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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 cooperator.

Every year in late March we sent each cooperator 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 cooperators 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 cooperator'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 cooperators 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 cooperator 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 cooperator 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 cooperators conducted surveys at frequent (one-to-ten-day) intervals throughout one or more seasons and years at a single station close to their home. Cooperator 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
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
For office use only – Mean
For office use only – Freq.

FIRST RUN Water 50°F; 15-30 April
BEGIN: Date / Time: / Wind: / Sky: / Air temp. (F): — END: Time: / Wind: / Sky: / Air temp. (F):

Site Number	Water Temp (F)	Wood frog	Chorus frog	Spring peeper	Leopard frog	Pickerel frog	Am. toad	E. gray tree frog	C. gray tree frog	Cricket frog	Mink frog	Green frog	Bullfrog
		CALL INDEX*											
1.													
2.													
3.													
4.													
5.													
6.													
7.													
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10.													

SECOND RUN Water 60°F; 20 May - 5 June
BEGIN: Date / Time: / Wind: / Sky: / Air temp. (F): — END: Time: / Wind: / Sky: / Air temp. (F):

Site Number	Water Temp (F)	Wood frog	Chorus frog	Spring peeper	Leopard frog	Pickerel frog	Am. toad	E. gray tree frog	C. gray tree frog	Cricket frog	Mink frog	Green frog	Bullfrog
		CALL INDEX*											
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THIRD RUN Water 70°F; 1-15 July
BEGIN: Date / Time: / Wind: / Sky: / Air temp. (F): — END: Time: / Wind: / Sky: / Air temp. (F):

Site Number	Water Temp (F)	Wood frog	Chorus frog	Spring peeper	Leopard frog	Pickerel frog	Am. toad	E. gray tree frog	C. gray tree frog	Cricket frog	Mink frog	Green frog	Bullfrog
		CALL INDEX*											
1.													
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*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)	Trend Analysis Technique: Percent Occurrence (combined period)
Wood frog (*Rana sylvatica*)	I	I
Chorus frog (*Pseudacris triseriata*)	I	I and II
Northern spring peeper (*Pseudacris crucifer crucifer*)	I	I and II
Northern leopard frog (*Rana pipiens*)	I	I and II
Pickerel frog (*Rana palustris*)	I	I and II
American toad (*Bufo americanus americanus*)	II	II
Eastern gray treefrog (*Hyla versicolor*)	II	II
Cope's gray treefrog (*Hyla chrysoscelis*)	II	II
Blanchard's cricket frog (*Acris crepitans blanchardi*)	III	II and III
Mink frog (*Rana septentrionalis*)	III	III
Green frog (*Rana clamitans melanota*)	III	III
Bullfrog (*Rana catesbeiana*)	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 averaged 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

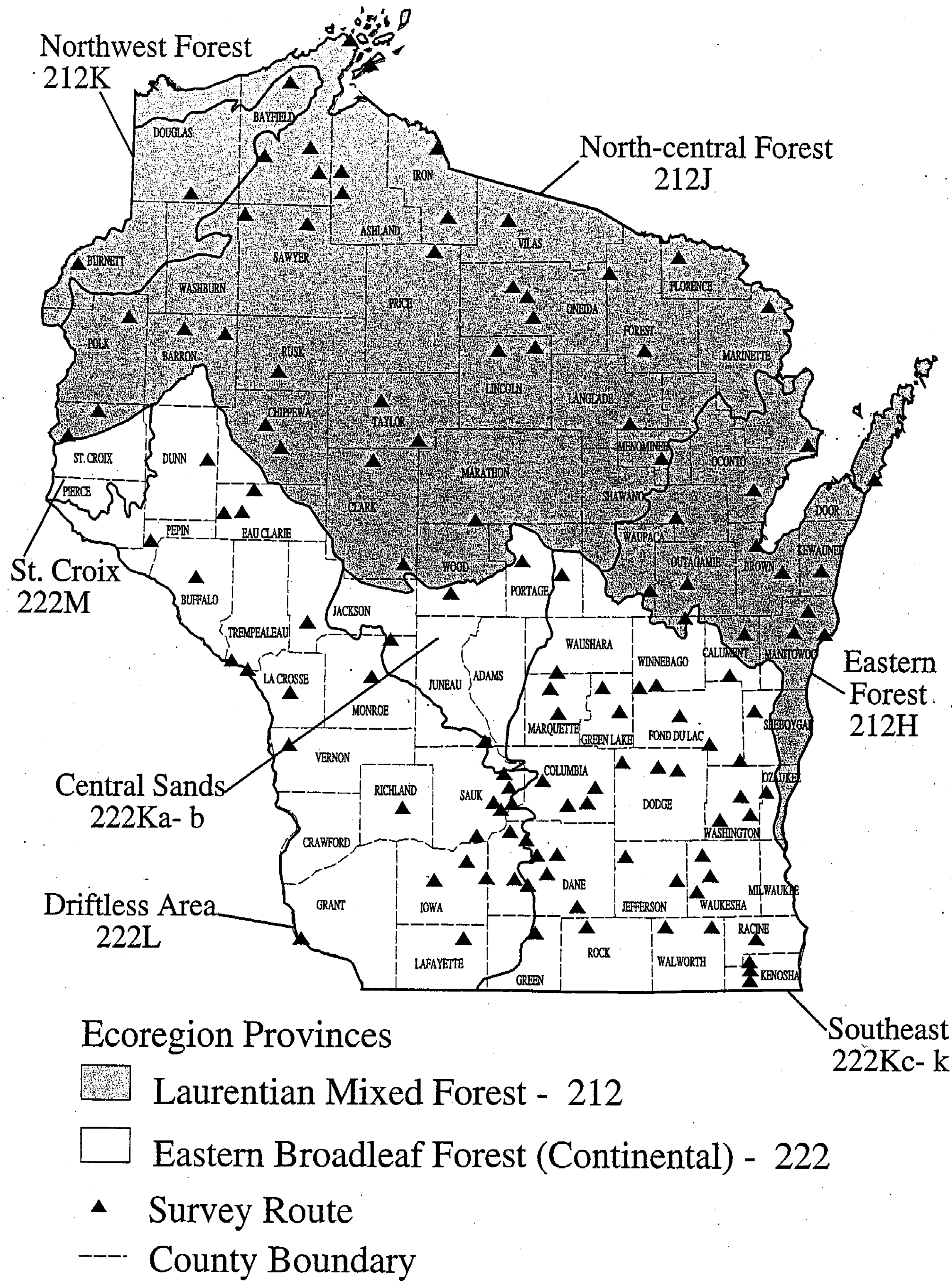


Figure 21-2. Distribution of Wisconsin Frog and Toad Survey routes.

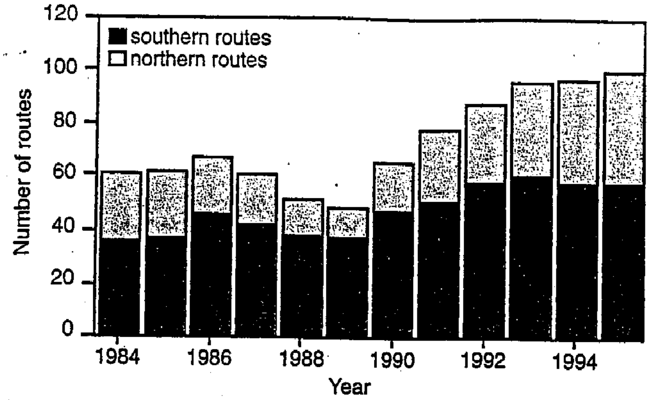


Figure 21-3. Number of Wisconsin Frog and Toad Survey routes run annually, 1984–1995.

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 (km²)	Km²/ 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)

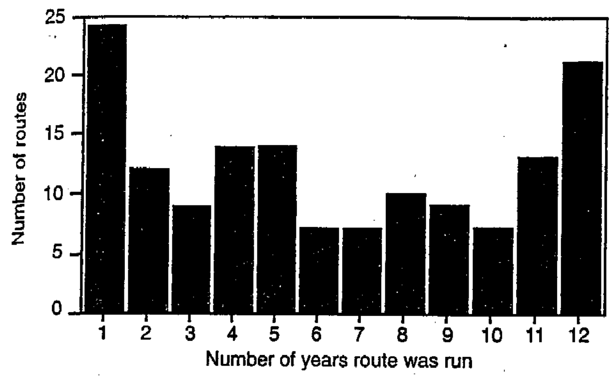


Figure 21-4. Number of years that Wisconsin Frog and Toad Survey routes were run, 1984–1995.

