logistics coordinator within a day or two to confirm receipt of the plot samples with a list of the plots received. Either copy the lichen IA on e-mail acknowledgment or e-mail the IA that plots have been received and the regional coordinator has been notified in some other way. By acknowledging receipt, the lichen specialist accepts responsibility for sample custody.
2. Keep a list of comments/suggestions for the field crew and contact crew members or the regional logistics coordinator about concerns **early** in the field season. Immediately contact the crew supervisor if a plot has no data card. If none were filled out, stress the importance of completing them. If they were filled out and not sent, request they be mailed to the specialist for storage with plot samples. Typical problems are samples damp or too small, unclear packet data notation, missing abundances, or overcollecting. Periodically report to the lichen IA (copying e-mails, etc.) about field season activities.
3. The lichen specialist receives a master tracking file from the IA or the regional FIA crew coordinator. In that tracking file—soon after each plot collection is received—enter date received plus date collected, county,

and collector's name (from the plot data card) in separate columns in the row corresponding to the plot's P3HEX¹ (=HEXID) number. If you are informed that a plot on the list was not searched for lichens, add the reason in the file (nonforest, access denied, etc.) and do nothing more.

4. E-mail or call the regional FIA contact person as soon as you notice **any** problems with P3HEX numbers (such as numbers not on the master list, duplicate numbers, wrong county, etc.). Resolve these problems as soon as possible through consultation with the regional FIA contact person. Send copies of e-mail correspondence to the lichen IA. Please note that lichen data are submitted and stored under the P3HEX number. There are also P2HEX numbers and plot identifiers consisting of state code, county code, and **plot** number in this program; if plot samples come in with either of the latter identifiers, **every** plot number (all forms, the plot data card, and every single sample packet) must be changed to the corresponding P3HEX. To avoid having to do this too much yourself, e-mail the field crew coordinator if this happens and tell them they or the field crew should check over and change everything to the correct number scheme before they send the samples to you. And buy an 8-number stamp to make it easier on yourself—you don't send back samples, at least at first, that arrived to you with the wrong number set—you fix them.
5. **By November 1st**, send the IA an updated copy of the master tracking file that includes your notes for all P3HEXs for which plot samples were received, for plots for which you were notified the plot was searched but no lichens were found, and for other plots as you received information.

B. For processing all specimens

1. Acknowledge receipt of plot samples from any other source, as needed. For each set of plot specimens, identify the contents of each packet. Consult the most recent Lichen Species Notes file and other lichen identification notes for current taxonomic usage in the FIA program. Record species name on the packet along with any incidental species and note "remarks" pertinent to the identification (ID). List any chemical tests performed and their results. See instructions under "Data Recording—Details" for cases of multiple collections of the same species, missing values, and incidentally collected species.

¹ All numbers in this document representing P3HEX or HEXID are fictitious examples, not actual plot numbers.

2. Create one “Lichen ID data sheet” per plot; preprinted forms with hand-entered information and computer-generated final lichen ID data sheets are equally acceptable. At the top of the Lichen ID data sheet, enter information from the data card. For each sample, record data (species code, bag number, abundance) as outlined below in the “Guide to the Lichen Identification Data Sheet.”
3. Return lichen specimens to their original packets. After identification, rebundle each plot with its original plot data card.
4. If you identify a species that is **not** on the current FIA list of taxonomic names (REF_LICHEN_SPECIES), please use the table included in the National FIA Lichen Database, not older versions that can be found on the Web—for which there is no assigned code number, notify the IA of the species name, state, and plot number. A code number will be needed before data entry can be completed, so the sooner that new species are reported, the better. Only one person, usually the lichen IA, may assign new code numbers for newly encountered species.
5. Each lichen specialist creates and adds to each year an official voucher set of specimens for a particular lichen region, documenting the specialist’s taxonomic decisions for each species found. The voucher set should include at least one good example of each species found over the years of the specialist’s participation in the FIA program, plus any other noteworthy collections (e.g., excellent specimen, odd variant, good range extension, etc.) selected from FIA plot samples. In the comments section of the lichen ID data sheet, record which packets were removed for vouchers. During the season, keep these “To Curate” packets (which later will be repackaged as vouchers) separate from the original plot bundle. When ID has been completed, curate the voucher specimens into new, labeled, acid-free 100-percent cotton bond paper packets (#7 below).
6. If it is convenient, photocopy the original plot data card, staple the original to the plot’s original lichen ID data sheet, and bundle the copy with the plot samples. Photocopy the completed lichen ID data sheet and retain the copy until you have confirmation that the original sheets have been received by the IA. (Submit receipts for copying as needed.) The lichen IA may well want your copies for archiving with FIA offices when you are ready to discard them.
7. **Vouchers.** When ID is complete, repack vouchers into packets made from acid-free 100-percent cotton bond paper. Preprint herbarium-quality labels directly on the packet paper or prepare separate labels, using the label template and instructions provided here (fig. 9) or as separate files

