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THE NMSU HERBARIUM DATABASE AND MONOCOT ANALYSIS

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The Northeast Missouri State University (NMSU) herbarium (NEMO) database provides a utilization model for computer management of a small regional collection. This paper explains the project plan, outlines database structure and presents applications, using examples from NEMO Missouri monocot specimens.

The NEMO herbarium contains over 20,000 plant specimens, primarily from the United States, and specializing in flora of northeast Missouri (Ford and Rugge, 1994). Although development of the collection database is an ongoing project with long- and short-term objectives, the ultimate goal is to have label information from every NEMO specimen entered into a computerized database.

A computerized specimen catalog facilitates information retrieval and analysis, allowing rapid and efficient sorting and list production. This enhanced information management enables the herbarium to better serve a diversity of needs and to fulfill its role in teaching, research and service. A discussion of the purpose, organization and procedures of the NEMO project can provide insights useful in creating guidelines and recommendations for other similar programs.

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DATABASE PROJECT DESCRIPTION

The NEMO project uses dBase III Plus software (Ashton-Tate Corporation, 1986) running on a Zenith 386 PC-compatible microcomputer with a 40 megabyte hard drive. Specimen label information is typed into the appropriate data field on the screen form (Fig. 1). Field sizes and definitions are summarized in Appendix 1. Specific procedures and further details are discussed in the NEMO herbarium manual (Ritter and Ford, 1993). The major consideration is consistency of data entry, including proper placement of field contents, uniform punctuation, and standard abbreviations (Fig. 2).

The collection catalog is being created through a stepwise process, begun in January 1992. Initially, only Missouri vascular plant collections are being entered into the computerized database. After this is completed, non-Missouri (other states, foreign, and horticultural) and non-vascular plant specimens will be included as separate files.

The project does not attempt to confirm correct species identification, but obvious taxonomic incongruities (mixed collections, gross misdeterminations) are noted and corrected as possible. In addition, determinations for many Missouri specimens are being confirmed by staff of the Flora of Missouri Project. Nomenclature for Missouri collections is also updated according to a standard reference, Yatskievych and Turner (1990). After being entered into the database, each specimen is marked by a press-on dot placed in the lower right-hand corner of the sheet.

The data entry process also provides occasion for other collection maintainance tasks that increase the overall quality of the herbarium. Any deteriorated or damaged specimens are set aside for remounting or repair, thereby upgrading the material. Other simple operations such as reorganizing folders, minor label changes, etc. are routinely dealt with. A running tally is kept by family of specimen numbers for Missouri, other states and foreign collection site categories.

FAM	MISSOURI SPECIMEN DATA (NEMO)		GROUP
SPECIES		DET	
COUNTY T /R	SECT	PART	PART2
LAT(N)/LONG(W)	/	ELEVATION	LOCALITY
			(CONT):
HABITAT			C ?
PLANT			C ?
NOTES			MISC
COLLECTOR	ET AL	NUMBER	
DATE (D/M/Y)	PHEN	ACCESSION	

Figure 1. Sample (blank) screen form for data entry into the NMSU Herbarium Database.

FAM Lili	MISSOURI SPECIMEN DATA (NEMO)		GROUP: M
SPECIES Erythronium albidum		DET	
COUNTY Rand T55N/R14W PART2 NW1/4	SECT 30	PART SW1/4	
LAT(N)/LONG(W) Huntsville, 6.5 mi N	/	ELEVATION 650 ft.	LOCALITY
			(CONT F):
HABITAT W slopes of deciduous oak-hickory woods			C F
PLANT			C F
NOTES coll w/ Dimit & Leonard; "Dogtooth Violet"			MISC T
COLLECTOR Conrad	ET AL T	NUMBER 8978	
DATE (D/M/Y) 03 Apr 1981	PHEN fl	ACCESSION 12962	

Figure 2. Sample entry into the NMSU Herbarium Database. Note that fields for which data are not present on the specimen label are left blank in the database record.

Table 1. Taxonomic and floristic summary of the NEMO herbarium, indicated by the number and percent of area flora at indicated ranks represented by NEMO monocot specimens.

	Missouri	Adair County
Families	19 (83 percent)	18 (100 percent)
Genera	112 (63 percent)	79 (91 percent)
Species	326 (46 percent)	172 (85 percent)

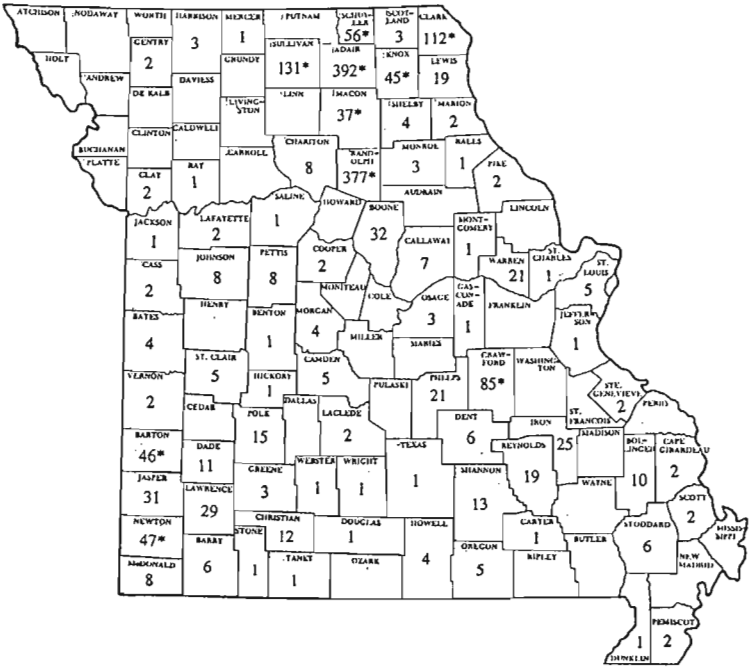

Figure 3. The geographic distribution of NEMO Missouri monocot collections, as indicated by the number of specimens for each county. The ten counties with the most collections are indicated with an asterisk (*).