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 experience 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

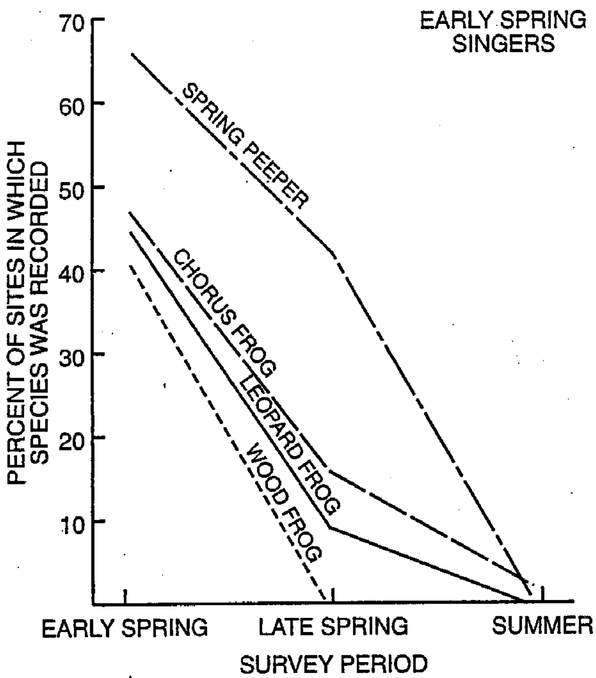
The call phenology—which suggests how we determined which survey periods are required to provide valid data for each—for all species except Blanchard's cricket frogs are illustrated in Figure 21-5. However, daily variation of call index values could be extreme, especially with marked changes in air temperature 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



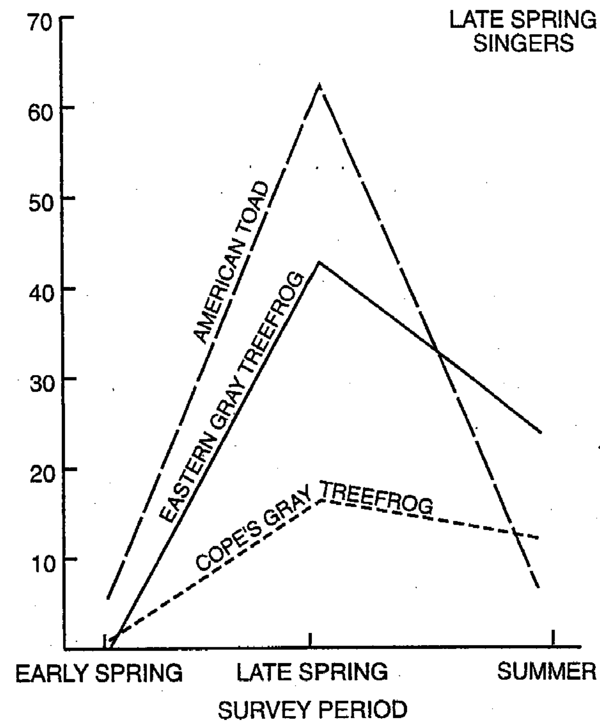
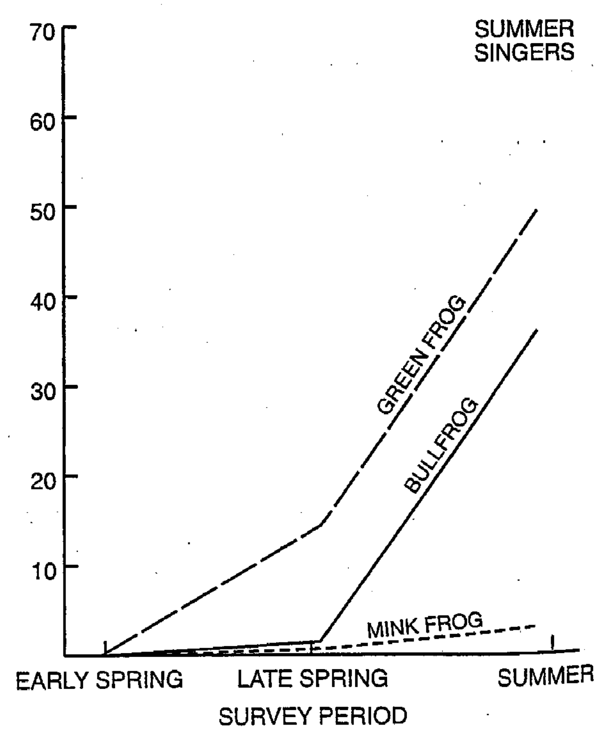


Figure 21-5. General call phenology according to survey period, Wisconsin Frog and Toad Survey, 1981–1983.

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



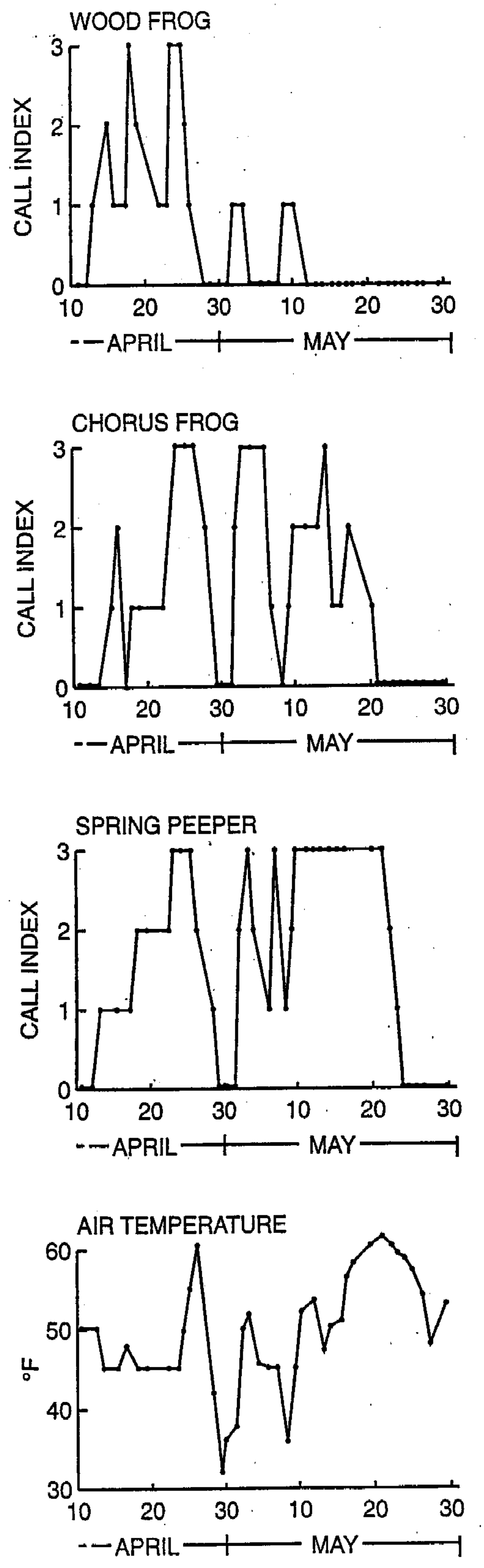


Figure 21-6. Frog call phenology at a bog in Oneida County, Wisconsin, 1984.

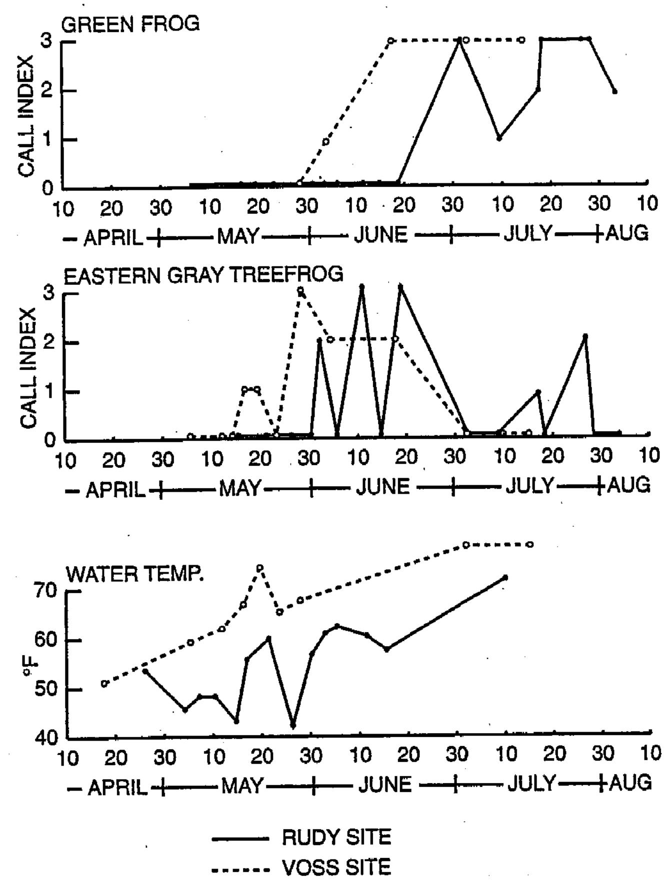


Figure 21-7. Frog call phenology at two Wisconsin wetlands, 1984.