Lichens of Maryland 2005 Mid-Atlantic Voucher Specimen Forest Inventory and Analysis Program <i>Physcia aipolia</i>			
Medulla K+ yellow			
FIA Plot (State-County-Plot): 24-19-1605			
Coll No:	5	Abundance:	3
Approx. Latitude:	38.460228	Longitude:	-76.01896
Elevation:	7 ft		
Date:	28 May 2005		
Collector:	Jane Doe		
Identified:	John Smith	No.:	J. Smith 4000
ID notes:			

Figure 9—Example voucher label: to be printed on a sheet that is then folded into a packet. Note: the bottom margin for this sheet will need to be reduced to its smallest allowed value to position the label properly.

by the IA. List any chemical tests performed and their results. **Please note:** as of the 2005 field season, public herbarium voucher labels **may not** include the P3HEX number. Voucher labels **must** include the FIA state code, county code, and public “PLOT_FIADB” identifier (in the format **state-county-plot**) as well as public (i.e., fuzzed) plot coordinates provided to the lichen ID specialist. Labels must be black laser-printed, photoduplicated, or handwritten with archival-quality ink, on acid-free 100-percent cotton bond paper. Inkjet or other water-soluble ink printers and colored ink are not acceptable. If attaching separate labels, use white glue such as Elmer’s™ or a glue stick that is labeled “permanent and acid free” (the adhesive of some glue sticks degrades over time). Prepare a list of your vouchers; keep a copy for yourself. In your second and later years as an ID specialist, you will add to your original voucher set rather than duplicating the entire set each year.

The official voucher collections are eventually deposited in public herbaria. For ID specialists living away from that herbarium, official vouchers are quite inconvenient to access on a routine basis. ID specialists working remotely should keep for themselves a second informal voucher set made from crew samples, to the extent possible.

8. If contracted for these tasks, prepare electronic files for: Plot / Species code / Abundance code data (see “Electronic Data Entry” section)

9. By October 31 (check contract), preliminary ID of blind check plots should be submitted (electronic files) to the IA.
10. By about February 1 of the following year (check contract), e-mail electronic data and other files to the lichens IA, and send hard copies and samples via a mailing service that includes package tracking (submit receipts for postage as needed).
 - The completed original Lichen ID data sheets (hard copy or electronic) ± hard copy plot data cards (keep a photocopy until they are received).
 - Bundled samples with their plot data cards or copies.
 - Lichen specimen mailing forms (hard copy that accompanied the samples when they were originally mailed to you) but keep a photocopy of these forms for your records.
 - Curated voucher specimens (from selected specimens previously set aside) and corresponding voucher species list.
 - Contributions to the isomorph list and identification notes in the REF_LICHEN_SPP_COMMENT table, and contributions to additional technical identification notes for your region (both electronic).

Isomorphs

Isomorphs differ chemically but are morphologically identical or nearly so. We encourage specialists to contribute additional species to the regional lists included in the REF_LICHEN_SPP_COMMENTS table for the sake of future specialists and the program's data quality. In the identification process, isomorphs or near isomorphs are identified to species (or species groups) only to the extent possible with the combination of unambiguous cortical and medullary spot tests and long-wave ultraviolet lamp exam results. Thin-layer chromatography analysis, which is necessary to identify some chemical species or to confirm tentative identifications of other chemical species, is not done routinely in this program. Also, anatomical sections to reveal microscopic details (such as spore examination or light microscopy examination of fungal tissue type in cortices of some specimens) are not generally done. In some cases, these would be needed to distinguish near-isomorphs. Note: you can do these more detailed procedures if you wish, but the FIA program will not pay for your time!

Guide to Completing the Lichen Identification Data Sheet

If you have **any** questions about how to fill out a Lichen ID data sheet, please call us to clarify—it will save us all a lot of time! Electronic files are acceptable if they have all of the characteristics of the hard copy data sheets described below. Figure 10 is an example of a region-specific data sheet, figure 11 is an example of a generic blank sheet; figure 12 is an example of a data sheet filled out following instructions.