ANALYSIS OF MISSOURI MONOCOTS

The NEMO Missouri monocot collection comprises ca. 1750 specimens. The present study analyzes monocot data categories related to taxonomic representation, floristic composition, localities, collectors and collection dates.

NEMO Missouri monocot holdings include 19 families, 112 genera and 326 species (Table 1). This represents 83 percent, 63 percent, and 46 percent of the total state monocot flora, respectively (Steyermark, 1963). For Adair County (site of NEMO) monocots, the collection has 18 families, 79 genera and 172 species. This comprises 100 percent, 91 percent and 85 percent, respectively, of the recorded county flora.

The decreased completeness at lower taxonomic ranks is expected, both statewide and more locally, because of increasing taxon (group) size. However, the higher percentages for all ranks on the county basis reflect an emphasis by local collectors for the nearby flora. The benefit derived from these readily generated species-area comparison lists is that one can focus collecting and exchange efforts on obtaining species that are not represented well in the herbarium.

The geographic distribution of NEMO Missouri monocot collections is summarized in Fig. 3. Among these, 37 counties (out of 114 total) are not represented (32 percent), and will be targeted for future acquisitions. The ten numbers with asterisks indicate those counties that are represented by the most monocot specimens. Adair County, having 392 collections (23 percent), and surrounding counties (with the notable absence of Putnum) rank highest, reflecting local collecting bias. The other top counties contain a university field station (Crawford), project sites (Randolph), and family residences and/or vacation spots (Barton and Newton).

The NEMO herbarium contains vouchers of 80 county records for 67 monocot species from 11 Missouri counties (Fig. 4). It also has specimens of seven state-listed species (Missouri Department of Conservation, 1994) from four monocot families (Table 2). The collection is consulted by Missouri Department of Conservation staff working on plant protection, as well as by university researchers studying ecology and population biology.

Figure 4. The geographic distribution of county records in the NEMO herbarium, indicated by numbers of records per county.

Table 2. State-listed Missouri monocots (Missouri Department of Conservation, 1994), with taxon, county, and present state rank of NEMO specimens indicated. For state ranks, E=endangered, R=rare.

Family	Species	County	State Rank
Cyperaceae	*Carex nigromarginata* var. *nigromarginata*	Douglas	E
Cyperaceae	*Cyperus grayoides*	Scott	E
Cyperaceae	*Cyperus plukenetii*	Stoddard	E
Cyperaceae	*Scirpus polyphyllus*	Bollinger	R
Liliaceae	*Amianthium muscitoxicum*	Oregon	R
Poaceae	*Tridens muticus* var. *elongatus*	McDonald	R
Potamogetonaceae	*Potamogeton pusillus* var. *pusillus*	McDonald	E

NEMO was established in 1947, by purchase of 2000 specimens dating as early as 1886 (Ford and Rugge, 1994). The distribution of Missouri monocot collections by year is summarized in Fig. 5, which demonstrates some interesting points. The greatest addition of specimens occurred after 1967, during the 23 years when Dr. Melvin Conrad was curator. The local peaks represent special projects and collecting trips, such as vegetation surveys done in the early 1980's (Dimit et al., 1980; Kangas and Conrad, 1985).

NEMO Missouri monocot specimens reflect the efforts of 81 different collectors. All except 11 of these collectors have contributed 10 or fewer specimens (Fig. 6), with 40 collectors being represented by a single sheet. Of the top collectors, 6 have 11-50 monocot specimens, 3 have 51-100 collections and 2 have over 100 sheets.

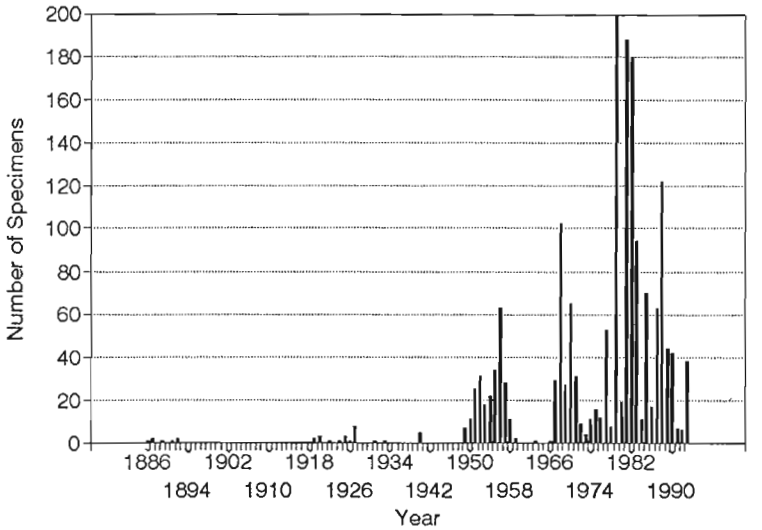

Figure 5. Numbers of specimens in the NEMO herbarium per year of collection.

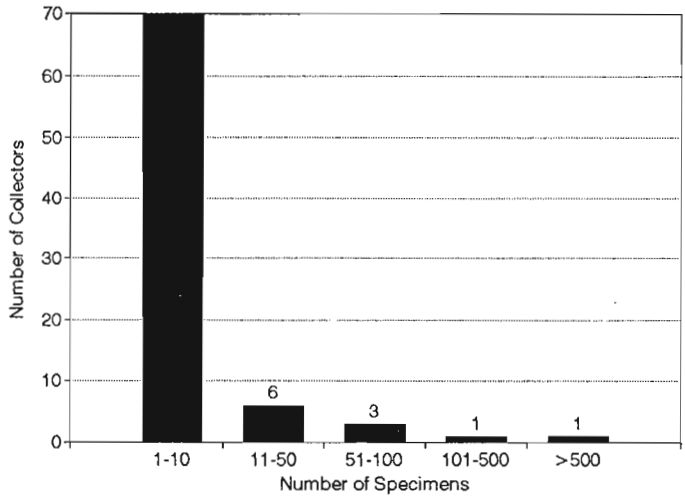

Figure 6. The number of collectors in various specimen-number classes, based on data from monocot collections in the NEMO herbarium.

