

Monitoring Long-term Trends in Wisconsin Frog and Toad Populations

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Recent, possibly widespread declines in amphibian populations (Blaustein and Wake 1990) are disturbing because of the important roles of amphibians in many ecosystems. Moreover, their complex life cycles, insectivorous habits, permeable skin, and sensitivity to water chemistry in the egg and larval stages probably make them good bioindicators of environmental stress. There is little geographic or taxonomic pattern to the reported declines, some of which are from sites free from local anthropogenic disturbance. Causative factors are usually unknown and may be various, including habitat destruction, chemical contamination, introduction of predators, global climatic changes, acidic precipitation, or synergistic combinations of these factors (Blaustein and Wake 1990; Phillips 1990; Wyman 1990). Recent discoveries of malformed anurans, including at least seven species in fourteen Wisconsin counties (Dubois 1996), have heightened concern over amphibian populations.

Determining the nature, extent, and causes of amphibian population declines is hampered by a dearth of long-term population data. In fact, many reported declines have been based on local, short-term, or anecdotal evidence and may not reflect important or widespread problems. There is clearly a need for a coordinated system of research and monitoring that will determine and characterize significant population trends and identify causes (Blaustein and Wake 1990; Pechmann et al. 1991). This includes long-term population monitoring for a large number of species over wide areas that will identify changes in geographic ranges and distinguish regional and long-term trends from those

that are local or short-term. Such a monitoring system could alert researchers and managers to species and regions in need of attention and suggest patterns or causes of declines. The North American Amphibian Monitoring Program (NAAMP) was initiated in 1994 (Mac 1996; NAAMP 1996) to investigate monitoring needs and methodologies and to suggest standards. For anurans, which advertise their presence during the breeding season with species-specific vocalizations, volunteer-based auditory surveys have been recommended by the NAAMP as the best monitoring method for most of the continent. Suggested standards for these surveys are still being modified, but the basic methodology is based on the long-running Wisconsin Frog and Toad Survey (WFTS).

The WFTS was initiated in 1981 in response to known and suspected declines in several frog species, especially bullfrogs (*Rana catesbeiana*), northern leopard frogs (*Rana pipiens*), pickerel frogs (*Rana palustris*), and Blanchard's cricket frogs (*Acris crepitans blanchardi*). Annual statewide coverage began in 1984. The primary purpose of the WFTS is to determine the status, distribution, and long-term population trends of the state's twelve species. Its secondary purpose is educational. In this chapter, we describe the WFTS and its analytical methods, sample adequacy, and results. We discuss logistical considerations for initiating and maintaining such a program, some of its values and limitations, and possible modifications.

Methods and Study Area

Survey Methodology

The WFTS, begun in 1981 by Ruth Hine of the Wisconsin Department of Natural Resources (WDNR), was based on the initial recommendations and audio instructional tape of Jansen and Anderson (1981). After three years of experimenting and gathering phenological data with the help and comments of several volunteers, Mossman and Hine (1984) standardized the criteria and procedures for the survey. The survey was patterned after the successful North American Breeding Bird Survey (BBS) (Robbins et al. 1986; Peterjohn et al. 1994) and relies on cooperators identifying each of the state's twelve anuran species by their characteristic breeding calls. Cooperators were enlisted through word of mouth, notices in newsletters and magazines, presentations at nature centers and meetings, and contact with reliable observers from other cooperative programs, such as the statewide black tern survey and the natural areas breeding bird survey. In subsequent years, cooperators were added from various sources, and beginning in 1992 WDNR wildlife managers routinely ran surveys or enlisted new cooperators. Initially, routes were established wherever cooperators were available, although poorly sampled areas of the state were increasingly targeted. In the early 1990s, WDNR biologists set a goal with the WFTS of establishing at least two routes in each county. Our current goal is to stratify coverage geographically according to ecoregions and sections established by the U.S. Forest Service (USFS).

By 1995, the survey included approximately 120 permanent roadside routes throughout the state. Each route comprises ten listening stations selected subjectively by a volunteer observer to be within hearing distance of wetlands that represent the range of local anuran breeding habitats, such as ephemeral ponds, lakes, meadows, marshes, and wooded swamps. Stations were located far enough apart that individual frogs could not be heard from more than one station. Depending on the local topography and vegetation characteristics, interstation distances were as close as about 400 meters, but were generally greater, usually on the order of 0.8 to 3 kilometers. Routes were run after sunset under favorable conditions (i.e., relatively warm air temperature, wind less than 13 kilometers, and preferably humid or after recent rains). Most routes were 15 to 40 kilometers long and took two to three hours to complete. At each station the observer listened for five minutes (or up to ten minutes if necessary due to noise interference) and

recorded one of the following call index values for each species heard:

- 1 = individuals can be counted; there is space between calls
- 2 = calls of individuals are distinguishable, but some calls overlap
- 3 = full chorus; calls are constant, continuous, and overlapping

Because the annual calling period of each species is usually short and is different from the calling periods of other species, cooperators were asked to run each route a total of three times every year, once each during the following sampling periods:

Early spring = 8–30 April and when pond temperatures have reached 10°C

Late spring = 20 May–5 June and when pond temperatures have reached 15.5°C

Summer = 1–15 July and when pond temperatures have reached 21°C

Water temperatures were recorded where feasible and where they appeared to represent the conditions in which frogs call. Air temperature, wind speed (Beaufort scale), and sky condition were recorded at the beginning and end of each route. Cooperators were asked to comment on such things as changes in wetland conditions and problems with background noise and were encouraged to invite along at least one other reliable observer who could run the survey alone if the primary cooperator was unable to do so at some future time.

To avoid overlap with other routes, when a new route was established we sent the interested cooperator county maps of the area indicating the locations of previously established stations. We suggested that the cooperator run eleven or twelve stations during the first year and then select as permanent stations the ten with the least noise interference or access limitations—problems that were not always initially apparent. The cooperator then returned a county road map with the stations indicated, and we sent back photocopies of the appropriate 7.5' topographic maps on which to mark the exact locations. These photocopies were returned to us along with narrative and legal descriptions of each station location and a general description of nearby wetlands. We checked these for accuracy and clarity and made three clear sets of the route description and of the appropriate topographic and county maps with the station locations marked on them. New cooperators were asked to purchase (at cost) a copy of Jansen and Anderson's (1981)

instructional audio cassette tape of anuran breeding calls from the Madison Audubon Society. There were no formal training sessions. People interested in initiating a new route were usually asked first to go along on a previously established route with an experienced cooperater.