Lichen Identification Data Sheet

Forest Inventory and Analysis – Northeast Region – Eastern Urbanized – MA, CT, RI, NJ

Plot Number _____

Date Collected _____

State _____

County _____

Collector _____

Lichen Specialist _____

		DATA TO ENTER		DATA FROM FIELD COLLECTION PACKETS						
	Species	Sp. Code	Abund.	Bag #	Abund.	Bag #	Abund.	Bag #	Abund.	Comments
	<i>Allocetraria oakesiana</i>	1012			1..2..3		1..2..3		1..2..3	
	<i>Candelaria concolor</i>	8301			1..2..3		1..2..3		1..2..3	
	<i>Cladonia chlorophaea</i>	1210			1..2..3		1..2..3		1..2..3	
	<i>Cladonia coniocraea</i>	1211			1..2..3		1..2..3		1..2..3	
	<i>Evernia mesomorpha</i>	2403			1..2..3		1..2..3		1..2..3	
	<i>Flavoparmelia caperata</i>	2601			1..2..3		1..2..3		1..2..3	
	<i>Hypogymnia physodes</i>	3116			1..2..3		1..2..3		1..2..3	
	<i>Imshaugia aleurites</i>	3301			1..2..3		1..2..3		1..2..3	
	<i>Melanelixia subaurifera</i>	4015			1..2..3		1..2..3		1..2..3	
	<i>Myelochroa aurulenta</i>	4201			1..2..3		1..2..3		1..2..3	
	<i>Myelochroa galbina</i>	4202			1..2..3		1..2..3		1..2..3	
	<i>Parmelia squarrosa</i>	4805			1..2..3		1..2..3		1..2..3	
	<i>Parmelia sulcata</i>	4806			1..2..3		1..2..3		1..2..3	
	<i>Parmeliopsis ambigua</i>	5201			1..2..3		1..2..3		1..2..3	
	<i>Parmotrema hypotropum</i>	5314			1..2..3		1..2..3		1..2..3	
	<i>Parmotrema margaritatum</i>	5318			1..2..3		1..2..3		1..2..3	
	<i>Phaeophyscia pusilloides</i>	5613			1..2..3		1..2..3		1..2..3	
	<i>Phaeophyscia rubropulchra</i>	5614			1..2..3		1..2..3		1..2..3	
	<i>Physcia aipolia</i>	5702			1..2..3		1..2..3		1..2..3	
	<i>Physcia millegrana</i>	5716			1..2..3		1..2..3		1..2..3	
	<i>Physcia stellaris</i>	5723			1..2..3		1..2..3		1..2..3	
	<i>Physconia detersa</i>	5901			1..2..3		1..2..3		1..2..3	
	<i>Physconia leucoleiptes</i>	5911			1..2..3		1..2..3		1..2..3	
	<i>Platismatia tuckermanii</i>	6106			1..2..3		1..2..3		1..2..3	
	<i>Punctelia rudecta</i>	6708			1..2..3		1..2..3		1..2..3	
	<i>Pyxine sorediata</i>	6808			1..2..3		1..2..3		1..2..3	
	<i>Usnea hirta</i>	8041			1..2..3		1..2..3		1..2..3	
	<i>Usnea subfloridana</i>	8072			1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
					1..2..3		1..2..3		1..2..3	
	<i>Cladonia squamules— note presence here ->></i>				1..2..3		1..2..3		1..2..3	

Figure 10—Sample regional lichen identification data sheet.

Lichen Identification Data Sheet

Plot No. _____

Field Collect. Date _____

Lichen specialist _____

County, State _____

Collector _____

ID Date _____

= Coll. No. A = Abundance on packet. Abun = Final Abundance (see rules). Sp. Code – See Epiphyte Master List

Species Name		FINAL DATA		DATA FROM PACKETS								Comments
		Sp. Code	Abun.	#	A	#	A	#	A	#	A	
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

3/2003

Abundance codes used by field crews: 1 = Rare (1-3 individuals seen), 2 = Occasional (4-10 individuals seen),

3 = Common (> 10 individuals seen, but on fewer than half of legal substrates),

4 = Abundant (more than half of the legal substrates have this species).

Species codes: Refer to Epiphyte Master List for lichen species code numbers.

Figure 11—Sample generic blank lichen identification data sheet.

Lichen Identification Data Sheet

Plot No 5512336 [fictional plot no.]

Field Collection Date July 29, 2002

Lichen specialist Sally Q. Specialist

County, State Casino, NV

Collector Ernest Crewmember

ID Date 10/05/02

= Coll. No. A = Abundance on packet. Abun. = Final Abundance (see rules). Sp. Code – See Epiphyte Master List

Species Name		FINAL DATA		DATA FROM PACKETS								Comments
		Sp. Code	Abun.	#	A	#	A	#	A	#	A	
1	<i>Flavopunctelia soledica</i>	2704	3	1	3	7	2	5	0			
2	<i>Melanohalea subolivacea</i>	4017	3	3	2	8	2	9	3			
3	<i>Phycia adscendens</i>	5701	1	6	1							
4	<i>Phycia biziana</i>	5705	3	2	1	5	2	11	2			
5	<i>Usnea hirta</i>	8041	2	10	2							
6	<i>Xanthomendoza fallax</i>	8203	2	4	1	12	1					
7	<i>Phaeophyscia hirsuta</i>	5605	0.01	11	0							
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												

3/2003

Abundance codes used by field crews: 1 = Rare (1-3 individuals seen), 2 = Occasional (4-10 individuals seen), 3 = Common (> 10 individuals seen), 4 = Abundant (more than half of the legal substrates have this species).
Species codes: Refer to Lichen Species Master List for lichen species code numbers.