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,

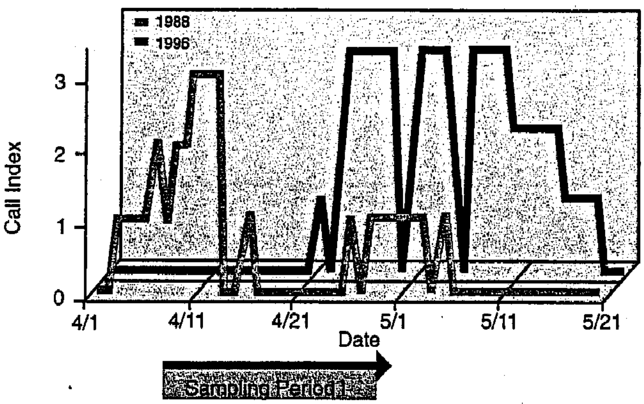


Figure 21-8. Wood frog call phenology at Eckstein North Pond (Oneida County, Wisconsin) in two extreme years, with early spring sampling period.

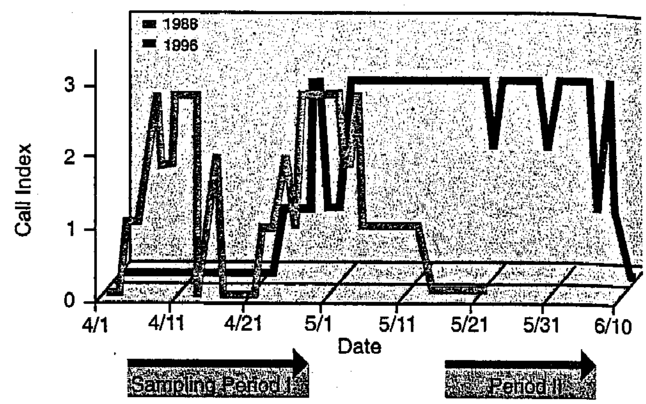


Figure 21-9. Spring peeper call phenology at Eckstein North Pond (Oneida County, Wisconsin) in two extreme years, with spring sampling period.

habitat generalists such as American toads and green frogs showed little geographic pattern, although the infrequent occurrence of green frogs in the Eastern Forest region is conspicuous.

Population Trends

Power analysis of the 1984 to 1994 data indicated that the WFTS sampled seven of the twelve species well enough to detect a 3 percent mean annual change in the frequency of occurrence over a twenty-year period (at $p < 0.10$ and 75 percent power; Table 21-4). The spring peeper is especially well sampled—only four routes of occurrence (with analyzable data) are predicted to be necessary to meet the above adequacy requirement. This is presumably because the species is widespread, detectable, and regular in occurrence; that is, if it is present at a site, it is likely to be heard. Another contributing factor is that the rate and direction of spring peeper population trends apparently do not vary extremely between routes. Cope's gray treefrogs are not quite sampled adequately (they occurred on forty-five routes with analyzable data, whereas forty-seven were required by the above criteria), but their sample is adequate to detect only declines, for which just thirty-four routes are required. We note that in practice at least fourteen routes would be a reasonable minimum sample for any species. With fewer than fourteen samples, it is unlikely that variances can be estimated with sufficient precision to allow statistical tests.

The least well sampled species (followed by the number of routes of occurrence necessary for adequate sampling) were bullfrogs (262), pickerel frogs (150), mink frogs (116), and Blanchard's cricket frogs (too few data to calculate). These species are the least common anurans in the state. They have irregular distributions and typically have low frequencies of occurrence on the routes on which they are found. However, they would be considered adequately sampled if less stringent criteria were used. For example, power analysis estimated that the current set of routes would be adequate to detect a 5 percent mean annual change in populations of pickerel frogs, mink frogs, and bullfrogs over a twenty-year period at $p < 0.2$, and a 50 percent power.

The results of statewide trend analyses are summarized in Table 21-4 and in Figure 21-11. We have selected the route frequency regression as our standard technique because it reduces the results at stations to presence or absence instead of attempting to relate the index values to an actual population size. For example, for a given species the route index regression equates three stations each recording index values of one with a single station recording an index value of three; the route adjusted index regression equates about seventeen stations recording an index value of one with a station recording an index value of three. The two other route regression techniques are useful for comparison. For example, when two or three techniques estimate similar trends for a species, it strengthens the evidence for these trends. Although the percent occurrence technique is simpler than the three route regression techniques and does not control for biases (such as differences in the distribution of routes run annually or oversampling in particular regions), it produces trend graphs similar in most cases to those of the route frequency regression,

Table 21-3. Statewide status and regional occurrence of anurans in Wisconsin

Species	State-wide Status**	Northwest Forest	North-central Forest	Eastern Forest	Driftless Area	Central Sands	Southeast
		Approximate Mean Percent of Stations of Occurrence*					
Wood frog (*Rana sylvatica*)	FC	61	63	59	17	57	21
Chorus frog (*Pseudacris triseriata*)	C	35	35	21	38	48	63
Northern spring peeper (*Pseudacris crucifer crucifer*)	C	93	88	64	74	97	49
Northern leopard frog (*Rana pipiens*)	C	27	19	44	28	40	35
Pickerel frog (*Rana palustris*)	U	2	0	0	10	0	0
American toad (*Bufo americanus americanus*)	A	48	42	44	38	62	37
Eastern gray treefrog (*Hyla versicolor*)	C	70	65	50	50	94	30
Cope's gray treefrog (*Hyla chrysoscelis*)	FC	46	4	1	17	70	21
Blanchard's cricket frog (*Acris crepitans blanchardi*)	R	0	0	0	2	0	0
Mink frog (*Rana septentrionalis*)	U	33	6	0	0	0	0
Green frog (*Rana clamitans melanota*)	A	59	59	26	59	75	54
Bullfrog (*Rana catesbeiana*)	U	0	14	3	1	0	6

*Mean percent of stations on which species occurred each year, for routes run during the appropriate survey period, as approximated in route regression analysis. Data included only for routes that contributed to trend analysis.
**Our assessment. A = abundant, C = common, FC = fairly common, U = uncommon, R = rare.

especially for well-samples species (Fig. 21-11), and provides more comparative information. When the route regression analyses were run on the combined period data (for those species requiring surveys in both the early and late spring periods; Table 21-1), the estimated trends were similar to those computed using data from each species' primary calling period (Table 21-5).

Altogether, these analyses suggest a strong increase for wood frogs, a slow but significant decline for spring peepers, and probable declines for northern leopard frogs, pickerel frogs, and Cope's gray treefrogs. Eastern gray treefrog and American toad populations appear to be stable or increasing. Well-sampled species also showed some significant regional trends (Table 21-6), which are discussed below.

Wisconsin experienced drought conditions during the period 1986-1989, although conditions varied regionally in terms of duration, extent, seasonality, and peak year. This period also included the years of poorest coverage in the WFTS (Fig. 21-3); however, the trend plots for some species (Fig. 21-11) suggest that populations (or at least annual population index) declined temporarily during this period. Trend analyses conducted during those years (e.g., for the period 1984 to 1988) indicated declines for several species and engendered some concern which further monitoring proved to be unwarranted. The trend plot for green frogs—a species that inhabits permanent water bodies statewide—was highly correlated with the July Palmer Drought Index ($r = 0.757$; $p = 0.004$; Fig. 21-12).