Every year in late March we sent each cooperater the appropriate route description and a set of topographic and county route maps, along with standard instructions and information on the natural history, distribution, and identification of each species (including range dot maps from Vogt 1981); two data sheets (Fig. 21-1); a form letter that included news on the survey and other amphibian matters (e.g., discussing a common problem that cooperaters had noted or that we had in interpreting data, with recommended solutions); a report on coverage and trends through the previous year (sometimes this was not sent until later in the year); a self-addressed, stamped return envelope; and often photocopies of recent popular or semipopular articles on amphibians. Sometimes we included a personal note or made contact via telephone or e-mail in response to a cooperater's question or problem. The instructional materials, route maps and descriptions, and a completed data sheet were returned to us at the end of the season. A postcard was sent to all cooperaters in the fall as a reminder to return data. For a more complete description of the survey methods and sample instructional materials and route description, see Mossman and Hine (1984).

Returned data were checked for accuracy and entered into an SAS computer databank. Records of state-endangered Blanchard's cricket frogs were accepted only with documentation, such as photographs, recordings, or specimens, and documentation was requested for records that were extralimital according to Vogt's (1981) maps. Dubious records or those from far outside the recommended survey periods and temperature ranges were flagged and not used in most analyses; during seasons with a particularly early or late phenology, and based on observer comments, some exceptions were made. In fact, in 1989 we lengthened the first survey period, shifting the starting date from 15 April to 8 April (and allowing even earlier surveys when necessary), because several observers in southern counties believed they were missing wood frogs (*Rana sylvatica*) during years when spring arrived early. For most of the dubious records, we tried to contact the observer to verify that a mistake was not made in entering data onto the data sheet, to ask for verification for that or future records of the same species, or to encourage the cooperater to take special care in recording the species in the future.

All routes are considered permanent. Changes have been allowed only during the first few years of a route's history (in which case the earlier years' data were not used in trend analyses) or on rare occasions when an insurmountable access problem developed or background noise at a particular station increased to the point that results were not comparable with earlier years. These cases were resolved by one of three options: the cooperater replaced the station with another one as similar as possible to the original, the route was abandoned, or the route was changed without regard to similarity to the original and treated as a new route.

During the first few years of the WFTS, we used survey data to examine geographic distributions and to investigate the relationships among call index values, water and air temperatures, and dates. To help with the latter issue, several cooperaters conducted surveys at frequent (one-to-ten-day) intervals throughout one or more seasons and years at a single station close to their home. Cooperater Ron Eckstein did this at one site every year during 1983 through 1996. We include his data for 1996 (although we report on trend analysis only through 1995) because phenologically it was instructive as an extremely late year.

Analysis

We used several regression techniques to measure population trends for individual species. Analyses from four techniques are reported here. Three of these techniques were developed recently with the support of the U.S. Geological Survey's Biological Research Division (BRD; formerly known as the National Biological Service), based on their procedures for determining trend "estimating equations" for BBS data (Link and Sauer 1994). In these techniques, a particular route was considered completed for a particular species in a particular year only if it was run during the seasonal sampling period that corresponded to the species' peak calling period (Table 21-1). That is, data from the early spring sampling period were used only for wood frogs, northern spring peepers (*Pseudacris crucifer crucifer*), western and boreal chorus frogs (*Pseudacris triseriata triseriata* and *P. t. maculata*, respectively), leopard frogs, and pickerel frogs. If this was the only period in which a particular route was run during a particular year, then the data were used for computing only these trends. Likewise, data from the late spring period were used to calculate trends for American toads (*Bufo americanus americanus*) and both species of treefrogs (eastern [*Hyla versicolor*] and Cope's [*Hyla chrysoscelis*]), and data from the sum-

WISCONSIN FROG AND TOAD SURVEY -- Field Data Sheet
 Bureau of Endangered Resources
 Department of Natural Resources
 Box 7921, Madison, WI 53707

Observer name(s), RUN 1 _____ Route No. _____
 (Add address and phone on back.) RUN 2 _____ Year _____
 RUN 3 _____ County _____

INSTRUCTIONS: Use this form for new or established survey routes. Each route consists of 10 listening sites, and is repeated 3 times during the breeding season, according to the minimum water temperatures and approximate range of dates given below for each survey period. Run surveys after dark, when wind velocity is less than 8 mph. Listen 5-10 minutes at each site and record a call index value of 1, 2, or 3 (see below) for each species calling. See back of sheet for wind and sky codes and additional comments. Return to above address by 15 August.



SITE NAME	FIRST RUN Water 50°F; 15-30 April				SECOND RUN Water 60°F; 20 May - 5 June				THIRD RUN Water 70°F; 1-15 July											
	Date		Date		Date		Date		Date		Date									
	BEGIN:	END:	BEGIN:	END:	BEGIN:	END:	BEGIN:	END:	BEGIN:	END:	BEGIN:	END:								
1.	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:								
2.	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:	Wind:								
3.	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:	Sky:								
4.	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):	Air temp. (F):								
5.	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)	Water Temp. (F)								
6.	Wood frog	Chorus frog	Spring peeper	Leopard frog	Pickrel frog	Am. toad	E. gray tree frog	C. gray tree frog	C. gray tree frog	Mink frog	Green frog	Bullfrog								
7.*	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number	Site Number								
8.	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*	CALL INDEX*								
9.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
10.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.	Mean	Freq.

*The call index is a rough estimate of the numbers of calling males of a particular species, according to the following index values:
 1 Individuals can be counted; there is space between calls.
 2 Calls of individuals can be distinguished but there is some overlapping of calls (intermediate between "1" and "3").
 3 Full chorus. Calls are constant, continuous and overlapping.

Figure 21-1. Data sheet for Wisconsin Frog and Toad Survey.

Table 21-1. Sampling periods required for each species in Wisconsin Frog and Toad Survey analyses. I = early spring, II = late spring, III = summer.