Table 3. A list of the top NEMO Missouri monocot collectors, with the name, time period, and number of specimens (percent of total monocot collections) indicated. Collector's names are presently known for a total of 1745 NEMO monocot specimens (99.7 percent).

Rank	Name	Year(s)	Specimens
1.	Melvin Conrad	1967-1990	965 (55.3 percent)
2.	Ernest Palmer	1919-1959	211 (12.9 percent)
3.	Randall Walker	1979-1983	95 (5.4 percent)
4.	Tom Welton	1982	66 (3.8 percent)
5.	David Broyles	1982-1984	56 (3.2 percent)
6.	Julian Steyermark	1951-1956	45 (2.6 percent)
7.	Yuki Gleason	1988	45 (2.6 percent)
8.	Sylvia Hein	1982-1983	22 (1.3 percent)
9.	Rebecca Haefner	1979	16 (0.9 percent)
10.	Max Bell	1959-1966	11 (0.6 percent)
11.	Douglas LeDoux	1973-1978	11 (0.6 percent)
		Total specimens	1543 (89.2 percent)

The major collectors of Missouri monocots at NEMO are identified in Table 3, along with their collecting time-period and number of specimens. The top collector is Mel Conrad, former curator, whose 965 sheets represent over half of the NEMO monocot holdings. The remaining individuals are professional biologists (Palmer, Steyermark, Bell, LeDoux) and students or other amateur affiliates (Walker, Welton, Broyles, Gleason, Hein, Haefner).

CONCLUSIONS

At least two future applications related to the database are anticipated. One is to implement computer label production for new accessions and duplicate specimens. The second plan is to interface with a geographic coordinate-based mapping system to produce species distribution maps. The potential for networking and facilitated information exchange among herbaria and investigators is obvious, and such progress is beginning.

The examples presented above show that, even on a small scale, the database approach to specimen management can increase the value of a collection. In addition, it provides direction for future collecting and further research. Suggestions and/or questions relating to the project are welcome.

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APPENDIX 1

Field Definitions for NEMO Missouri Specimen Data: screen form name, field width (spaces allowed), and description; listed in the order displayed (Figs. 1 and 2), from left to right and top to bottom.

FAM(4): First four letters of the plant family name (-aceae form); in ambiguous cases, the first distinct letter is used for the fourth position (e.g., Polygalaceae=Pol**a**, Polygonaceae=Pol**o**).

GROUP(1): A for algae, B for bryophyte, C for cultivated, D for dicot, F for fungi, G for gymnosperm, L for lichen, M for monocot, P for pteridophyte.

SPECIES [2 fields] (13+15): Latin binomial name, excluding authority; subspecific designations are listed in the PLANT field.

DET(20): Person (last name) who identified the specimen and date, when known (e.g., Ford 2 Feb 92).

COUNTY(4): First four letters of the county.

T(3): Township number and direction.

R(3): Range number and direction.

SECT(2): Section number of the collection locality.

PART(5): Subdivision of the section--usually by quarters or halves (e.g., NE1/4, S 1/2).

PART2(5): Second (nested) part designation.

LAT(N)/LONG(W) [2 fields] (4+4): Geographic coordinates (north latitude/west longitude) in degrees and minutes of the collection locality.

ELEVATION(4): Altitude of the locality in feet.

LOCALITY(62): Collection site identification (e.g., city name, road number, mileage and direction information).

CONT(1): Logical (True/False) field that indicates whether the locality field is continued--overflow information is entered in the NOTES field.

HABITAT(50): Environment or position of the specimen (e.g., field, by RR, north of barn).

C(1): Logical field that indicates habitat or plant (below) field continuation (see CONT above).

PLANT(50): Habit or characteristics of the specimen (e.g., tree, 1m tall, petals red), including subspecific designations.

NOTES(60): Uncategorized and overflow field information or any remarks related to the specimen (e.g., new county record).

MISC(1): Logical field that indicates if the NOTES field contains data (T) or is empty (F).

COLLECTOR(11): Last name of the person who made the collection; in ambiguous cases, first initial is included for differentiation.

ET AL(1): Logical field, coded T if more than one collector is listed--additional last names are typed in the NOTES field.

NUMBER(6): Collector's fieldbook collection number.

DATE (D/M/Y) [3 fields] (2+3+4): Number of the collection day, first three letters of the collection month, and all four digits of the collection year.

PHEN(2): Phenology (life cycle stage) of the plant (bu=bud, co=cone, ff=flower and fruit, fl=flower, fr=fruit, sp=spore, st=sterile).

ACCESSION(5): NEMO herbarium number (transcribed from the herbarium accession stamp).

STATUS OF *BROMUS NOTTOWAYANUS* (POACEAE) IN MISSOURI

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Satin brome (*Bromus nottowayanus* Fernald) is perhaps one of the most misunderstood members of Missouri's flora. The species was described from specimens collected by M. L. Fernald and B. Long along the Nottoway River in Virginia in 1907 (Wagnon, 1952). Chase's (1951) range map for satin brome depicted the distribution of this species as Virginia, Maryland, North Carolina, Indiana, Illinois, Tennessee, and Arkansas. Chase listed the habitat for this species simply as "rich woods," whereas Wagnon (1952) reported that satin brome was found in "damp areas, usually in deep shade of wooded ravines along streams."

In recent years, we have discovered five localities for *B. nottowayanus* in Missouri:

Boone Co. Rock Bridge State Park, along Gans Creek, T47N R12W S7 and S8, 25 June 1993; *McKenzie 1237*; 26 June 1993; *McKenzie 1238;* 27 June 1993; *McKenzie 1240*; 7 August 1993; *McKenzie 1259*; 4 Sep 1993, *McKenzie 1266* (all MO).