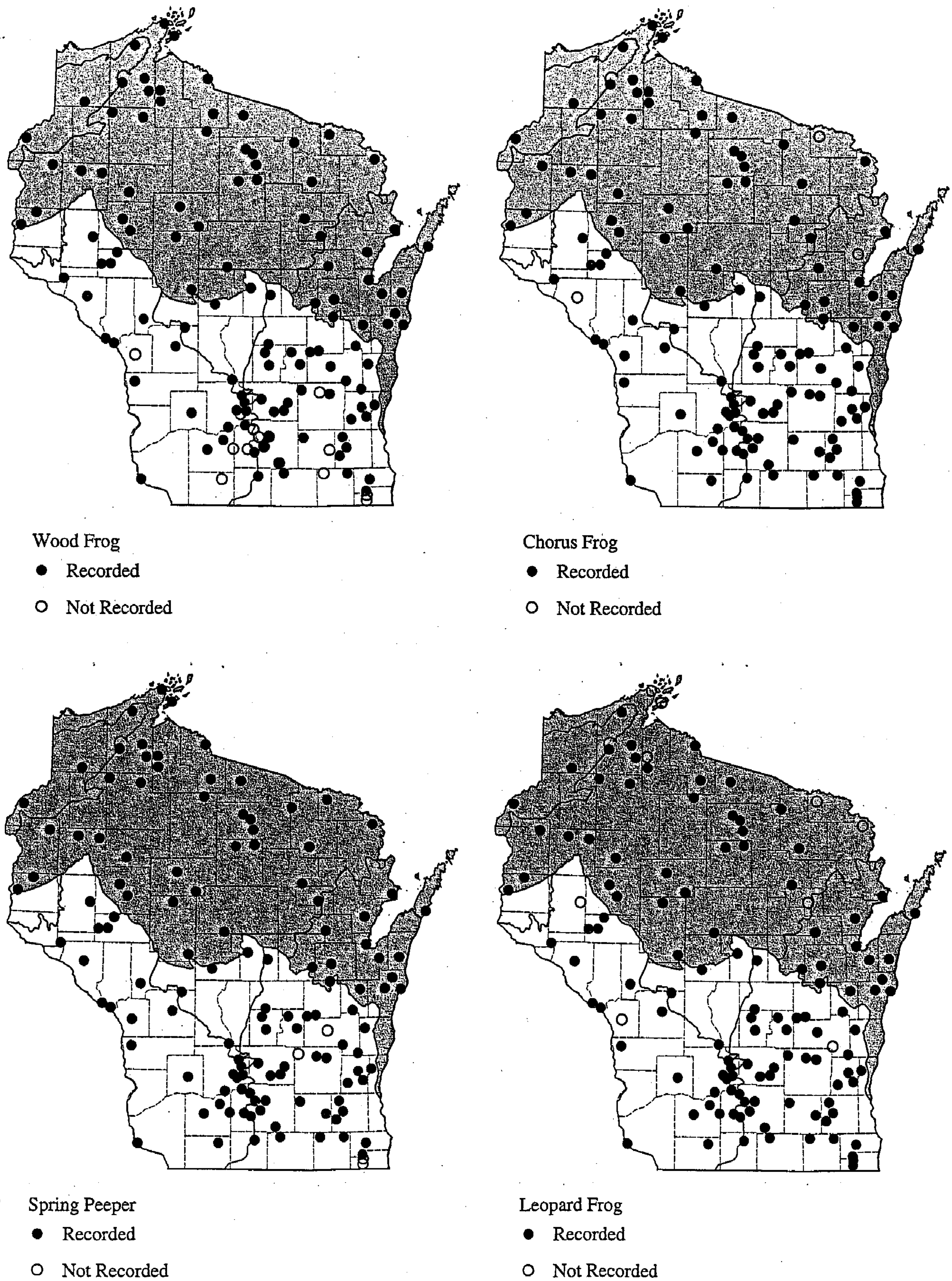
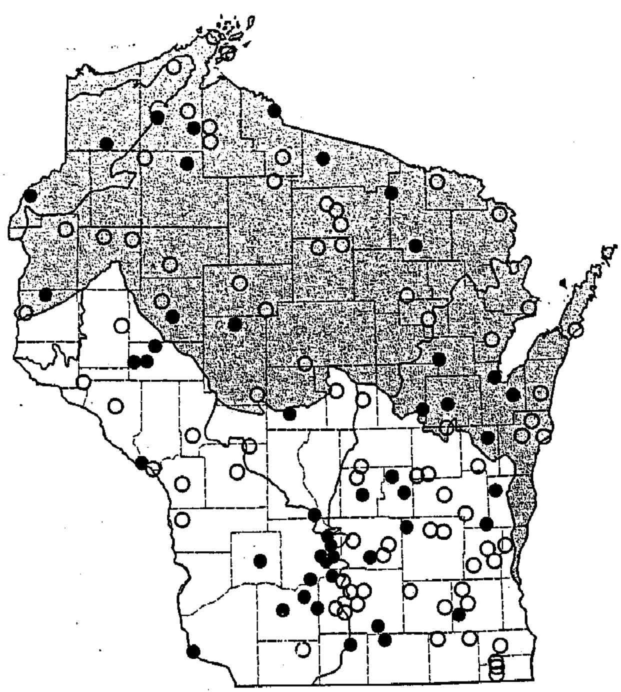
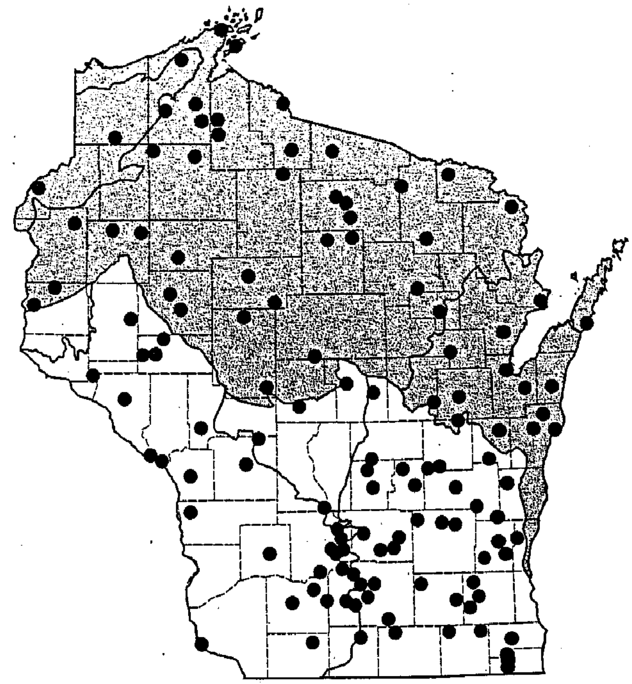


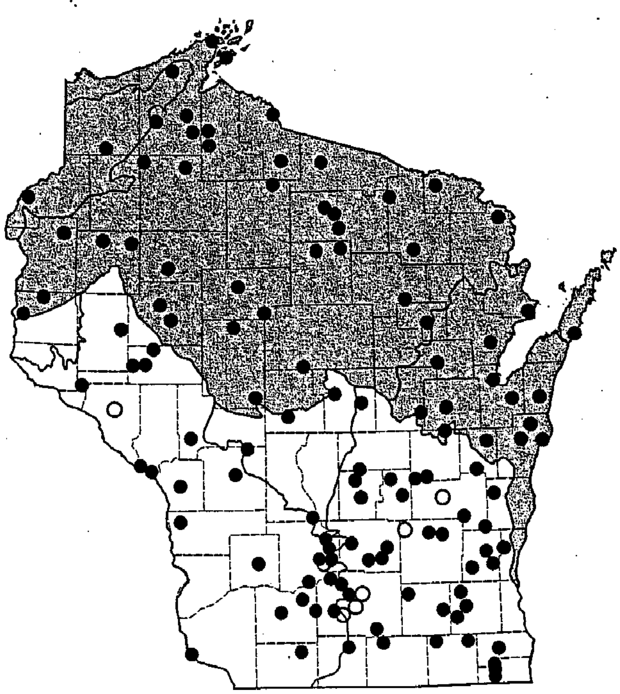
Figure 21-10. Anuran distribution maps based on Wisconsin Frog and Toad Survey data, 1981–1995.



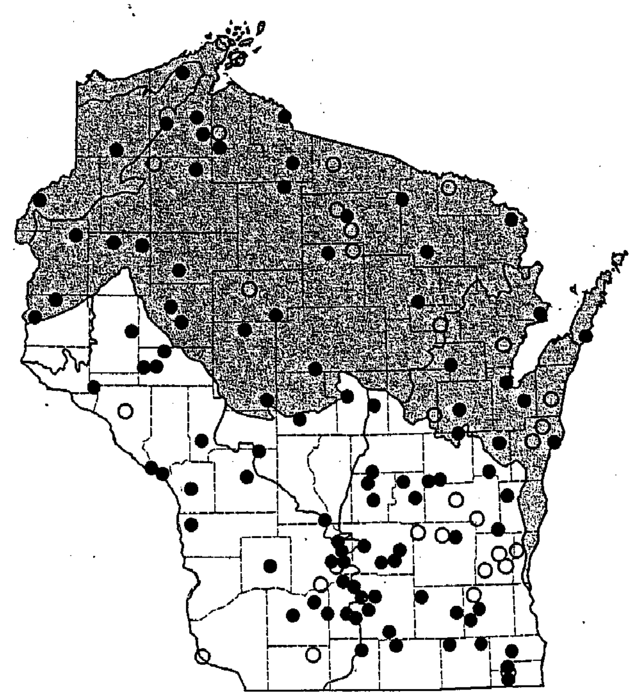
Pickerel Frog
- ● Recorded
- ○ Not Recorded



American Toad
- ● Recorded
- ○ Not Recorded

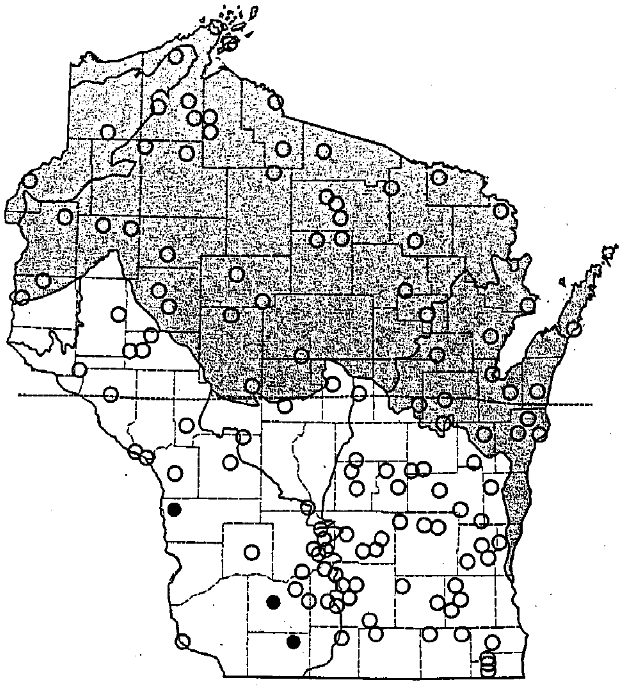


Eastern Gray Treefrog
- ● Recorded
- ○ Not Recorded



Cope's Gray Treefrog
- ● Recorded
- ○ Not Recorded

Figure 21-10. (cont.)