Species	Trend Analysis Technique	
	Route Regressions (single period)	Percent Occurrence (combined period)
Wood frog (<i>Rana sylvatica</i>)	I	I
Chorus frog (<i>Pseudacris triseriata</i>)	I	I and II
Northern spring peeper (<i>Pseudacris crucifer crucifer</i>)	I	I and II
Northern leopard frog (<i>Rana pipiens</i>)	I	I and II
Pickerel frog (<i>Rana palustris</i>)	I	I and II
American toad (<i>Bufo americanus americanus</i>)	II	II
Eastern gray treefrog (<i>Hyla versicolor</i>)	II	II
Cope's gray treefrog (<i>Hyla chrysoscelis</i>)	II	II
Blanchard's cricket frog (<i>Acris crepitans blanchardi</i>)	III	II and III
Mink frog (<i>Rana septentrionalis</i>)	III	III
Green frog (<i>Rana clamitans melanota</i>)	III	III
Bullfrog (<i>Rana catesbeiana</i>)	III	III

mer period were used for Blanchard's cricket frogs, mink frogs (*Rana septentrionalis*), green frogs (*Rana clamitans melanota*), and bullfrogs. For each route an index to abundance was computed for each species in each year. In the route frequency regression technique, the number of stations of occurrence was added (range = 0 to 10). The route index regression technique summed the index values from each station (range = 0 to 30). In the route adjusted-index regression technique, we arbitrarily assigned to each call index value a number that we believed better estimated the relative abundance of animals represented by that value (call index 1 equals three calling males, call index 2 equals twenty-five calling males, call index 3 equals fifty calling males); these values were then summed for each route as in the preceding technique (range = 0 to 500).

Trends for each route were then computed by using

estimating equations, regressing the appropriate dependent variable (frequency, summed index values, or summed adjusted index values) on year, and these trends were averaged for all routes in each ecoregion, expressed as mean annual percent change for that ecoregion. Before averaging, however, the trend for each species on each route was weighted according to the relative abundance of the species on that route (routes with a high average frequency of occurrence or high mean index value contributed more to the estimated ecoregional trend than did routes in which the species was less common) and an estimate of the variance in the trend estimate (routes in which the trend was precisely estimated contributed more than routes in which the trend was imprecise). The mean trend for each ecoregion was then weighted according to the area of that ecoregion, and these weighted means were aver-

aged to produce a standard trend (Geissler and Sauer 1990).

The fourth technique, percent occurrence, was used early in the WFTS program, and although trends are calculated by a much less sophisticated manner than in the route regression techniques, the data selection procedure was more complicated. Even though each species' calling period usually peaks within one of the three sampling periods, some species are also frequently recorded in another period. Thus, a particular species may be more detectable at individual ponds in either period in a given year; this is presumably because of annual and geographic variations in phenological progression, differences in water temperatures between different ponds (even within a given route), and the effects of different environmental conditions on different survey nights. A species whose main calling period often spans two survey periods is treated as follows for each route in each year: the call index at each of the ten stations is compared between the two periods ("combined period" data, Table 21-1), and the largest value is selected for analysis. Data are not used when only one of the required survey periods was sampled. In other techniques of analysis (not described here), these maximum station-index values were used to calculate trends, but in the percent occurrence technique, these are reduced to presence or absence for each station, and the stations of presence are summed and expressed as a percentage of all stations surveyed statewide that year. These annual percentages are regressed on year, and the slope is compared to zero by using a t-test. Trends are expressed as mean annual change in percent occurrence.

We also ran the three route regression analyses on combined-period data.

A power analysis was used to measure the statistical ability of the WFTS to detect population trends at various levels of certainty over various time periods (Mossman et al. 1996). Power analyses consider variables such as number of routes, counts per route, count variance, duration of monitoring, and interval between monitoring events to evaluate the statistical ability (power) of a monitoring program to detect trends in species abundance, given that a trend actually occurs. A power level of 75 percent, for example, indicates that if a nonzero trend actually exists, the trend analysis is expected to detect this trend in at least 75 percent of cases (i.e., a 25 percent chance of committing a type II error but not rejecting a false null hypothesis). Power depends on the alpha level of the test, which sets the probability of falsely rejecting a null hypothesis. An alpha level of $p < 0.1$

means that when the analysis detects a nonzero trend, it will be associated with true zero trend (type I error) about 10 percent of the time. In our power analyses we used eleven years of data (1984 to 1995) and the statistical methodology described by Sauer (1996). That is, given the variability in the WFTS data set for a particular species, we estimated how many routes would be needed to detect, for example, a mean annual change of 3 percent over a period of ten years or a mean annual change of 1 percent over a twenty-year period. The analysis was run on many combinations of precision parameters, including 1, 2, 3, and 5 percent annual mean changes, ten-year and twenty-year periods, and various levels of power and alpha.