Boone Co. Three Creeks State Forest, along Turkey Creek, ca. 0.80-2.01 km SW of Deer Park, T47N R12W S21, 3 July 1993, *McKenzie 1242*; 10 July 1993, *McKenzie 1243* (both MO).

Boone Co. Pinnacles Youth Camp, along Kelly Branch of Silver Fork Creek, ca. 1.1 km ENE of the intersection of Routes

63 and 124, ca. 19.3 km N of Interstate 70 in Columbia, T50N R13W S12, 17 July 1994, *McKenzie 1465* (MO).

Lewis Co., Accola Woods Preserve, ca. 1.5 mi N of Route 16 between Monticello and Canton, shaded terrace along small stream in mesic woodland, T62N, R7W S26, 24 July 1989, *Ladd 13756* (MOR)

St. Louis Co., Greensfelder County Park, ca. 2.4 km N of Allenton, open woodland along intermittent stream T44N, R3E S22, 3 Aug 1989, *Ladd 13758* (MOR).

Following these findings, George Yatskievych of the Missouri Department of Conservation discovered that Wagnon (1950a, 1952) had included Missouri within the historical range of *Bromus nottowayanus*, based on four Missouri specimens cited in Wagnon's dissertation (1950a): Jackson Co., *Mackenzie* on 10 June 1896 (NY); Madison Co., *Greenman* on 20 May 1927 (NY); Saint Louis Co., *Eggert* on 5 July 1887 (MO, NY); Saint Louis Co., *Eggert* on 23 July 1893 (MO, NY). The two specimens archived at MO are currently on loan to Dr. Leon E. Pavlick of the Royal British Columbia Museum in Victoria, British Columbia, who has been studying them in conjunction with floristic and taxonomic research on the genus *Bromus* in North America (Pavlick, 1995).

In his treatment of perennial bromes in North America, Wagnon (1950a, 1952) also added southern Ontario, New York, Iowa, Oklahoma, Texas, Michigan, and New Jersey to the range of this species. Steyermark (1963) and Yatskievych and Turner (1990) did not include satin brome in the Missouri flora.

CURRENT STATUS IN MISSOURI

The current status of *Bromus nottowayanus* in Missouri is poorly known. Collections cited by Wagnon (1950a) and recent collections by the authors suggest that the species may have been scattered throughout the state historically.

Presently, satin brome occurs along Gans Creek, Turkey Creek, and the Kelly Branch of Silver Fork Creek in Boone County; a small drainage in St. Louis County; and the south branch of Sugar Creek in Lewis County. Eggert's vouchers that were cited by Wagnon (1950a) were possibly taken from the same general area later discovered by Ladd in 1989. The current

status of the species in Madison and Jackson Counties, as listed by Wagnon (1950a), is unknown. According to Dr. Pavlick, the Jackson Co. collection is from Swope Park, in Kansas City.

On 22 July 1993, McKenzie, with Roxie Campbell and Stephanie Smith, both of the Missouri Department of Natural Resources, conducted a thorough survey of *Bromus nottowayanus* along Gans Creek, in Rock Bridge State Park. These investigations led to the discovery of 12 separate populations with 9880 total culms in 1,269 clumps. Although this is by far the largest population of this species known in Missouri, most plants are concentrated along a 1 km stretch of Gans Creek. It is likely that further survey work along the many streams in Missouri will lead to the discovery of additional populations.

HABITAT AND ASSOCIATED SPECIES IN MISSOURI

Extant populations of *Bromus nottowayanus* in Missouri inhabit rich, shaded woods along small to medium-sized streams (1-2 order streams, or approx. 3-6 m wide). In Boone County, *B. nottowayanus* inhabits rich bottomland terraces at the junction of rich slopes and the stream floodplain in mature deciduous woodlands, in shaded or partially shaded areas. The species is usually within 18-24 m of the stream. Although the species is usually found within the stream floodplain, it can occasionally be found further up rich slopes adjacent to a stream. Satin brome is typically found in sandy or sandy loam soils, or soils with a rich, deep, organic layer. In Boone County, common associates include (nomenclature of Yatskievych and Turner, 1990) *Asarum canadensis*, *Chasmanthium latifolium*, *Cinna arundinacea*, *Desmodium glutinosum*, *Diarrhena americana*, *Elymus villosus*, *E. virginicus*, *Laportea canadensis*, *Uvularia grandiflora*, and *Veratrum woodii*. Other associates along Gans Creek include *Adiantum pedatum*, *Arisaema dracontium*, *A. triphyllum*, *Brachyletrum erectum*, *Carex hirtifolia*, *Cryptotaenia canadensis*, *Cystopteris protrusa*, *Elymus hystrix*, *Festuca subverticillata* (*F. obtusa*), *Galium concinnum*, *Panicum clandestinum*, *Tradescantia subaspera*, and *Verbesina alternifolia*.

At the Lewis County site, associates include *Carex jamesii, Circaea lutetiana, Clematis virginiana, Cystopteris protrusa, Desmodium glutinosum, Geum canadense, Hydrastis canadensis, Hydrophyllum virginianum, Parthenocissus quinquefolia, Phlox divaricata, Polemonium reptans, Rubus pensilvanicus, Sanicula odorata, Veratrum woodii,* and *Viola pubescens*.

Interestingly, satin brome is often spottily distributed along a stream, although there is seemingly favorable habitat either upstream or downstream of existing populations. All of these woodlands are known to reflect the effects of intensive post-settlement anthropogenic disturbances and alterations of prevailing process regimes, so the presettlement population dynamics of satin brome cannot be inferred from these modern remnants.