Figure 12—Sample completed lichen identification data sheet. Data are ready for entry.

Use this guide with a blank Lichen Identification Data Sheet (fig. 11) provided in this appendix or feel free to tailor the data sheets to taxa in your region with pre-entered species names and codes (see fig. 10). If you create electronic lichen ID data sheets, please maintain columns as they appear in the Lichen ID data sheet files provided. Also maintain species order on the sheet as you entered them in the data file; **do not** re-sort them.

First, fill out the upper fields from the plot data card, as follows. These fields differ somewhat on different lichen ID data sheets.

Plot No. P3HEX	<u>[from Plot Data Card]²</u>	Field Collection Date:	<u>[from Plot Data Card]</u>
Lichen specialist:	<u>Your name</u>	County, State:	<u>[from Plot Data Card]</u>
Collector:	<u>Crew name</u>	ID Date:	<u>[your date]</u>

Next, identify all species in each packet and enter data in the “Species Name” and “Data From Packets” fields as specified below. Use the attached sample Lichen ID data sheets as guides. After you identify the species(s) in the first packet, do the following:

- Fill out the species name in the lefthand column (or find the species name in preprinted regional versions. If not already there, write the name in a blank space at the end of the list.)
- On the right hand section of the lichen ID data sheet (under the heading “Data From Packets”), enter the Collection No. from the packet into the first “#” column, and the abundance code as marked on the packet into the first “A” field. (If using preprinted forms like fig. 9, enter the Collection No. in the “Bag #” column, and circle the appropriate abundance code in “Abund.”)
- If **Incidental Species** are found, write or locate their name(s) in the appropriate place on the lichen ID data sheet and clearly handwrite an abundance of zero (0). (If using preprinted forms, draw a line through the 1..2..3 numbers and write in the zero.)
- For **Abundance Code 4**—on preprinted forms—draw a line through the 1..2..3 and handwrite 4 in the abundance column.
- If the **Abundance Code is missing** from the packet, enter a zero (0) abundance on the packet and Lichen ID data sheet for that collection.

² Please verify that all the information, especially the P3HEX (= HEXID = old FHM hexid) number, on the Plot Data Card is the same as the number on the sample packets, and that it has been correctly copied to the ID sheet. Report any anomalies to the lichen IA immediately.

- If a **Collection Number is missing**, assign it a sequential number starting after the last numbered packet. Continue identifying species in all remaining packets. If a species is identified more than once, fill in subsequent bag #'s and **Abundance** codes to the right of the first entry, as needed.

Once all packets are identified, fill in the boxes under the heading “Final Data” (or “Data to Enter”). These two columns are to the right of the species name column.

Species code. If the code is not preprinted, fill in “Sp. Code” (Species Code) from the LICH_SPPCD field in the most recent version of REF_LICHEN_SPECIES.

Abundance code. Fill in the Final Abundance code (“Abun” or “Abund”) using the addition rules in the section “Calculating the Final Abundance Scores” below.

If contracted to do electronic data entry, enter the data and prepare a text (.txt) file using the instructions provided in the section “Sample Lichen Data File.” The order of species on the lichen ID data sheet should match the order of entry into the electronic data file; this makes using lichen ID data sheets to proofread electronic data output easier and less prone to errors.

Data Recording—Details

Incidentally collected species—

Despite the best efforts by the field crew, the lichen specialist will occasionally encounter species collected incidentally along with the target species. These species need to be identified by the specialist, but will not have an abundance code assigned by the field crew. The incidental species name should be recorded both on the packet and lichen ID data sheet. Also on the lichen ID data sheet, note the collection or bag number and record a missing value indicator of zero (0) in the abundance column.

Missing values—

As with incidental species, when an abundance code is absent from a packet, it is entered on the lichen ID data sheet as zero (0).

Entering ‘0’ abundances—

If the final abundance for a species is zero, it is entered into the computer as 0.01. At a later time—after data have been submitted to the Forest Service for analysis—0.01 values automatically will be converted to 3s for most kinds of analysis. This substitution is used because a score of 3 is by far the most probable value for the abundance code.

Handling multiple collections of the same species—

In the field, crew members are instructed to err on the side of assuming that individual specimens are different, when they are unsure if a new specimen is different from ones already collected. So it is expected that, in many cases, two or more collections

from a given plot will be of the same species. This should be noted on the lichen ID data sheet by recording multiple specimen numbers on the same species line.