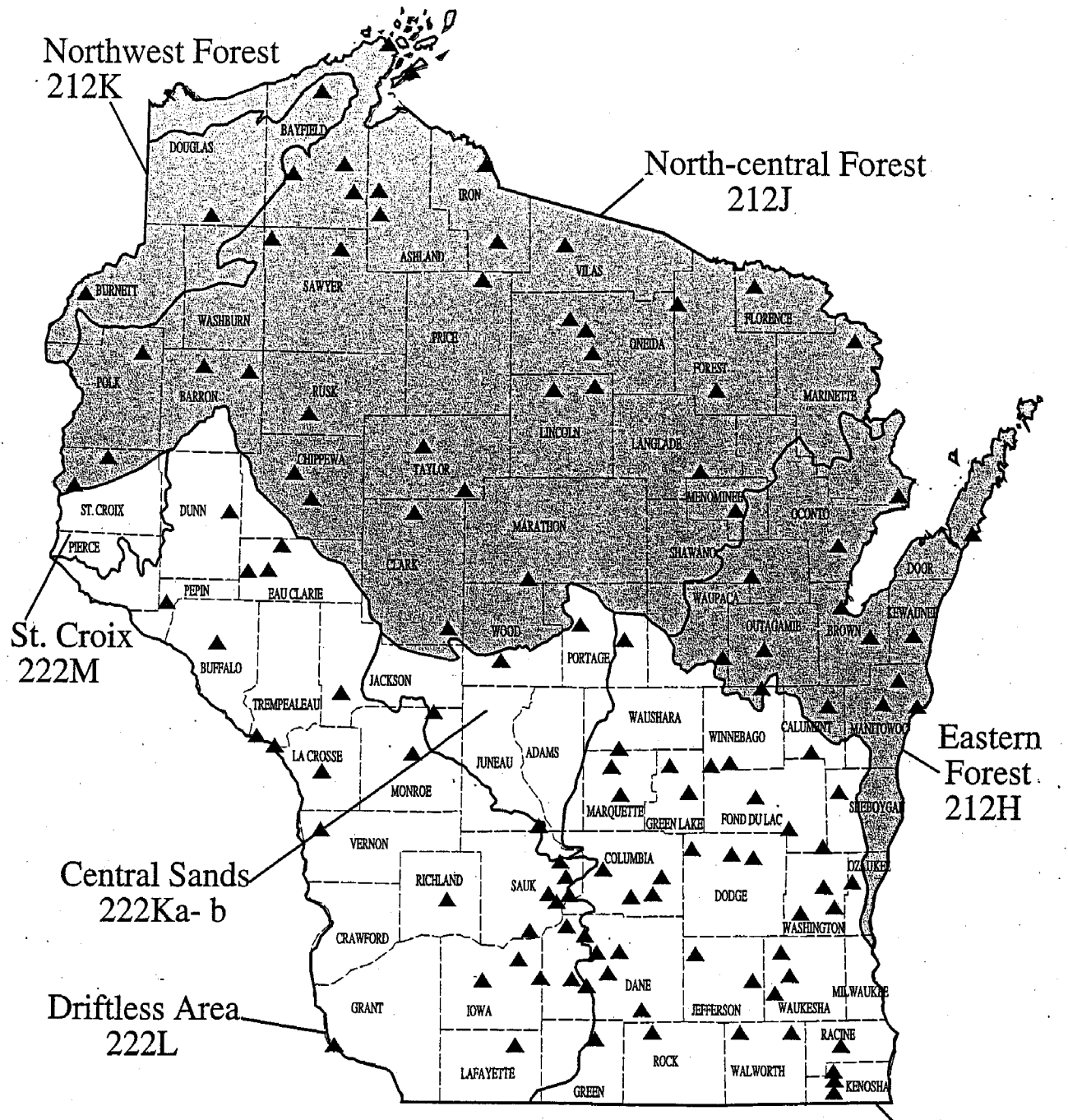
To compare population trends with drought conditions that might affect habitat availability or quality, we used the Palmer Drought Severity Index—a monthly index based on soils and on current and previous precipitation and temperatures (Palmer 1965). Data for the nine Wisconsin climatological regions were acquired from the state climatologist.

In 1987, we mailed cooperators a questionnaire requesting information on occupation, age, experience with amphibians prior to joining the WFTS, how they learned about the WFTS, why they joined the WFTS, what has maintained their interest, and comments on techniques, data forms, instructional materials, reports, coordination, and any other topics.

Ecoregions

We stratified our data and report our results according to the six ecoregional sections found in Wisconsin (McNab and Avers 1994; Keys et al. 1995) and additionally separated the Central Sands from the remainder of southeastern Wisconsin. For brevity, we called these "regions" and have abbreviated their names (Fig. 21-2; Table 21-2).

The Northwest Forest region mostly comprises extinct glacial lake beds with sandy or peaty soils and is dominated by pine and oak barrens and woods, some more mesic forest, and relatively nonintensive agriculture. This region has numerous lakes, streams, marshes, and bogs. The large North-central Forest region is mostly forested with northern hardwoods, although nonintensive agricultural land is scattered and more intensive agriculture dominates some southern parts. Much of this region is on Precambrian shield overlain by morainal deposits and sandy outwash; lakes and bogs are common. The Eastern Forest region was historically dominated by mesic maple, beech, and pine forests, with



- Ecoregion Provinces**
- Laurentian Mixed Forest - 212
 - Eastern Broadleaf Forest (Continental) - 222
 - Survey Route
 - County Boundary

Figure 21-2. Distribution of Wisconsin Frog and Toad Survey routes.

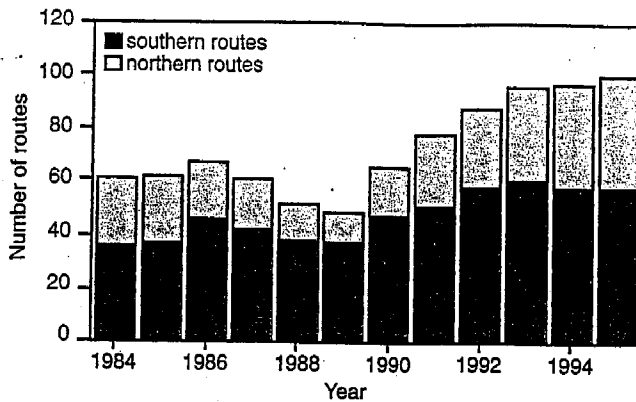


Figure 21-3. Number of Wisconsin Frog and Toad Survey routes run annually, 1984-1995.

substantial cedar swamps. Large marshes were present along the west shore of Green Bay. Forest stands are now concentrated west of Green Bay and are scattered among agricultural fields on the Door County peninsula and southward. Some marshes remain, the largest along the west shore of Green Bay. The area along the Fox River leading into Green Bay is highly industrialized, and the southern lobe of the region is densely populated.

The Central Sands represent the bed of extinct Glacial Lake Wisconsin and its associated uplands. This region includes extensive natural and restored marshes, sedge meadows, lowland hardwoods, and conifer bogs, as well as commercial cranberry operations, irrigated cropland and pasture, and large tracts of pine and oak forest, aspen, and pine plantations. The pre-Euro-

American settlement landscape of the Southeast region was primarily oak savanna with some major prairies, oak woodland, and wetland complexes. It is now mostly agricultural with small scattered woodlots and some fairly extensive marshes. Urbanization is spreading from the major metropolitan areas of Milwaukee and Madison.