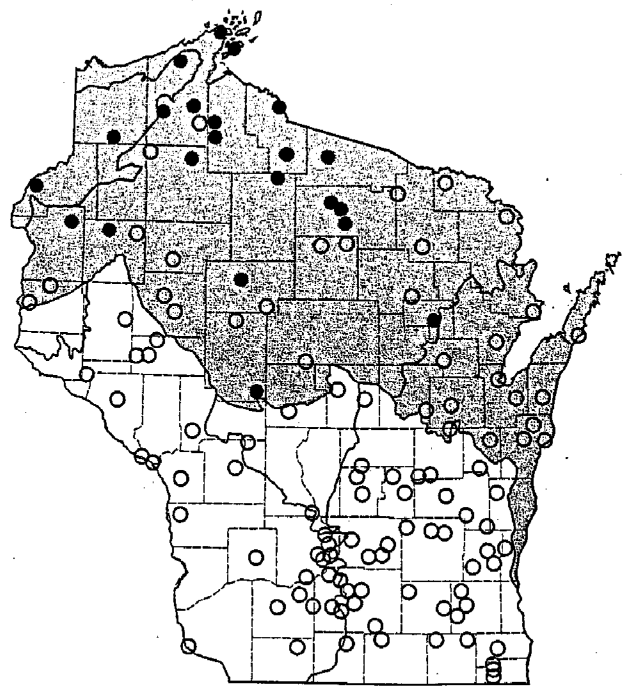


Cricket Frog

● Verified

○ Not Verified

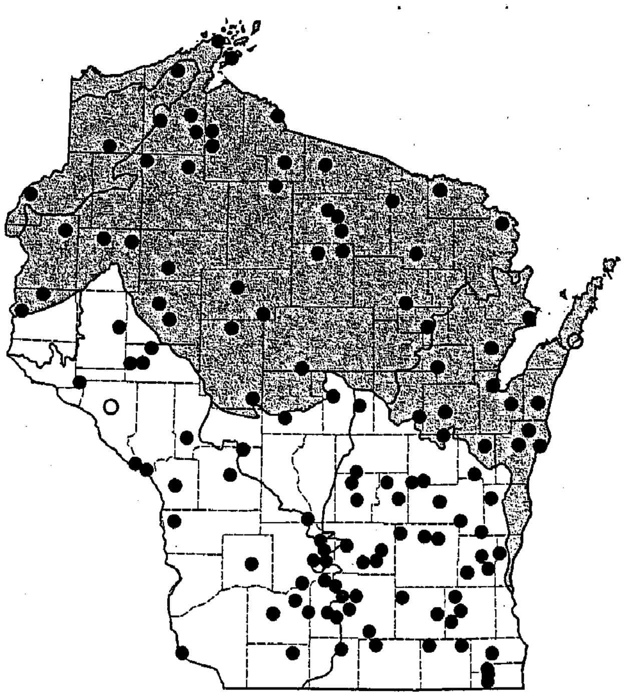
--- Historic Range Limit



Mink Frog

● Recorded

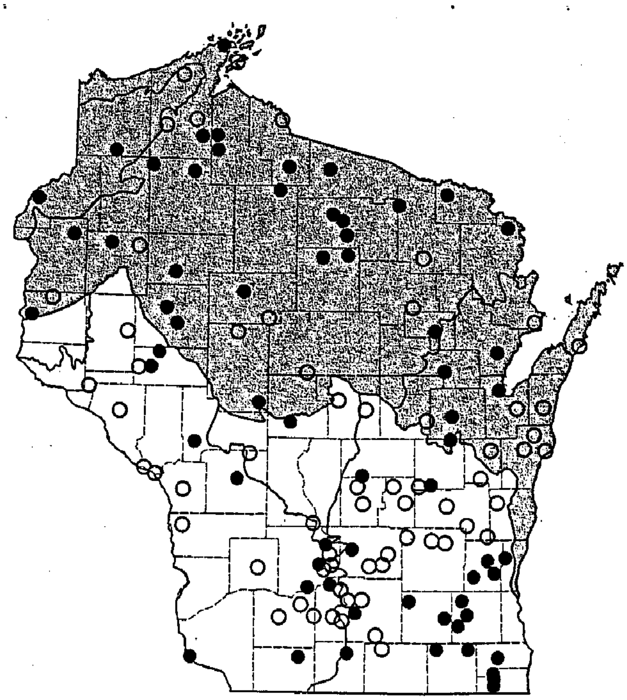
○ Not Recorded



Green Frog

● Recorded

○ Not Recorded



Bullfrog

● Recorded

○ Not Recorded

Figure 21-10. (cont.)

Table 21-4. Relative abundance, sample adequacy, and estimated trends for Wisconsin anurans

	Occurrence		Sample Adequacy[1]			Trend[2]				
Species	Routes[3]	Mean % of Stations[4]	A	B	C	Frequency[5]		Index[6]	Adjusted Index[7]	% Occurrence[8]
Wood frog (*Rana sylvatica*)	90	34	+	+	-	+2.5**	(42)	+4.2***	+5.1**	+0.76
Chorus frog (*Pseudacris triseriata*)	109	49	+	+	+	-1.1	(53)	+0.3	+2.0*	-0.66
Northern spring peeper (*Pseudacris crucifer crucifer*)	109	76	+	+	+	-0.6**	(49)	-1.1***	-1.3***	+0.14
Northern leopard frog (*Rana pipiens*)	91	35	+	+	+	-2.1*	(50)	-1.8	-1.4	-1.19***
Pickerel frog (*Rana palustris*)	19	5	-	-	-	-2.6	(63)	-3.2*	-4.6**	-0.28**
American toad (*Bufo americanus americanus*)	102	44	+	+	-	+1.4	(37)	+1.7	+1.2	+0.42
Eastern gray treefrog (*Hyla versicolor*)	96	53	+	+	+	+0.2	(45)	+0.8	+0.8	+1.06*
Cope's gray treefrog (*Hyla chrysoscelis*)	45	18	-	+	-	-2.4*	(64)	-2.0	-1.3	-0.77**
Blanchard's cricket frog (*Acris crepitans blanchardi*)	2	1	-	-	-	—	—	—	—	—
Mink frog (*Rana septentrionalis*)	12	12	-	-	-	-1.5	(50)	+1.2	+3.2	-0.13
Green frog (*Rana clamitans melanota*)	103	60	+	+	+	-0.4	(58)	+0.6	+2.2**	+0.39
Bullfrog (*Rana catesbeiana*)	36	7	-	-	-	-1.2	(50)	-0.4	+0.0	-0.02

[1] Based on ability of survey to detect given mean annual changes in frequency of station occurrence at $p < 0.10$ and 75 percent power: A = 3%/yr over twenty-year period; B = 3%/yr decline only (1-tailed test) over twenty-year period; C = 3%/yr over ten-year period.

[2] * = $p < 0.10$, ** = $p < 0.05$, *** = $p < 0.01$.

[3] Number of routes for which data were sufficient to contribute to route regression analyses.

[4] Mean percent of stations on which species occurred each year, for routes run during the appropriate survey period.

[5] Route frequency regression technique based on number of stations of occurrence; trend is mean annual percent change (see Methods). Number in parentheses represents percent of routes with estimated declines.

[6] Route index regression technique based on summing call index values for all stations on route; trend is mean annual percent change (see Methods).

[7] Route adjusted-index regression technique based on summing adjusted call index values for all stations on route; trend is mean annual percent change (see Methods).

[8] Percent occurrence technique or regression of pooled, unweighted frequency of station occurrence data for all routes; trend is annual change in percent occurrence (see Methods).