Recording genus-only specimens—

Use the comments section to explain why a genus-only specimen is not named to species. Note if it is too small, or tell how it differs from other species in the genus already listed. Defend your decision: clearly indicate how this specimen is different from species already identified in the notes section on the lichen ID data sheet. If a good specimen does not match a described species, a voucher should be prepared. Enter a genus-only code into the electronic data file (and record this on the lichen ID data sheet) only when you are quite certain that this specimen cannot be referred to a species in the genus that is already identified for this plot, or if no other members of that genus were found. There is one exception: enter a *Cladonia* sp. if it has podetia but cannot be identified to species and it appears different from all other *Cladonia* species recorded on the plot; do not enter squamules only. In the notes section on the Lichen ID data sheet, make a note that podetia are present, or the data will not be entered.

Recording unknown specimens—

The code 9999 should be used for a specimen that cannot even be assigned to genus when it is of reasonable size and has particular identifying characters. Specimens that are too small to identify should not be assigned this code. Non-lichenized fungi collected by the crews fits into this category. Any sample that fits this designation should be included as a voucher specimen.

Calculating Final Abundance Scores

In the field, the following criteria are used to assign abundance scores (see table 5 on page 44) as reported on the packets:

- 1** = Rare (1 to 3 individuals seen)
- 2** = Occasional (4 to 10 individuals seen)
- 3** = Common (>10 individuals seen, but on fewer than half of legal substrates)
- 4** = Abundant (more than half of legal substrates have this species).

After all collections from the plot have been recorded, a final abundance score needs to be calculated for those species having two or more specimens, following the rules in table 6. Record that number on the lichen ID data sheet in the appropriate “Final Data” or “Data to Enter” column, using the following rules for combining values.

Table 6—Conversion of multiple field abundance codes for one species to final plot abundance

Recorded values	Final abundance
1 + 1	2
1 + 1 + 1 + 1 + 1	2
More than five 1s	3
1 + 2	2
2 + 2	2
1 + 1 + 2	2
1 + 1 + 1 + 2	3
1 + 2 + 2	3
3 + any others	3
4 + any others	4
0 + 1	3
0 + 2	3
0 + 3	3
0 + 4	4
0 (any number of 0s with no other values)	0.01

Electronic Data Entry—Creating a Data Input File for FIA Lichens

The “compact data entry” file structure described below is the official data entry format and is also acceptable to “PC-ORD” data analysis software. Such a file, when used with a master file of lichen species names containing number codes and 6-letter acronyms (SPP_ACRONYM in REF_LICHEN_SPECIES) together allow data manipulation in PC-ORD.

These instructions are for entering data in your favorite word processing program, or in a simple text editor program. If you are comfortable using spreadsheets, instruction #11 tells how to enter data efficiently into a spreadsheet. If you aren’t really familiar with spreadsheets, stick to using a word processor.

Files

1. Prepare three files (or only two if there are no QA samples): Plot Data, QA Data, and Notes.
2. Give filenames that include either the whole region or the states (such as NY+ME or NYME—no commas or other punctuation allowed) and the year (03 is fine) without spaces. For example, name the plot data file “NYME03-Data” and the QA file “NYME03-QAData.” Use the same root name for the notes file; for instance, “NYME03-Notes.”

3. Save all data files to submit as simple text files, using your word processing or spreadsheet program. Such files have a “.txt” extension. You save as one of these: ASCII DOS text **or** text only **or** tab-delimited text (or ASCII text). Comma-delimited text is acceptable, but not preferred. It depends on your software what it is called. You can also prepare the compact data document using Simple Text or Notepad or other software that automatically saves in a .txt extension, thus avoiding having to convert. The choice is yours.

Data Entry

1. For these compact data files, do not type any characters other than letters, numbers, and forward slashes. Use either the space bar between entries or a customized tab setting. End each data record with a hard return (“Enter”). **Note:** there is no title allowed in the body of the file.
2. For hot audits and blind checks, the crew person’s plot is entered into both the regular plot data file and the QA data file. In the QA file, you will have two or more samples for each plot number. In **only** the QA file, give the crew sample one letter after the P3HEX number (such as 5512536a), and the expert sample a different letter after the same P3HEX number (such as 5512536x). In the Notes file, tell exactly who—field crews and experts, by name—each letter stands for. Use letter codes assigned by the IA if you are sent such a file; create your own set of letter codes if you are not sent them. Use the same letter for the same person throughout the file. You can also write other notes to the lichens IA there.
3. States are entered into the file in alphabetical order. P3HEX numbers for one state are grouped together. Within a state, list P3HEX numbers in **ascending numerical order** (smallest number first).
4. On the top line of the file’s first page, type “**BREAK**” or “**break**” (capital letters optional) flush left to the margin, no spaces. Hit “Enter.” On the next line, type the two-letter postal code for the state flush left to the margin, no spaces (caps optional). Hit “Enter.” Type the first P3HEX number and proceed as described below. When a state’s data entry is complete, hit “Enter.” With no blank lines, type “**break**,” then the next state’s postal code, and so on. If there is a blank line between states, it will cause an error in the regions’ uploading of data. When you finish the last entry for the last state, hit “Enter,” but type nothing more.
5. A data record for a single plot consists of two lines at minimum. The first line gives the P3HEX number, flush left to the margin. There are eight spaces allowed to this entry—no blank spaces. Put the P3HEX in the first seven spaces. For QA plots, add one letter in the 8th space (see #2 above). Hit “Enter.”