The hilly Driftless Area, with its characteristic sandstone and dolomite exposures, was missed by the last Pleistocene glaciers. It contains mostly small farms and ridgeside oak and maple woods. Small, wet meadows are occasionally associated with the many spring-fed "coulee" streams. Marshes and lowland hardwoods are concentrated along the Mississippi River floodplain and the several large rivers that feed the Mississippi. Pasture is more common here than elsewhere, especially in stream bottoms and in some of the former prairies and oak savannas south of the Wisconsin River. No routes occurred in the St. Croix region, which is mixed agriculture and woodlots, with scattered ponds and marshes.

Results

Coverage

During the experimental period of 1981 to 1983, 65 routes were run at least once, with five to fifteen stations per route. Most were run multiple years, and 21 of these remained as permanent ten-station routes. Thus, although we consider 1984 as the first year of the survey for data analysis, some routes began as early as 1981. During 1984 to 1995, the annual number of routes surveyed (during at least one of the three periods) ranged from 58 to 100 (Fig. 21-3). Fluctuations in coverage

Table 21-2. Geographic distribution of Wisconsin Frog and Toad Survey routes run at least twice during 1984-1995

Code	Ecoregion Section Description (with abbreviation)	No. Routes	Area (km ²)	Km ² / Route
212K	West Superior Mixed Forest (Northwest Forest)	3	6,361	2,120
212J	South Superior Mixed Forest (North-central Forest)	37	58,380	1,578
212H	North Great Lakes Mixed Forest (Eastern Forest)	14	13,515	965
222M	Minnesota Morainal Oak Forest (St. Croix)	0	2,039	—
222L	North-central Driftless Broadleaf Forest (Driftless Area)	27	30,427	1,127
222Ka-b	Southwest Great Lakes Broadleaf Forest—Central Wis. Sands (Central Sands)	3	6,941	2,314
222Kc-k	Southwest Great Lakes Broadleaf Forest—Glaciated (Southeast)	38	27,222	716
	Total (or mean)	122	144,885	(1,188)

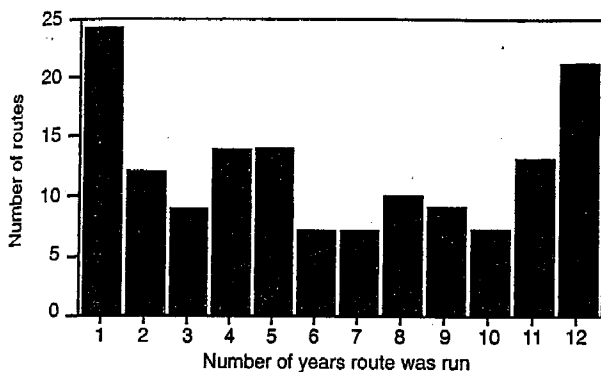


Figure 21-4. Number of years that Wisconsin Frog and Toad Survey routes were run, 1984–1995.

reflect changes in staff effort and agency support, which was greatest during 1981 to 1985, then declined and subsequently recovered as a staff herpetologist (R.H.) was hired, WDNR managers assumed more responsibility for ensuring regional coverage, and a growing concern for declining amphibian populations spurred public interest. One hundred forty-seven routes were run at least once; 122 were run at least twice and thus contributed data to the route regression trend analyses. Sixty-seven routes were surveyed in seven or more years, and 21 were surveyed all twelve years (Fig. 21-4). The geographic distribution of routes run at least twice is summarized in Figure 21-2 and Table 21-2. Routes were not well stratified geographically because volunteers were easiest to enlist around Madison and were especially hard to obtain in the least-populated areas of the state. In particular, the Southeast and Eastern Forest regions were sampled at roughly two to three times the intensity of other regions of the state. Routes in the Driftless Area were concentrated in Dane and Sauk Counties, and large areas of the north were not sampled. New routes were added annually, especially after 1989 in undersampled counties; coverage in the northern half of the state improved from a low of 13 routes in 1989 (26 percent of all routes run that year) to a maximum of 43 (43 percent of the routes) in 1995 (Fig. 21-3). A few routes became inactive when cooperators moved or dropped out of the program and replacements could not be found. Several additional routes—not counted here—were initiated but never completed and provided no data for analysis.

Cooperator Involvement and Comments

Hundreds of people conducted WFTS routes as either primary or secondary observers, several of them for

twelve or more years. Thirty-nine cooperators returned questionnaires in 1987. Their occupations ranged widely: professional biologists and naturalists (fourteen), homemakers (six), university professors, a medical doctor, a farmer, an engineer, a librarian, a janitor, a retired accountant, and others. Most (twenty) were between thirty-one and forty years old, with only two younger; three were over age sixty-five. The current age distribution is probably broader, as most of these cooperators are still running surveys and many more have been added. Respondents learned about the WFTS from many sources, including personal contact with WDNR/WFTS staff (sixteen), presentations by WDNR/WFTS staff at professional meetings or naturalist programs (five), other cooperators (three), formal naturalist training programs, other WDNR volunteer surveys, public radio programs, and newsletters and magazines of groups such as the Wisconsin Phenological Society, Wisconsin Wetlands Association, Nature Conservancy, Sierra Club, and WDNR. The range of prior experience with amphibians was wide: most cooperators said they had none, many had minimal experience (e.g., “just my own interest with the frog pond on our land” or “fish bait”), and a few were veterans (e.g., professional field naturalists or “graduate-level herpetology class and collecting experience. Also lots of frogging when I was young.”).

Respondent comments on WFTS methodology and logistics conformed to those made over the years in notes, in conversations, and on completed data sheets returned to WFTS staff. The most consistent and important of these were that: (1) materials need to be sent out by mid-March at the latest—well in advance of the breeding season, (2) cooperators need annual reports on findings, and (3) the ranges of acceptable dates and water temperatures, though essential as guidelines, need to be flexible enough to accommodate years with extreme phenologies. As a result of such correspondence and more years' experience with the WFTS, we increased our staffing to provide better reports and more timely mailings to cooperators, extended the beginning date of the first calling period a week, and became slightly less strict about the dates of formal survey periods in unusual years.