DESCRIPTION AND FLOWERING PERIOD

As suggested by the common name, *Bromus nottowayanus* is immediately recognizable in the field by the bright, satin sheen of the underleaf surfaces (Fig. 1). The initial field impression is that the satin sheen originates from the upper leaf surface. However, at closer examination, it is apparent that the leaf blades become inverted immediately after emerging from the junction of the leaf blade and sheath at the culms, and that the satin sheen one observes originates from the leaf undersurface. The species is also characterized by having densely pubescent sheaths, a usually nodding inflorescence, pubescent lemmas, and a conspicuous tuft of hairs at the summit of the sheath opposite the ligule. Satin brome grows in openly caespitose colonies, usually with few to many flowering culms per clump. In Missouri, anthesis for satin brome is primarily from the first week of July through approximately the first week of August.

The obscurity and confusion associated with satin brome stems from three separate, but somewhat related problems: 1) questions whether the taxon is specifically distinct or of possible hybrid origin; 2) persistent nomenclatural problems surrounding the two closely related species *B. pubescens* Muhl. ex Willd. and *B. latiglumis* (Shear) A. Hitchc.; and 3) the disappearance of the characteristically satin sheen of *B. nottowayanus* when

Figure 1. Habit of *Bromus nottowayanus* at Gans Creek, Rock Bridge State Park, August 1993.

dried for museum collections, resulting in confusion with either *B. pubescens* or *B. latiglumis*. Questions surrounding the validity of satin brome as a distinct species originated when Wagnon (1952) stated, "This plant is given specific rank with considerable doubt," and further postulated that the taxon was probably a hybrid between *B. latiglumis* and *B. pubescens*, because the species resembles the other two, "in morphological characters as well as an intermediate period of anthesis and a similar habitat." We believe that further analysis of differences in flowering periods, habit, and habitat requirements of the three species provides strong evidence that three distinct taxa are involved.

Whereas Mohlenbrock (1972) and Pavlick (1995) recognized satin brome as a distinct species, most treatments have followed Wagnon's (1950a, 1952) suggestion and placed *B. nottowayanus* in synonymy with either *B. latiglumis* or *B. pubescens* (e.g., Kucera, 1961; Gould, 1975). Radford et al. (1964) placed both *B. nottowayanus* and *B. latiglumis* in synonymy with Canada brome, *B. purgans* L. (*B. pubescens*).

The correct status of satin brome was further clouded by the nomenclatural uncertainty surrounding *B. latiglumis* and *B. pubescens*. Wagnon (1950a, 1950b, 1952) attempted to sort out the confusion involving the nomenclature of these species, both which have been treated by various authors as *B. purgans* L. Wagnon asserted that *B. purgans* should be the proper name for the only native brome in North America characterized by having conspicuous, well developed phalanges that are prolonged into auricles or short, divergent spurs at the summit of the sheath, which we now call *B. latiglumis*. As pointed out by McNeill (1976), however, the name *B. purgans* could not be used because it is an illegitimate name (it has since been declared a rejected species name under the International Code of Botanical Nomenclature). Nonetheless, McNeill (1976) only exacerbated the problem by proposing that *B. altissimus* Pursh, which was not validly published, was the correct name for *B. latiglumis*. McNeill (1977) subsequently caught his error and conclusively showed that *B. latiglumis* is the correct name for this taxon. Some authors, however, further complicated the matter (e.g., Chase, 1951; Kucera, 1961; Radford et al., 1964) by incorrectly

using the name *B. purgans* L. for the common and widespread species we now call Canada brome. Wagnon (1950a, 1950b, 1952) provided convincing evidence why *B. pubescens* is the correct name for Canada brome.

Finally, the conspicuous satin sheen of *Bromus nottowayanus* disappears once a specimen is dried in a plant press. This apparently has led to some museum specimens of *B. nottowayanus* being misidentified as either *B. latiglumis* or *B. pubescens*.

CHARACTERS USEFUL IN SEPARATING *B. NOTTOWAYANUS, B. PUBESCENS,* AND *B. LATIGLUMIS*

The most conspicuous field characteristics that distinguish *B. nottowayanus* from *B. pubescens* and *B. latiglumis* are its bright, shiny, satin sheen to the leaf undersurfaces and the conspicuous tuft of hairs at the summit of the sheath opposite the ligule. The sheaths of satin brome are usually much more densely pubescent than on any specimen of *B. pubescens*, but because there is considerable amount of variation in sheath pubescence in *B. pubescens*, this field mark should be used in concert with other characteristics.

Satin brome can be easily separated from *B. latiglumis* by the conspicuous satin, underleaf surfaces; the lack of conspicuous, well developed phalanges that are prolonged into auricles or short, divergent spurs at the summit of the sheath; the fewer leaves and nodes; the more upright or erect culms; and the generally earlier flowering period. *Bromus nottowayanus* differs from *B. pubescens* in its more restrictive habitat (see below); its shiny leaf undersurfaces; the later flowering period; and the presence of a conspicuous tuft of hairs at the summit of the sheath opposite the ligule.

In Missouri, there appear to be some differences in habitat requirements of the three species, but there is some overlap between *B. nottowayanus* and *B. pubescens*, and between *B. pubescens* and *B. latiglumis*. *Bromus pubescens* is by far the most widely distributed species, and occurs in a variety of

woodland and rocky habitats ranging from dry, partially sunny, upland slopes to deeply shaded, moist woodlands (Kucera, 1961; Steyermark, 1963; Mohlenbrock, 1972).

Bromus nottowayanus inhabits rich or rocky bottomland terraces at the junction of rich slopes and the stream floodplain in mature woodlands, in shaded or partially shaded areas. The species is usually within 18-24 m of the stream. Although the species is usually found within the floodplain, it can occasionally be found further up rich slopes adjacent to a stream. Satin brome is typically found in sandy or sandy loam soils, or soils with a rich, deep, organic layer.