6. On the second line, enter species and abundance information. Each species entry is a couplet of numbers. At the beginning of the line, type the first species number code, space (or tab), then type the species abundance code. Space again, then type the next species code, space, abundance code, space, and so on. Abundances of “0” are entered as “0.01” If there are lots of species, the data may require two or more lines. Keep typing and let the line wrap automatically for as many lines as needed. Species code numbers and abundances should be entered **in the order they appear** on the plot lichen ID data sheet, whether on a hand-annotated preprinted sheet/species list or on an electronically generated sheet.
7. After the last species abundance code, hit the space bar once, type a forward slash “/” and then hit Enter. If the space is missing, there will be no error generated in PC-ORD; however, a missing space will generate an error in the FIA database when the data are uploaded. In FIA lichens data protocol and PC-ORD software, “/” signals the end of a record for a single plot. Start the next P3HEX on the next line.
8. Plots searched and found to be empty of lichens should be included in the electronic dataset. For an empty plot, type the P3HEX on the first line, hit Enter, type a forward slash on the second line, then hit Enter.
9. If a lichen specimen is identified only to genus (and hence is listed as “Genus sp.” on the lichen ID data sheet), enter it into the electronic data file **only** if either it is different from other species based on notes on the lichen ID data sheet, or there are no other species of that genus found on that plot. Also, **only**-enter “*Cladonia* sp.” Only for a specimen that has a note saying podetia are present but the specimen can’t be assigned to a species or FIA species group and it appears different from any other *Cladonia* sp. on the plot. **Never** enter the genus-only code for a specimen consisting only of squamules.
10. There are several strictly squamulose or crustose genus and species names, such as *Normandina pulchella*, *Hypocenomyce* spp. and *Catapyrenium* spp., listed in REF_LICHEN_SPECIES. **Do not** enter these into an FIA electronic data file; just note them on the lichen ID data sheet. See the REF_LICHEN_SPP_COMMENTS table.

11. **For spreadsheets.** You can enter data in two ways: (1) enter exactly as described above, listing plots in numerical order by state, or (2) put the HEXID and data all on one line, sorting lines later by number and then manipulating the sheet into the two-line format, adding “break” and state codes.

Method A. In the top left cell, type “break.” In the next cell down, enter the two-letter state code. In the third cell down, type the P3HEX. In the fourth cell down, enter species and abundance data using the protocol above, but each time the directions say “space,” move one cell to the right. A forward slash ends the record (and occupies the cell to the right of the last abundance code). Do not leave empty cells in the row.

Method B. To record in one line, enter the P3HEX in the leftmost cell, put the first species code in the next cell right, list abundance in the third cell, and so on. Within a state, use the sort function to put P3HEX lines in ascending order (smallest number first). The last thing you do, after data entry is complete, is copy your page to a new page, and manually add a blank line after EACH data entry line. Next, highlight and cut the data to the right of each P3HEX number (all species and abundance pairs, plus the forward slash) and paste in the next row down, flush left. That gives you the two-line data record that is needed. Add **break** and the state code—on the two rows directly above the start of each state’s records. Save the new page as a tab-delimited text (.txt) file, and submit copies of both the spreadsheet and text file.

12. Be sure to **proofread** your data file completely before you send it to the lichen indicator advisor! This includes checking to confirm that plots are listed in numerical order.

Following is an example data file as it should look. It is followed by selections from that file to illustrate important file features, along with explanatory comments. Data for plot 5512336 are summarized from figure 12 above. Note: The HEXID numbers throughout this document are fictional examples.

Example of a DATA INPUT text file

```
BREAK
NV02
5512336
2704 3 4017 0.01 4002 3 5701 3 5705 3 8000 3 8214 3 8203 1 /
5512546
2704 3 4017 3 5701 0.01 1008 0.01 5705 3 5723 3 5801 0.01 6303 3 8041 3 8203 3 /
5512552
2704 3 4017 3 4002 3 5701 3 5705 2 8041 3 8214 2 8203 3 /
5512571
2704 3 4004 1 4017 3 5701 3 5705 3 8044 3 8203 2 /
BREAK
NV02
5512536
2704 3 4017 3 5701 1 5705 3 8041 2 8203 2 5605 0.01 /
5512542
5602 3 5605 3 5705 3 8203 2 /
5512566
/
5512578
2704 3 4017 3 5701 2 5705 3 5611 0.01 8000 3 8214 3 /
5512579
607 3 610 3 8152 2 1200 2 2704 3 4017 3 4004 0.01 4800 3 5201 3 5612 3 5600 3
5611 3
5701 2 5906 3 6303 3 6920 3 8044 3 3106 3 /
55612610
610 0.01 4017 3 5723 3 5701 3 8044 3 8203 3 8214 3 8041 0.01 9000 3 /
5512613
4017 3 4002 3 5612 1 5723 3 5700 3 5701 1 8044 3 8214 3 /
BREAK
WY02
5512601
4002 3 5705 3 8214 2 8203 3 /
5512609
4017 3 /
55612744
2704 3 4017 3 4806 3 5907 2 5707 3 5705 3 5701 2 8041 3 8203 3 8214 3 /
5512767
4004 3 4017 0.01 5701 3 5705 3 8214 3 8044 3 /
```