Recording water temperatures was time-consuming for some cooperators. These measurements are useful to both the cooperator and WFTS staff in evaluating the count data but need be made only where accessible water appears representative of that in which frogs or toads are breeding.

Our request for verification of extralimital records

met with some resistance and general disregard, because field recordings are bothersome to most volunteers and are often difficult to make with hand-held tape recorders and because most of the species' distribution maps provided in the instructional materials were incomplete, resulting in cooperators being asked to document species that may be common in their area. Some cooperators were offended that they were "disbelieved" by WFTS staff, when in fact it was not usually a matter of our belief but one of strengthening the survey's scientific validity. We maintained the requirement that cricket frog records be documented and received some tape recordings.

We did not estimate the frequency of species misidentifications; however, our experience and repeated correspondence with cooperators suggest that they were rare, probably fewer than 2 percent of all accepted records. Early in the WFTS, considerable time was spent corresponding with cooperators to help them with identifications and noting species that merited special attention. It is noteworthy that most of the cooperators who ran surveys during the first year of the survey (1984) already had one to three years' experience from the preceding experimental years. In more recent years, less time was spent with correspondence, but cooperators were still contacted to document unusual or dubious records. In many cases, the observer made no subsequent reports of the species after being contacted by us—we presume this is because of increased attention to species identification rather than simply wanting to avoid the issue of documentation. The most likely species to be mistaken were leopard frogs versus pickerel frogs; eastern gray treefrogs versus Cope's gray treefrogs; Blanchard's cricket frogs versus Virginia rails (all early spring records of Blanchard's cricket frogs were probably the call of this rail). Cooperators also asked for training sessions, especially to help distinguish difficult calls, to help standardize use of the call index, and to meet other cooperators. Some asked for names of cooperators or knowledgeable people in their region to help them verify uncertain calls. We believe that good continuity was maintained over time and between routes by encouraging new volunteers to accompany experienced surveyors prior to becoming primary observers responsible for their own routes and by asking each primary observer to enlist at least one alternate who knows the route and methodology. We and local WDNR wildlife managers helped to enlist alternates in some cases but were unsuccessful in others. Cooperators were generally satisfied with the instructional tape, printed materials, and data

form, and most indicated confidence in being able to identify all species in their area.

Several other problems occurred in the WFTS, which anyone initiating such a survey should be prepared to encounter. One involves producing clear and accurate route descriptions and maps. Every new route that was run took considerable staff time and effort to: verify that stations did not overlap others; find, photocopy and send topographic maps; verify that descriptions and maps corresponded; and compose master copies and make three clean copies of each. This often involved additional correspondence with the cooperator. In some cases, adequate descriptions took years to acquire because cooperators were unfamiliar with topographic maps or did not understand the detail necessary to ensure that someone unfamiliar with the route or area could run it correctly, perhaps far in the future, based only on these materials; precise locations are also necessary for our current effort to analyze habitat relationships. Our persistence on these matters probably contributed to at least one cooperator quitting. Another problem occurred when cooperators did not return route descriptions and maps, although this was alleviated somewhat by having multiple central copies (as long as they lasted). Another occurred when, on rare occasions, a cooperator did not visit a station or run the entire route because he or she "knew" that no frogs were calling (e.g., because wetlands had dried up from drought); these negative data would obviously be important. In some cases a cooperator tried to replace a station with one that "has more frogs."

In addition to these experiences were the problems inherent in a program that has generally been understaffed: misplaced materials, inability to respond to all cooperator questions and concerns or to check returned data and route descriptions carefully, and difficulty producing meaningful and timely reports. During 1986 to 1989, staff time was reduced. The remaining time was necessary just to run the program and maintain quality control, nearly to the exclusion of data summary and analysis, or in attempts to enlist new cooperators. The lack of feedback frustrated many cooperators, and although some dropped out temporarily or permanently, most persevered. The program has depended on the patience and perennial communication of both the staff and the cooperators.

Cooperators volunteered for the WFTS for many reasons, the most commonly stated being to contribute to the conservation of amphibians, learn more about frogs and toads, and have a reason to get outside and experi-

ence the night. Although some cooperators were apprehensive about being out alone at night, nearly all appeared to enjoy the survey. They said it helped them appreciate not just the anurans they were recording but also the many other night creatures they heard or saw. It helped them enjoy the progression of spring and to learn about the seasonal and longer-term changes in wetlands. For many it was a family event or a chance to expose schoolchildren, Scouts, or friends to nature at night. Some cooperators disseminated instructional materials to schools and elsewhere. Among responses to the questionnaire were:

With only a dozen calls, listening for frogs and determining species is easily learned. It gives me a good opportunity and impetus to get out and see/listen to familiar wetlands—it's fascinating how they change throughout the season. At times, "curiosity seekers" accompany me—people who are curious to learn and be closer to understanding a little more about the workings of nature. This gives me a good opportunity to share what I know . . . this is a wonderful way to incorporate "laypeople" into DNR work. In addition to monitoring frog species, any observers or interested folk get a better perspective of the variety of life in wetlands. Not to mention they recognize the existence of wetlands "in their own backyard" and the forces that affect them.

It's a blast: stars overhead, fireflies in the wetlands, and anurans calling everywhere. As a friend put it, "It's an instant institution!"

If only this type of survey had been conducted fifty years ago in the Green Bay west shore marshes!

Too many forms. You guys get paid to fill these out. We don't. It is somewhat disconcerting that after six years of describing my survey route, you still haven't figured it out.

Phenology and Call Index Variability

The call phenology—which suggests how we determined which survey periods are required to provide valid data for each—for all species except Blanchard's cricket frogs are illustrated in Figure 21-5. However, daily variation of call index values could be extreme, especially with marked changes in air temperature and wind velocity. This variability is illustrated in Figure 21-6 and emphasizes the desirability of avoiding nights when temperatures have recently dropped.

The broader pattern of call phenology for individual

species also varied between wetlands due to differences in water temperature, which may have been affected by factors such as geography, water depth, presence of springs, and wetland size. The earlier calling period of green frogs and gray treefrogs (Fig. 21-7) in a shallow wetland that warmed up relatively quickly in spring (Voss site) is shown in comparison to a deeper, cooler wetland (Rudy site). Daily air temperatures were similar at both sites.