In our personal field experience, *B. latiglumis* is found in sandy soil or sandy/gravelly soil, in partial shade to full sunlight, and is usually associated with the flood plain, stream islands, and "alluvial banks" (Kucera 1961) of medium-sized streams, or along wetland margins. Nonetheless, is has also been reported from "moist, open woods" (Mohlenbrock 1972), "damp, shaded ground" (Kucera 1961), and "rich, wooded slopes and bluffs, usually in limestone areas" (Steyermark 1963).

Although *B. pubescens* can be found near streams, it does not appear to be as closely associated with stream floodplains as do *B. nottowayanus* and *B. latiglumis*. To date, we have found *B. latiglumis* on larger streams than those where we find *B. nottowayanus,* and we have yet to document the two species along the same streams.

One of the major differences separating the three species is their flowering period. In Missouri, anthesis for *B. pubescens* is primarily from the first week of June through the first week of July, but primarily from the first week of July through the first week of August for *B. nottowayanus*, and primarily mid-August through mid-September for *B. latiglumis*. There is occasional overlap in anthesis between *B. pubescens* and *B. nottowayanus* on one end of the scale and between *B. nottowayanus* and *B. latiglumis* on the other end of the scale, but in Missouri there is apparently no overlap between the anthesis of *B. pubescens* and *B. latiglumis*, the two species Wagnon (1950a, 1952) hypothesized having crossed to produce *B. nottowayanus*.

Bromus nottowayanus is possibly a flood-adapted species (especially flash floods). Extant populations of satin brome at Rock Bridge State Park and Three Creeks State Forest in Boone County in 1993 were subject to at least two flash floods where the force of the water knocked over the plants. The populations appeared to bounce back very quickly without suffering any significant mortality. Flash flooding could be a means of dispersing mature fruits to appropriate habitat at downstream sites.

PROTECTION AND CONSERVATION

Current information on the status of satin brome throughout its North American range is lacking. Outside of recent searches for the species in Indiana (Michael Homoya, Indiana Department of Natural Resources, pers. comm., 17 Feb 1995), few field surveys have been conducted for *Bromus nottowayanus*. In Missouri, all recently examined populations in Boone, Lewis, and St. Louis Counties are under public ownership, and thus receive some level of protection. *Bromus nottowayanus* is listed by the Missouri Department of Conservation (1992) as Status Undetermined. The Nature Conservancy currently ranks satin brome globally as G2/G3? (Kathy Crowley, The Nature Conservancy Minneapolis Regional Office, pers. comm., 19 Apr 1995). Additional surveys are needed throughout the species' range to determine if satin brome should be added as a possible candidate for consideration under the Endangered Species Act. Because of its attractive appearance, satin brome has excellent potential for propagation as an ornamental.

KEY TO PERENNIAL SPECIES OF *BROMUS* IN MISSOURI

The following key to perennial species of bromes in Missouri includes further differences among *B. nottowayanus, B. latiglumis*, *B. pubescens*, and *B. inermis* Leysser ssp. *inermis*; the last is the only non-native perennial species known to occur in the state.

a. Plants with creeping rhizomes; panicles erect with stiffly ascending branches; lemmas glabrous and awnless or with awns less than 2 mm long; introduced species . . . . . **1.** *B. inermis*

a. Plants tufted, lacking creeping rhizomes; panicles drooping (somewhat spreading in *B. latiglumis*); lemmas pubescent and with awns 2-8 mm long; native species

b. Culms generally erect with 6-10 leaves; junction of sheaths and base of leaf blades lacking two well developed phalanges that are prolonged into auricles or short, divergent spurs; second glume primarily 3-nerved; anthesis primarily the first week of June through the first week of August

c. Widely distributed species common in a wide range of habitats; anthesis primarily from the first week of June through the first week of July; underleaf surfaces lacking a conspicuous satin sheen; summit of sheath opposite the ligule lacking a conspicuous tuft of hairs . . . . . **2.** *B. pubescens*

c. Rare species, restricted to junction of rich woods and flood-plain of small streams; anthesis primarily from the first week of July through the first week of August; underleaf surfaces with a conspicuous satin sheen; summit of sheath opposite the ligule with a conspicuous tuft of hairs . . . . . **3.** *B. nottowayanus*

b. Culms weak, often leaning or horizontal; junction of sheaths and base of leaf blades usually with two well developed phalanges that are prolonged into auricles or short, divergent spurs; second glume primarily 5-nerved; anthesis primarily mid-August through the mid-September . . . . . **4.** *B. latiglumis*

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ANNOUNCEMENT

Copies of plant lists and other information relating to the flora are requested for inclusion in the Society's flora file. Please send items to the archivist, Jim Bogler (see address on inside front cover).

CHRISTMAS TREE LICHENS

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For many years, lichens have been noted on our Christmas trees. On the 1993 tree, lichens seemed to be unusually abundant, thus stimulating my interest in collecting and identifying them. I was also interested in the apparent growth rates of these lichens in relation to the age of the tree, and possible identification of the tree's place of origin with regard to the specific lichens grown in that area (for example, southeastern Canada vs. north-central United States). My findings are reported below.

THE TREE

The 1993 Christmas tree was a balsam fir (*Abies balsaminea* (L.) Miller), and was grown in Nova Scotia, in eastern Canada. To be more precise, we received information from our retailer that our 1994 tree was grown in Gashen, Guysborough County, Nova Scotia, and the 1993 tree almost certainly originated from the same area.

The trunk of our tree, at least the portion available for study (the base remained in Canada when the tree was cut), was 228 cm long. At 12.5 cm from the base, a cross-section had 9 annual growth rings. At 25 cm there were 8 growth rings; at 135 cm, there were 6 growth rings, at 157 cm there were 5 growth rings, and at 185 cm (6 cm below the highest lichens) there were 3 growth rings.