Comments on the Example Data File

Only selected entries were copied here for illustration. Comments appear below each example.

BREAK

NV02

The two lines above label the state as a subgroup of the whole dataset. They go at the top of a group of data records. (The QA dataset will have one or two subgroups—either or both QA-Hot and QA-Blind. Use these titles in place of state codes.)

5512336

2704 3 4017 0.01 4002 3 5701 3 5705 3 8000 3 8214 3 8203 1 /

The two lines above make one data record, for HEXID 5512336. Note that the second abundance code is 0.01— that’s how you enter an abundance of “0.” Also note that there is a space between the last number (always an abundance code) and the forward slash, which signals the end of that plot record. There is a hard return (Enter) after the forward slash.

5512566

/

The two lines above illustrate how to enter a plot that was visited and searched but had no lichens.

5512579

607 3 610 3 8152 2 1200 2 2704 3 4017 3 4004 0.01 4800 3 5201 3 5612 3 5600 3
5611 3 5701 2 5906 3
6303 3 6920 3 8044 3 3106 3 /

When there are lots of species, the record may take two or more lines. In a word processor, do not make a hard return in the middle of the line of species and abundance codes—just let it wrap around on its own. In a spreadsheet, type all species information into a single row. When you export as a .txt file, soft line breaks will be added automatically.

5512610

610 0.01 4017 3 5723 3 5701 3 8044 3 8203 3 8214 3 8041 0.01 9000 3 /

5512613

4017 3 4002 3 5612 1 5723 3 5700 3 5701 1 8044 3 8214 3 /

BREAK

WY

5512601

4002 3 5705 3 8214 2 8203 3 /

As above, when one plot or state (or QA) subgroup ends, begin the next without leaving a blank line between.

5512609

4017 3 /

This plot above had only a single species.

BREAK

WY

5512601

4002 3 5705 3 8214 2 8203 3 /

5512609

4017 3 /

55612744

2704 3 4017 3 4806 3 5907 2 5707 3 5705 3 5701 2 8041 3 8203 3 8214 3 /

5512767

4004 3 4017 0.01 5701 3 5705 3 8214 3 8044 3 /

There is no special marker for the end of the file—just the final forward slash.

Appendix 5: Number of Lichen Surveys Conducted Each Year by State Using the Forest Inventory and Analysis (FIA) Protocol

Totals for four FIA regions (tables 7 through 10) include both on- and off-grid locations. Air Resources Management program survey numbers are shaded in gray.

Table 7—Number of lichen surveys from the FIA Pacific Northwest Region states

Pre-State	Year																					
	1994	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	Total	
AK	0	0	0	0	0	0	0	0	0	0	0	15	20	47	46	4	71	0	0	0	203	
AK	212	7	0	0	0	0	0	2	0	0	2	29	17	0	0	21	13	0	19	15	337	
CA	0	0	0	0	0	58	47	62	59	32	116	0	0	0	0	23	10	0	0	0	407	
CA	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	3	
HI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
OR	0	0	0	0	0	82	46	55	64	0	62	0	0	0	0	0	0	0	0	0	309	
OR	30	143	190	177	295	100	132	115	12	1	19	174	185	0	58	30	63	41	32	27	1,824	
WA	0	0	0	0	0	48	43	41	37	0	43	0	0	0	0	0	0	0	0	0	212	
WA	103	47	55	72	56	19	22	1	0	0	49	42	70	18	26	18	16	0	23	61	698	
Total	345	197	245	249	351	307	290	277	172	33	291	260	292	65	130	96	173	41	76	103	3,993	
AK = Alaska; CA = California; HI = Hawaii; OR = Oregon; WA = Washington.																						

AK = Alaska; CA = California; HI = Hawaii; OR = Oregon; WA = Washington.