Daily and seasonal patterns of calling sometimes varied markedly from year to year at the same site as a result of annual weather differences, particularly with regard to temperature and precipitation. The difference in the wood frog call phenology at the same site during one of the earliest and latest springs over the 1983 through 1996 period is shown in Figure 21-8. In 1988, wood frogs essentially ceased calling after 13 April, as evening air temperatures dropped from the 3.3° to 10°C range to the -7.7° to 3.3°C range, and water temperatures dropped from the 10° to 11.1°C range to the 2.7° to 3.3°C range; a brief resurgence occurred later in the season as air and water warmed again. In 1996, breeding activity was delayed because of an unusually late spring, although it began when the pond remained half covered with ice. Similar plots for the spring peeper in the same wetland are shown in Figure 21-9 and illustrate the difficulty in establishing fixed sampling periods that are appropriate for the full range of phenologies to be expected over a span of several years.

Species Status, Abundance, and Distribution

WFTS data have contributed to our understanding of species status, abundance, and distribution, as summarized in the species accounts below, where WFTS species distribution maps (Fig. 21-10) are compared with those of Vogt (1981) and the Wisconsin Herpetological Atlas Project (Herp Atlas) (Casper 1996, Chpt. 22, this volume). The Herp Atlas maps incorporate the maps of Vogt (1981); they represent only those records documented by a specimen, photograph, or tape recording; they display distributions only to the county level; and they do not distinguish between recent and historical records. Because of the large number of cooperators running annual WFTS routes (approximately 1,000 listening stations visited one to three times each), it is not surprising that, for many species, the WFTS maps appear more complete than their atlas counterparts. However, except in the case of Blanchard's cricket frogs, most of the WFTS records remain undocumented, and a few may be erroneous. Although we believe that the vast

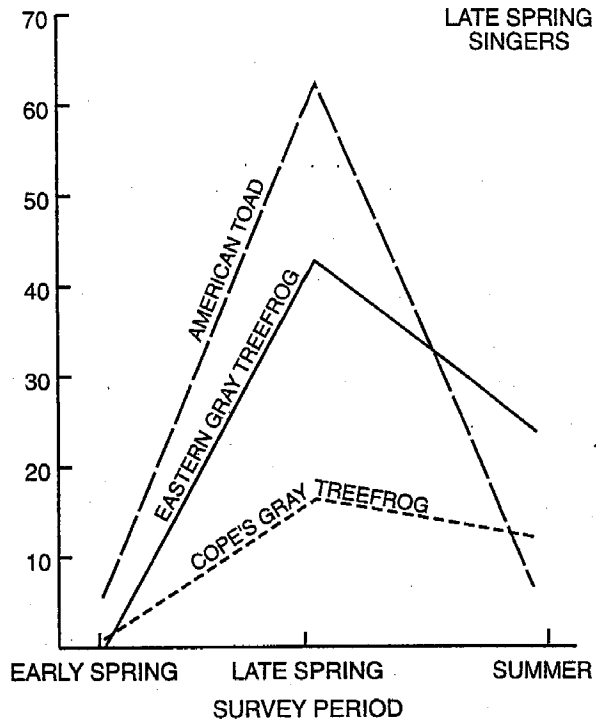
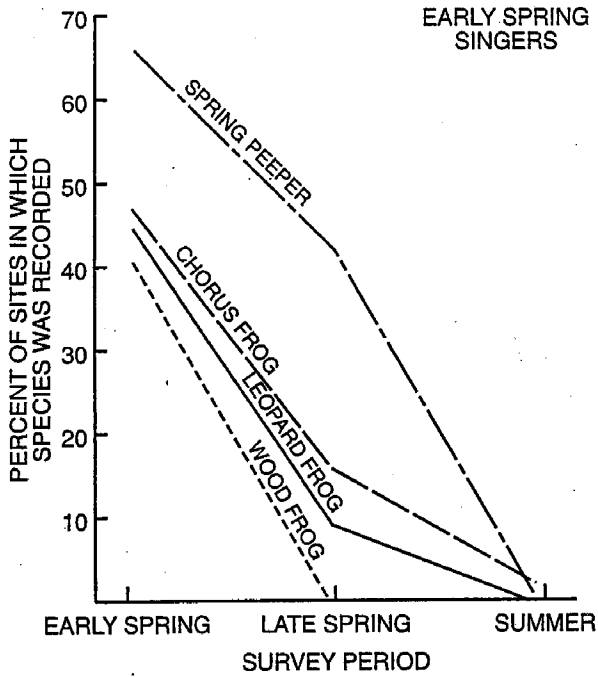
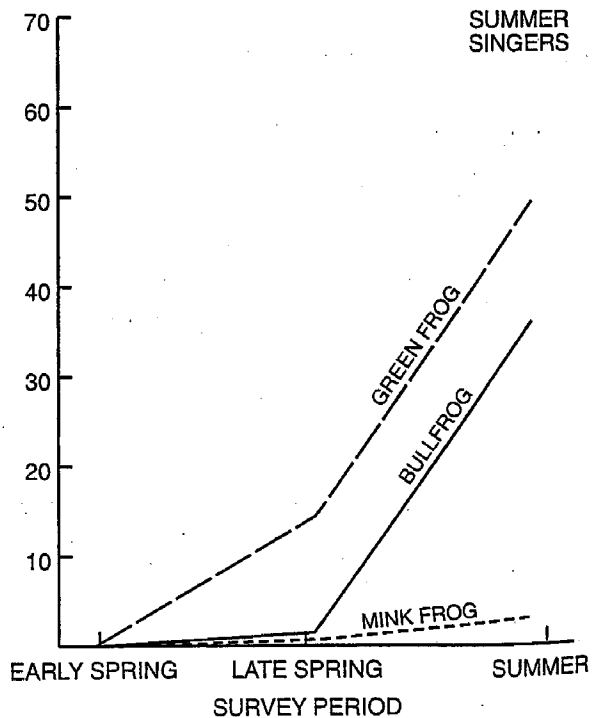


Figure 21-5. General call phenology according to survey period, Wisconsin Frog and Toad Survey, 1981-1983.

majority of records are correct, verification is still needed for species found in counties where the atlas has no documentation.