Table 21-5. Comparison of trends from route regression analyses using single-period and combined-period data (see Table 21-1)

Species	Frequency: Single	Frequency: Combined	Index: Single	Index: Combined	Adjusted Index: Single	Adjusted Index: Combined
Chorus frog (*Pseudacris triseriata*)	-1.1	-1.1	+0.3	-0.3	+2.0*	+0.9
Northern spring peeper (*Pseudacris crucifer crucifer*)	-0.6**	-0.4	-1.1***	-0.6*	-1.3***	-0.8**
Northern leopard frog (*Rana pipiens*)	-2.1*	-1.7	-1.8	-2.0	-1.4	-1.3
Pickerel frog (*Rana palustris*)	-2.6	-2.0	-3.2*	-2.4	-4.6**	-4.0***

Type of Route Regression Analyses

*= $p < 0.1$.
**= $p < 0.05$.
***= $p < 0.01$.

Species Accounts

The following accounts are in phenological rather than taxonomic order, according to WFTS data sheets and analyses. Readers should refer to Table 21-3 for statewide status and regional abundance data; to Table 21-4 for statewide abundance, trend, and sample adequacy summaries; to Table 21-6 for significant regional trends; and to Figures 21-10 and 21-11 for distribution maps and trend graphs, respectively. Except where stated otherwise, trend figures refer to percent annual change according to route-frequency regression analysis. For comparison, Herp Atlas maps and narratives are presented in Casper (1996), with an additional narrative in Casper (Chpt. 22, this volume); earlier distribution maps are in Vogt (1981).

Wood Frogs. Wood frogs are the most difficult of the relatively common species to monitor because of their early, short, explosive breeding season. They often begin breeding in vernal ponds while snow is still on the ground and occasionally when ice lingers on some breeding ponds, as early as late March in the southern counties and early April in the north. Although within a particular area they may be found calling over a period of three to four weeks, the peak generally lasts only a week, often less if interrupted by cold weather, and sometimes occurs only on one or two nights (Figs. 21-6, 21-8). The most effective and consistent sampling was done by observers who lived near their route and timed their first run according to the local wood frog activity. Because of these logistical difficulties and annual variations in wood frog breeding activity, year-to-year variation is generally high on individual routes and in regional and statewide data. Several cooperators mentioned that their ability to time the first survey run for wood frogs improved with experience. This factor undoubtedly contributed to the significant annual increases statewide and in the North-central Forest and Central Sands regions, as did the fact that in 1991 we extended the starting date of the early spring sampling period from 15 April to 8 April because several cooperators reported that wood frog activity had waned by 15 April in some years. The trend plot shows a sharp decline indicated during 1984 to 1986 (beginning prior to the onset of drought conditions), followed by a small peak in 1987, then a gradual increase (beginning after the survey period was modified) to a level not quite that of 1984. A more thorough analysis and additional years of data are needed to evaluate the relative effects of bias, drought, and other factors on this trend.

Wood frogs were encountered most frequently in the three northern and eastern forested regions, at about three times its frequency in the Southeast region (where forested habitat is limited) and Driftless Area (where breeding ponds are not common and the species nears its southwestern range limit). WFTS records suggest that the lack of southeastern records in Vogt's (1981) maps represented a relative scarcity rather than absence of the species in those counties. This is also borne out by the recent Herp Atlas data set, which is missing verified records from only eight counties. If populations recorded on the WFTS can be verified, the species will be documented in every county except Lafayette.

Chorus Frogs. Chorus frogs occurred on almost every WFTS route, often in large numbers; however, they were found at low frequencies and call index values in the

Table 21-6. Statistically significant regional trends (1984–1995) for Wisconsin anurans, based on route frequency regression analysis. N is number of routes contributing to trend analysis.

Species	Region	Trend	N
Wood frog	North-central Forest	+2.8*	35
(*Rana sylvatica*)	Central Sands	+6.3*	3
Chorus frog			
(*Pseudacris triseriata*)	Eastern Forest	-16.9**	11
Northern spring peeper	Central Sands	-0.6*	3
(*Pseudacris crucifer crucifer*)	Southeast	-1.5***	31
Northern leopard frog			
(*Rana pipiens*)	North-central Forest	-5.1**	20
American toad			
(*Bufo americanus americanus*)	Driftless Area	+3.3**	22

*= $p < 0.1$.
**= $p < 0.05$.
***= $p < 0.01$.

northeastern counties. The absence of northeastern records in Vogt's (1981) and Conant's (1975) range maps reflects these low densities. The Herp Atlas recently documented records for some of these counties, but WFTS data suggest that more of these counties will be added, as will the western counties of Trempealeau and Jackson. Chorus frog populations apparently rebounded somewhat after a decline in frequency during the drought years. Although the plot suggests an overall decline, statistical tests were equivocal, and the statewide trend is considered stable; however, a significant decline has occurred in the Eastern Forest region.

Northern Spring Peepers. Northern spring peepers were the most frequently encountered anuran in the WFTS, occurring on as many routes as chorus frogs but on more stations per route. To some extent this prevalence is due to the peeper's long calling period and to a call that is loud, persistent, and recognizable. At some stations it may even drown out the calls of chorus frogs and other species. Peepers were usually in full chorus by the middle of the first sampling period statewide, but in the north during the unusually late spring of 1996, they were more detectable during the second period (Fig. 21-9). Peepers evidently occur in every county but are markedly less common in the Southeast region than in other Wisconsin regions. Because of their excellent detectability and consistent calling patterns, they are well sampled by the WFTS, and small population changes can be detected. Almost every type of WFTS analysis since 1987 (except the 1984 through 1996 percent occurrence analysis) has indicated that, though abundant overall, this species has experienced a small but significant decline. The 0.6 percent per year decline in frequency represents a 26 percent loss if extrapolated over a fifty-year period. This is a species for which the survey appears to be well suited to provide early warnings of population declines.

Only 49 percent of spring peeper routes indicated a declining trend, suggesting that declines were more extreme than any increases. The statewide trend resulted mostly from a significant 1.5 percent annual decrease in the rapidly urbanizing Southeast region, where 61 percent of the routes had declining trends. Local peeper populations in this region were known to have disappeared both before and during the time of the WFTS, especially in urban and intensively agricultural regions, where Vogt (1981) noted peepers "do not thrive." Spring peepers warrant concern and further study while populations are still widespread.

Northern Leopard Frogs. Northern leopard frog populations had evidently declined in Wisconsin during decades just prior to monitoring by the WFTS (Vogt 1981). They experienced die-offs from unknown causes associated with red leg infections in the 1970s (Hine et al. 1981) and have been harvested for decades by biological supply companies. According to the WFTS, populations declined from 1984 to 1995. Populations, or at least breeding activity, may also have undergone a temporary