THE LICHEN FLORA

The diversity and distribution of the lichens on the tree were studied. A total of ten species was found. These exhibited three growth forms—three species were crustose, four were foliose, and three were fruticose. Specimens were determined

using Gowan et al. (1988) and Hale (1979, 1983), and were verified in some cases by Doug Ladd. Unfortunately, identification of some of the smaller samples proved difficult, and three of the taxa could not be determined confidently to species from the materials at hand. The species of lichens found to grow on the tree are summarized in Table 1.

Lichens were found growing in a zone from near the trunk base (22 cm from base) to about 37 cm from the tip of the tree (191 cm from base). This region corresponds approximately to the portion of the tree that was three to eight years old at the time that the tree was cut. However, a few samples were harvested from the bases of tree branches, and the ages of these branches were not determined.

Although overall lichen density was roughly constant along the colonized portion of the tree trunk, the distributions of individual species and of the three growth forms were less uniform. Crustose and fruticose species occurred exclusively below 117 cm from the base of the trunk, which may reflect an ecological adaptation to the more protected environment in the

Table 1. Species of lichens found growing on a trunk of balsam fir from Nova Scotia, grouped by growth form.

Species	Growth Form
Buellia sp. (cf. *B. stillingiana* J. Steiner)	crustose
Lecanora symmicta (Ach.) Ach.	
Pyrrhospora varians (Ach.) R.C. Harris	
Hypogymnia physodes (L.) Nyl.	foliose
Melanelia subaurifera (Nyl.) Essl.	
Parmelia squarrosa Hale	
Tuckermannopsis orbata (Nyl.) M.J. Lai	
Bryoria trichodes (Michx.) Brodo & D. Hawks.	fruticose
Ramalina sp. (cf. *R. roesleri* (Hochst.) Hue or *R. dilacerata* (Hoffm.) Hoffm.)	
Usnea sp. (cf. *U. subfloridana* Stirton)	

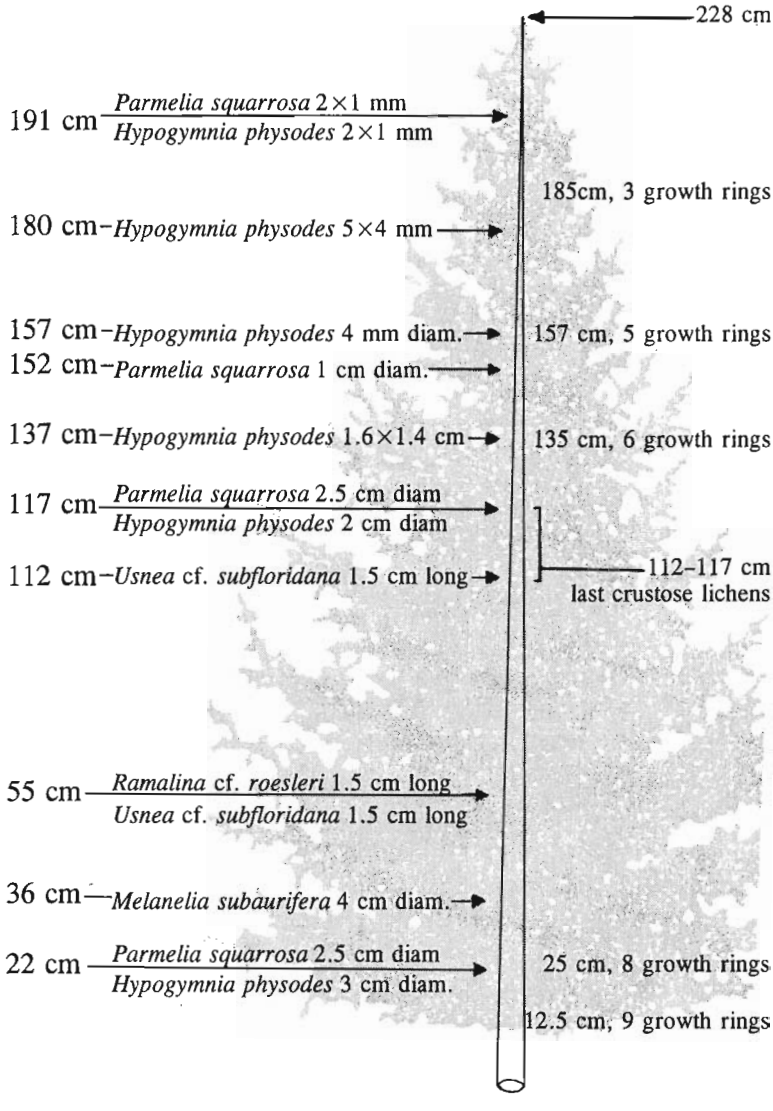

Figure 1. Distribution of some lichen species along the trunk of a balsam fir.

lower half of the tree, or might suggest that these lichens can only colonize older parts of the tree. In contrast, foliose taxa were present throughout the portion of the trunk on which lichens were found (Fig. 1). Additionally, although most species were restricted to the tree trunk, several small mats of *Bryoria trichodes* were hanging from the larger branches, and *Tuckermannopsis orbata* occurred mostly in the axils where medium-sized branches were attached to the trunk.

Individual samples varied greatly in size. The largest foliose sample was a colony of *Melanelia subaurifera* 4 cm in diameter that occurred in the region of 8 annual growth rings (Fig. 1). The largest fruticose lichens were a mat of *Bryoria trichodes* 4-5 cm long that occurred along the upper portion of the main trunk and several mats 3-4 cm long that were hanging from larger branches. Most of the other fruticose lichens were located along the lower half of the trunk and were 0.5-1.5 cm long.

The two most common species, *Hypogymnia physodes* and *Parmelia squarrosa*, were distributed at various places along the trunk (Fig. 1). This allowed some crude estimates of lichen growth rates to be calculated, based on the assumptions that each colony started growing when its portion of the tree was the same relative age and that growth rates are constant for all colonies of each species. It is of interest to note that unlike the samples of *Hypogymnia* and *Parmelia* discussed below, the 6 colonies of *Usnea* growing on the tree were uniformly 1.0 to 1.5 cm long, regardless of position. Thus, it seems reasonable to speculate that all of the *Usnea* on the tree became established at about the same time, whereas the other two genera apparently repeatedly colonized the tree over several years.