The general statewide abundance based on WFTS data and the experience of cooperators and ourselves is summarized in Table 21-3. Mean WFTS occurrence values for each region are also given in this table. These regional values, calculated as part of the route regression analysis, are average percent occurrences, estimated as area weighted averages of route average percent occurrences. Comparisons of abundance between species within the same area must be made cautiously, because species vary in their degree of detectability and because the various habitats may not have been sampled according to their abundance. Moreover, the extent to which these values reflect a given species' comparative abundance in different sections is uncertain, because the routes were chosen subjectively by different observers and because the sample is relatively small and irregularly distributed. However, the more marked discrepancies appear to represent true differences in a species' occurrence across different sections. Strictly speaking, a value in Table 21-3 reflects how widespread a species is in a section, because the value is based on the proportion of stations on which the species was recorded. It



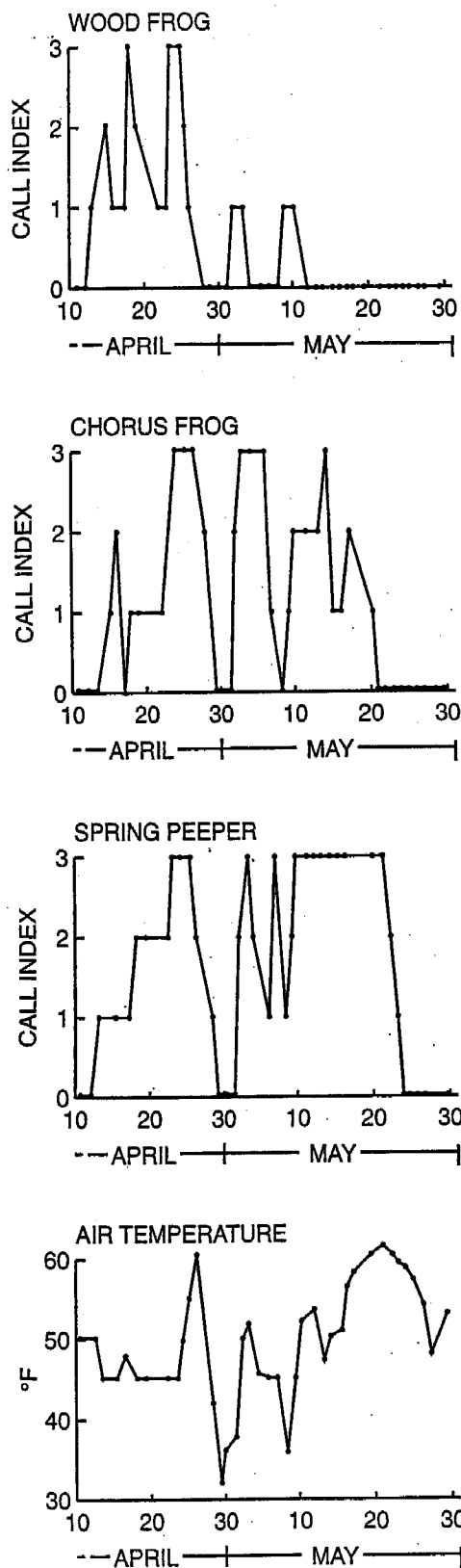


Figure 21-6. Frog call phenology at a bog in Oneida County, Wisconsin, 1984.

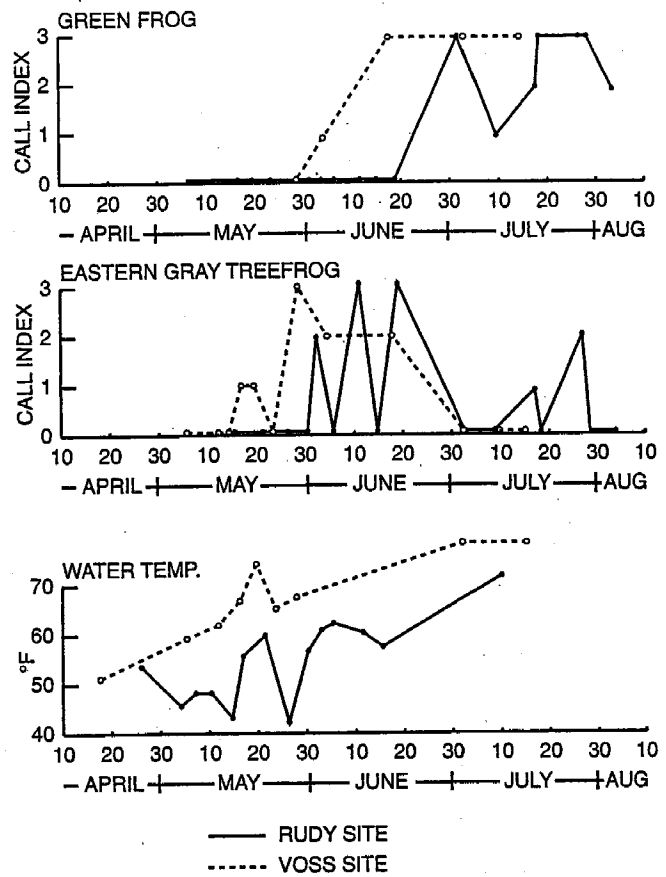


Figure 21-7. Frog call phenology at two Wisconsin wetlands, 1984.

probably also reflects a species' abundance, because a species is presumably easier to detect where it is more abundant, but an analysis of call index data would provide a better insight into the evaluation of abundance. Although most species appear to be fairly widespread across the state on the basis of their occurrence on routes (Fig. 21-10), some species were not recorded on many stations per route, at least in certain parts of the state (Tables 21-3, 21-4).

Several noteworthy patterns are apparent (Table 21-3). The relatively unforested and heavily populated Southeastern region had infrequent occurrences of forest-dwelling species such as wood frogs, spring peepers, and eastern gray treefrogs and frequent records of more open-country frogs such as chorus frogs, northern leopard frogs, and Cope's gray treefrogs. The opposite was true in the North-central Forest region. Both species of gray treefrog were common in the two major sandy sections of the state (Northwest Forest and Central Sands), which are former glacial lake beds. Common,