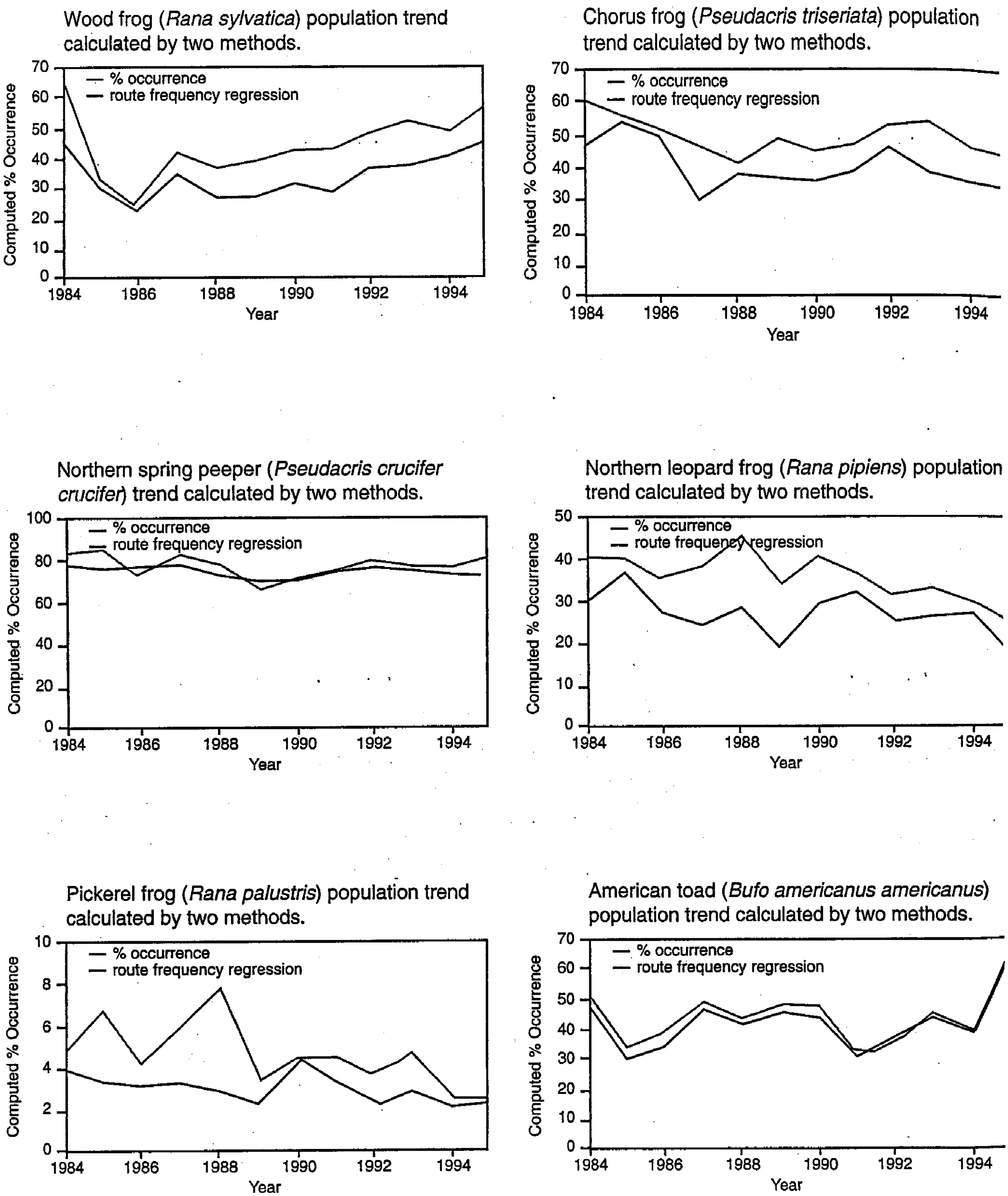
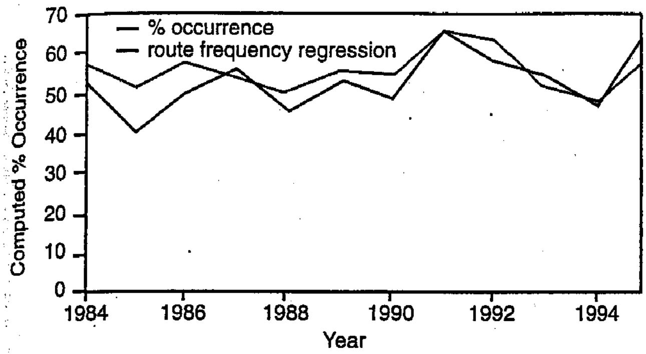
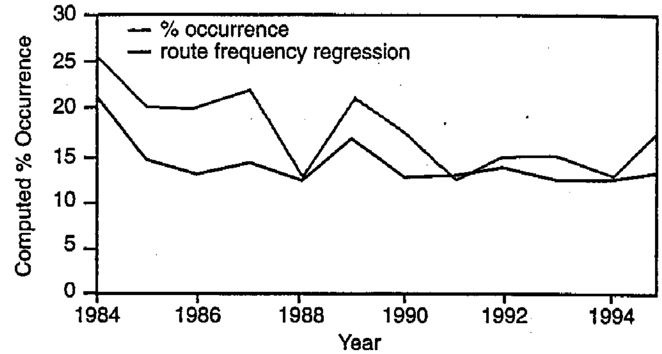


Figure 21-11. Anuran population trend estimates based on percent occurrence and route frequency regression analysis of Wisconsin Frog and Toad Survey data, 1984–1995.

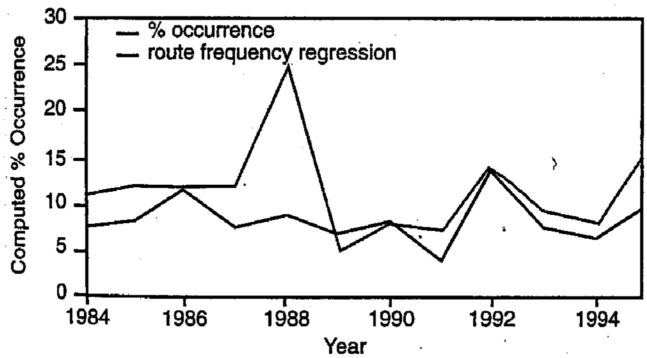
Eastern gray treefrog (*Hyla versicolor*) population trend calculated by two methods.



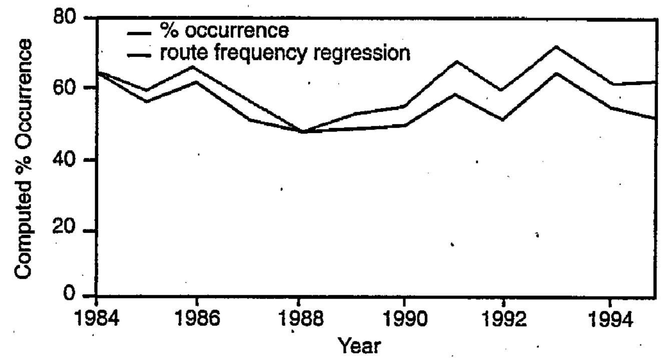
Cope's gray treefrog (*Hyla chrysoscelis*) population trend calculated by two methods.



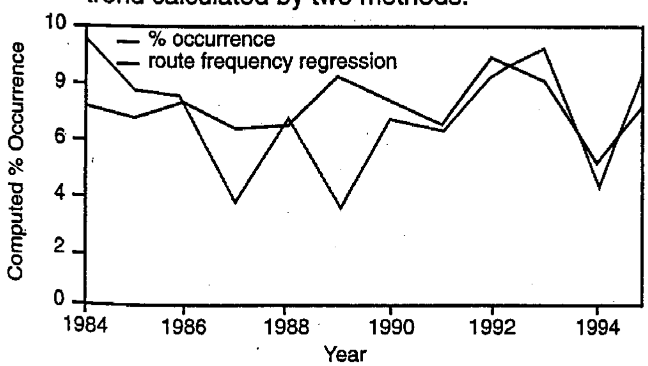
Mink frog (*Rana septentrionalis*) population trend calculated by two methods.



Green frog (*Rana clamitans melanota*) population trend calculated by two methods.



Bullfrog (*Rana catesbeiana*) population trend calculated by two methods.



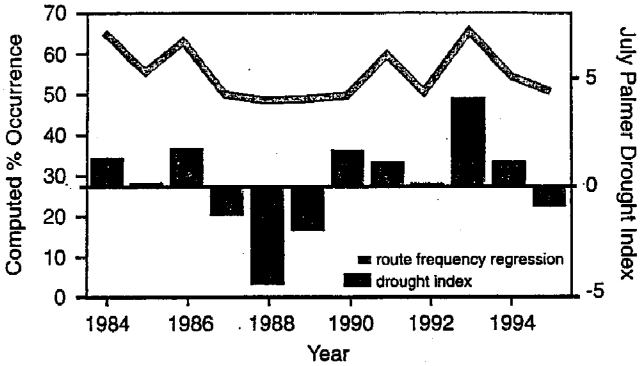


Figure 21-12. The correspondence between green frog (*Rana clamitans melanota*) population trend data and Palmer Drought Index data.

decline during the late 1980s drought. This species will breed in many habitats but is most common in open country. Its distribution is statewide, with frequencies of occurrence being lowest in the most heavily wooded (Northwest and North-central Forest) regions. The North-central Forest region has experienced a significant decline in leopard frog numbers.

Pickerel Frogs. Pickerel frogs were considered threatened in Wisconsin until 1987 but were subsequently downlisted after populations were found to be somewhat widespread. They often breed and overwinter in spring-fed streams and ponds. Although the calls of pickerel and northern leopard frogs can be confused, most cooperators submitting pickerel frog records were certain of them. While WFTS records occur from several counties for which the species has yet to be documented, the distribution of WFTS data resembles that of the Herp Atlas, showing populations concentrated in the Driftless Area and scattered elsewhere. We consider it common (and locally common) in the Driftless Area, rare elsewhere, and uncommon overall. WFTS data suggest that it is second only to Blanchard's cricket frogs in rarity. It was inadequately sampled by the WFTS, although data from nineteen routes suggest a decline that was significant in three of four analyses; 63 percent of these routes had declining trends. Its trend plot resembled that of the closely related leopard frog, which has a similar breeding phenology but occurs in a larger variety of—though generally more open—habitats. Because of its special concern status in the state, a separate monitoring program may be justified.

American Toads. American toads are abundant and breed statewide in a wide range of habitats. American toads occurred on all 122 routes that were run at least twice—about equally in all regions. They have a detectable call, but the calling season can be short during warm springs, when the peak may be missed because it occurs between the early and late spring sampling periods. WFTS data indicate a stable to increasing trend. American toads appeared to increase in abundance during the drought years.

Eastern Gray Treefrogs. Eastern gray treefrogs occur in every county surveyed. The statewide mean frequency of occurrence was second only to spring peepers. Values were highest in the Northwest, North-central, and Central Sands regions and lowest in the Southeast region. WFTS records suggest that this species occurs in several counties, especially in the Southeast, where documentation can be obtained to fill in apparent gaps in the Herp Atlas map. The statewide population trend was stable or increasing, with no apparent response to the drought years.