Table 8—Number of lichen surveys from the Forest Inventory and Analysis Intermountain Region states

State	Pre-1994	Year												Total							
		94	95	96	97	98	99	00	01	02	03	04	05		06	07	08	09	10	11	12
AZ	0	0	0	0	0	0	0	0	43	43	34	29	31	0	34	20	21	16	0	0	271
CO	0	38	39	16	0	0	0	0	44	47	54	48	0	0	30	29	34	24	0	0	458
ID	0	0	0	139	0	0	0	0	46	43	0	41	45	22	18	27	21	23	2	0	427
ID	0	0	0	0	0	0	0	9	0	0	7	0	0	0	0	6	0	7	0	2	31
MT	0	0	0	0	0	0	0	0	0	0	49	0	0	23	23	18	20	27	34	0	194
MT	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	9	0	0	2	0	21
NM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	61	0	0	81
NV	0	0	0	0	0	0	0	56	5	0	0	14	25	8	0	0	0	15	0	0	123
UT	0	0	0	0	0	0	0	130	0	0	0	0	36	13	14	22	15	20	0	0	250
WY	0	0	0	0	55	0	2	5	0	24	28	0	0	0	0	4	0	7	20	0	145
Total	0	38	39	155	55	0	188	58	141	164	183	132	137	66	119	135	131	200	58	2	1,965

AZ = Arizona; CO = Colorado; ID = Idaho; MT = Montana; NM = New Mexico; NV = Nevada; UT = Utah; WY = Wyoming.

Table 9—Number of lichen surveys Forest Inventory and Analysis in Northern Region states, by year

State	pre-1994	Year																Total		
		94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09		10	11
CT	0	4	0	0	0	2	5	3	4	2	6	0	0	0	0	0	0	0	0	26
DE	0	0	0	0	0	0	0	21	19	18	14	18	9	0	0	0	0	0	0	99
IA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
IL	0	0	0	0	0	10	13	0	0	0	0	0	0	0	0	0	0	0	0	23
IN	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	20
KS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MA	0	8	0	0	0	7	6	9	5	8	6	0	0	0	0	0	0	0	0	49
MD	0	7	1	0	0	0	0	0	5	3	3	14	7	0	0	0	0	0	0	40
ME	0	38	0	0	0	14	52	48	40	42	41	0	0	0	0	0	0	0	0	275
MI	0	0	0	0	0	18	39	0	0	0	0	0	0	0	0	0	0	0	0	57
MN	0	29	0	0	0	39	46	0	0	0	0	0	0	0	0	0	0	0	0	114
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NH	0	12	0	0	0	11	11	10	11	8	7	0	0	0	0	0	0	0	0	70
NJ	0	2	0	0	0	3	6	4	13	7	4	5	0	0	0	0	0	0	0	44
NY	0	14	0	0	0	0	0	38	58	49	44	40	0	0	0	0	0	0	0	243
OH	0	0	0	0	0	0	0	0	16	19	26	19	19	0	0	0	0	0	0	99
PA	0	8	22	0	0	0	28	80	148	50	36	6	0	0	0	0	0	0	0	378
RI	0	2	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	7
SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VT	0	12	0	0	0	6	9	12	6	10	8	0	0	0	0	0	0	0	0	63
WI	0	0	0	0	0	21	1	0	0	0	0	0	0	0	0	0	0	0	0	22
WV	0	0	19	0	0	0	26	27	25	28	28	10	0	0	0	0	0	0	0	163
Total	0	136	42	0	0	141	253	253	352	245	223	112	35	0	0	0	0	0	0	1,792

CT = Connecticut, DE = Delaware, IA = Iowa, IL = Illinois, IN = Indiana, KS = Kansas, MA = Massachusetts, MD = Maryland, ME = Maine, MI = Michigan, MN = Minnesota, MO = Missouri, ND = North Dakota, NE = Nebraska, NH = New Hampshire, NJ = New Jersey, NY = New York, OH = Ohio, PA = Pennsylvania, RI = Rhode Island, SD = South Dakota, VT = Vermont, WI = Wisconsin, WV = West Virginia.

Table 10—Number of lichen surveys from the Forest Inventory and Analysis Southern Region states

State	pre-1994	Year												Total							
		94	95	96	97	98	99	00	01	02	03	04	05		06	07	08	09	10	11	12
AL	0	30	0	0	0	0	38	38	0	0	0	0	0	0	0	0	0	0	0	0	106
AR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GA	37	34	0	0	0	0	42	39	0	0	0	0	0	0	0	0	0	0	0	0	152
KY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NC	18	0	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	56
OK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SC	8	0	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	33
TN	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
TX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VA	13	28	22	0	0	0	33	34	0	0	0	14	0	0	0	0	0	0	0	0	144
VA	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Total	85	111	22	0	0	0	113	174	0	0	0	14	0	0	0	0	0	0	0	0	519

AL = Alabama, AR = Arkansas, FL = Florida, GA = Georgia, KY = Kentucky, LA = Louisiana, MS = Mississippi, NC = North Carolina, OK = Oklahoma, SC = South Carolina, TN = Tennessee, TX = Texas, VA = Virginia.

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