For *H. physodes*, the lowermost colony was 3 cm in diameter, and was located about 22 cm from the base of the trunk, where the tree had 8 annual growth rings. The uppermost colony was 0.2 × 0.1 cm in size and was located at 191 cm from the base of the trunk, where the tree probably had 3 growth rings. The diameters of the six total colonies found on the tree are plotted in Fig. 2, and show a tendency toward a sigmoidal pattern of growth. The average growth rate for this

species in the limited sample set was approximately 0.56 cm per year.

For *P. squarrosa*, the lowermost colony was 2.5 cm in diameter, and also was located about 22 cm from the base of the trunk, where the tree had 8 growth rings. The uppermost colony was 0.2 × 0.1 cm in diameter and also was located at 191 cm from the base of the trunk, where the tree probably had 3 growth rings. The diameters of the four total colonies found on the tree are plotted in Fig. 2. Unlike *H. physodes*, however, the growth curve for *P. squarrosa* appeared more clearly sigmoidal. The average growth rate for this species in the limited sample set was approximately 0.46 cm per year.

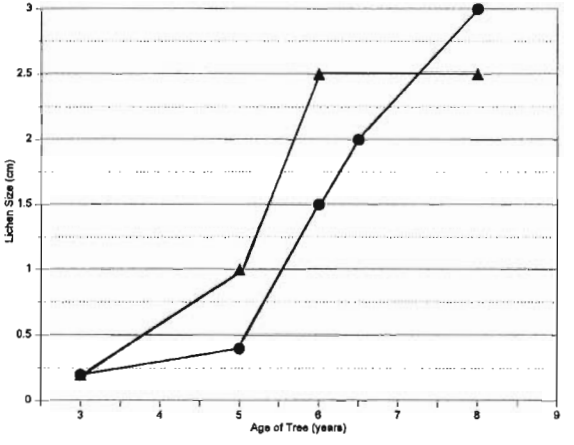

Figure 2. Growth rates in cm of *Hypogymnia physodes* (●) and *Parmelia squarrosa* (▲) as a function of tree age in years.

In conclusion, it seems remarkable that in only nine years as many as ten different species of lichen could become established on a balsam fir tree. In this specialized "micro-habitat", various species occupy different positions and differ in growth rates, as well as rates of colonization. Having studied the lichens on a tree of Christmas past, we look forward to studying them as well on trees of Christmas future.

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BOOK REVIEWS

George Yatskievych

Overby, Charlotte, editor, and Russ Mueller, cartographer. 1995. Missouri's Conservation Atlas. Missouri Department of Conservation, Jefferson City, MO. 264 pp. $15.00. ISBN 1-887247-00-9. Ringbound.

Obtaining detailed roadmaps of the state's counties has been a problem for many people in the past. The only comprehensive maps were available solely as large, individual sheets from the Missouri Highway Department. Thankfully, this wonderful new book places somewhat reduced, but legible versions of these maps into a single volume. For this reason alone, Missouri's Conservation Atlas belongs on the bookshelf of everyone interested in the out-of-doors in the state. It's so useful that a second copy under the car seat might not be a bad idea either.

However, the book provides a lot more information than just the black-and-white road maps. It also contains a comprehensive listing (as of the time of publication) of the public lands owned by the Missouri Department of Conservation, with instructions on the size and characteristics of each area, as well as how to get there. A lengthy table at the end summarizes things to see and do at each area, as well as other essential information, such as whether an area is handicap-accessible or whether there is a privy/restroom. This table also acts as an index to the areas covered. Some areas, such as urban nature centers, are featured in greater detail. A convenient glossary defines unusual terms used in the text, such as "cantilever sign" and "hand launch," and a chart at the end provides MDC office telephone numbers by region.

Several people who have used the book had only two suggestions on possible improvements for future editions. First, the metal ring binding does not fare well with use, and the back cover has a tendency to come loose from the rest of the book. Second, although "Department of Natural Resources" and "U.S. Army Corps of Engineers" are included in the glossary, the book presently accounts for only Conservation Department

lands. Future editions might be expanded to cover other public lands in the state.

Whether you are planning a weekend outing or just want to know where an unknown county road leads, this is the book for you. It is inexpensive, useful, and highly usable.

Daniels, Martha, and Charlotte Overby, editors. 1995. Missouri Nature Viewing Guide. Missouri Department of Conservation, Jefferson City, MO. x, 110 pp. $3.50. ISBN 1-887247-01-7. Paperbound.

This book is a perfect companion to the Conservation Atlas (reviewed above). The Missouri Nature Viewing Guide is patterned after the Watchable Wildlife Series, a state-by-state set of guides to places where readers may observe various types of wildlife, ranging from wildflowers and trees to fish, birds, insects, reptiles, and mammals. Most of these guides are published by Falcon Press of Helena, Montana and are quite inexpensively priced, but the Missouri guide is an even better bargain.

Aside from a brief set of introductory chapters, the body of the guide is devoted to discussions of 101 top areas in the state for readers to visit. For each site, there is an indication of size, ownership, and the nearest town, along with instructions on how to get there. Various categories of things to see are indicated with icons that are explained in the introduction. A beautiful series of photographs serves to increase readers' anticipation of good things to come during a visit.

The 101 sites covered are in a variety of ownerships, including Conservation Department lands, state parks, Corps of Engineers sites, local parks, and portions of the Mark Twain National Forest. Even a private nature sanctuary is included in the list of cooperators.

At the end of the book is a list of the state's twelve natural history "hot spots" and a guide to some of the more popular field guides for Missouri's biota. There is also a chart with 25 of the top wildlife species or categories by season and site, as well as an index. In short, this book has everything necessary to plan trips throughout the year.