Cope's Gray Treefrogs. Cope's gray treefrogs are evidently less than half as abundant as the closely related tetraploid eastern gray treefrog (Tables 21-3, 21-4). They were rare in the North-central and Eastern Forest regions and were recorded most frequently in the Northwest Forest and Central Sands regions, areas of predominantly sandy soils dominated by marshes, pine-oak forest, barrens, and conifer bogs. The latter two regions also had high populations of eastern gray treefrogs. Many WFTS records of Cope's gray treefrogs occur in counties for which there are no documented records in the Herp Atlas (Casper 1996). This is especially so in a large area of north-central Wisconsin, where cooperators reported this species from several routes but often from just one or two sites during only one or two years. More documentation is needed because of the difficulty in distinguishing its call from that of the closely related eastern gray treefrog. However, because vocalizations are the most reliable means of detecting and distinguishing between the two gray treefrog species in the field, it is not surprising that a cadre of auditory surveyors would discover populations in areas where no formal documentation existed. We are confident that the species in fact occurs in scattered locations in the north-central counties.

Cope's gray treefrog exhibited a significant 2.4 percent mean annual decline in frequency during 1984 to 1995, with declines noted on 64 percent of the routes on which trends could be computed. Although samples were small in most regions, all but the Eastern Forest region registered declines. Populations deserve continued scrutiny.

Blanchard's Cricket Frogs. Blanchard's cricket frogs, once so common that hundreds were collected from ponds in Madison's Tenney Park (Dernehl 1902) and one of the most common frogs in southern Wisconsin as recently as the 1950s (Hay, Chpt. 11, this volume), are now state endangered. Vogt (1981) noted a precipitous decline in the late 1970s, although the decline had begun previously. Blanchard's cricket frogs, now apparently absent from Madison, were found there as recently as 1972 (Mossman and Hine 1984). On the Lower Wisconsin River, an area of former abundance, cricket frogs had declined substantially by the late 1960s (Vogt 1981; Casper, Chpt. 22, this volume). Extensive daytime and nocturnal surveys along this waterway beginning in 1984 by M.J.M. failed to document a single individual. During 1984 to 1985, M.J.M. conducted five-minute auditory surveys of likely stream and pond habitat at fifty-six sites in the extreme southwestern counties of Grant, Lafayette, and Iowa. These included seven sites where cricket frogs had been found during the previous two years by WFTS cooperators; visual searches were also made at most of these previously reported sites. Cricket frogs were documented at sixteen sites, including six of those previously known. All confirmed sites were in pastured or recently pastured stream bottoms, except for six unpastured sites in Governor Dodge State Park. Some of these confirmed sites were among those checked later, as summarized by Hay (Chpt. 11, this volume). In 1985, M.J.M. also conducted auditory and visual searches at five sites in Kenosha and Washington Counties where cricket frogs had been recently reported, but none were found. Many other sites have been surveyed recently within the cricket frog's historical range in southeastern Wisconsin, but the species was not found (Casper, Chpt. 22, this volume).

Of the approximately seventy WFTS routes run at least once within the historical range of cricket frogs, the species was verified on only three (in Vernon, Iowa, and Lafayette Counties) and was likely on two others (in Iowa and Grant Counties). Two of the three routes with verified records were established specifically to sample potential cricket frog habitat within its current range and included previously identified populations. The third, in Vernon County, reflects one or two individuals tape-recorded in 1991 but not heard subsequently. All other WFTS reports of cricket frogs (including those initially reported by Mossman and Hine 1984) were undocumented and have not been re-reported in recent years; we consider them to be unlikely, although a few might have represented the last individuals of disappearing populations. Most of these apparent errors were made during the early spring sampling period when cricket frogs are not typically calling and at sites in which the species was not found later during the usual summer song period; most or all of these reported cricket frog calls were presumably the similar-sounding "kid-ic" call of the Virginia rail. After being alerted to the similarity and respective phenology of these two species' calls, several observers realized they had made this mistake. Since 1991, cricket frogs have been documented from only two to four stations per year, which is inadequate for monitoring population trends. Therefore, we did not include trend estimates for this species in Table 21-4.

The data from the WFTS, other surveys (Hay, Chpt. 11, this volume), and the Herp Atlas confirm the disappearance of cricket frogs from about 90 percent of their historical range in Wisconsin and their irregular occurrence at isolated sites within their remaining range. Undoubtedly, they now breed on but a fraction of a percent of the sites used as recently as the 1950s. Cricket frogs have also declined—possibly to the point of extirpation—in Ontario (Oldham 1992), Minnesota (Oldfield and Moriarty 1994; Moriarty, Chpt. 20, this volume), and parts of Iowa (Hemesath, Chpt. 23, this volume). The future of this species in Wisconsin may depend on information gathered from research and monitoring in nearby states, where populations are not yet at such critically low levels and where studies on limiting factors may be more fruitful.

Mink Frogs. Mink frogs are uncommon to fairly common in the northern third of the state. The maps of Vogt (1981) and the Herp Atlas (Casper 1996) document their occurrence only as far south as Burnett, Taylor, and Oconto Counties. We and other WFTS cooperators have not found them in apparently suitable boggy marshes in the western part of the Central Sands and adjacent areas; however, they may occur there, as suggested by an undocumented but reliable record from southern Clark County. Mink frogs were most frequently reported in the Northwest Forest region, but the statewide sample is inadequate to monitor trends.

Green Frogs. Green frogs are common to abundant statewide except for the Eastern Forest region, where they were recorded about half as frequently as elsewhere. They were absent from a Door County route that was run for eleven years. The statewide population is apparently stable, although numbers appear to vary according to drought conditions (Fig. 21-12).

Bullfrogs. Bullfrogs are distributed irregularly across Wisconsin, but according to the WFTS and Vogt (1981), they are most common in the North-central Forest region. Numbers were also high, at least during the mid-1980s, along the Mississippi River in Grant County (M.J.M.). Bullfrogs occurred on about half of the routes that were run at least two years. Bullfrogs tend to appear and disappear from individual sites over time, possibly because of introductions (Casper, Chpt. 22, this volume) and harvest (Vogt 1981). Apparently because of their irregular geographic and temporal distributions and relatively small sample, they were inadequately sampled by the WFTS. This species' vocalizations are unmistakable, and WFTS records suggest that many more counties will be added to its documented distribution in the Herp Atlas.

Discussion

The distribution and trend data reported here should be interpreted within the limitations of the survey methodology. The possibility of misidentifications is a qualification common to any study that relies on volunteers, but in this program—despite the lack of any training workshops and formal certification requirements—we consider it minor. Misidentifications are minimized by the quality of instructional materials, by communication between cooperators and staff (e.g., checking with cooperators on unusual records and encouraging new cooperators to accompany experienced ones before starting their own routes), and by the care obviously taken by most cooperators, most of whom have contributed data for several years. Misidentifications are more of a concern for distributional records than for trend calculations. In this regard, it is impractical to expect volunteers to document all potentially disputable records. However, with the help of the Herp Atlas we hope to better target species requiring documentation, which will be secured by the original observer, WFTS staff, or others interested in obtaining distributional records.

A potential problem stems from the qualitative definitions of call index values and the fact that each cooperator does not interpret them identically. Observers in Ontario agreed on presence or absence of species more than 95 percent of the time but agreed on index values of present species only 47 to 83 percent of the time; agreement was greatest among experienced observers (Shirose et al. 1997). Among inexperienced observers in Iowa, agreement was also high for presence or absence but was lower (56 to 83 percent) for call index values (Hemesath, Chpt. 23, this volume). In southeastern Wisconsin, differences in call index values were less between observers than between nights (Kline, Chpt. 38, this volume). Observer bias has not been investigated by the WFTS program, but we consider it to be minimal because: (1) WFTS cooperators are generally experienced (i.e., most have accompanied another observer before being responsible for their own route); (2) most run the same route for many years; (3) changes in personnel on a particular route are usually preceded by the requirement to have the two observers run the route together; and (4) at the beginning of the program most cooperators were already experienced. Further, our analyses thus far have relied primarily on presence or absence data rather than call index data. Nonetheless, it may be worthwhile for us to investigate observer bias and the value of providing training opportunities for observers in order to minimize it.

We have presented limited data here on the effects of date, drought, and air and water temperatures on the frequency and intensity of anuran calling and the sorts of problems these variations can cause for auditory surveys. These factors probably affect precision more than accuracy, and the WFTS has many data that should be used to look more closely at the causes of call variation. We have attempted to minimize these sources of variation by helping cooperators conduct surveys under the most appropriate seasonal and nightly conditions, within the general guidelines of date and water temperature, for each sampling period. We hope to assist cooperators further by enlisting regional contact people who can provide information on current conditions and breeding activity.

Although improvements in the WFTS are always sought, any change must be considered critically in regard to its potential to alter substantially the nature of the data. Thus we try to balance improvements with continuity. In the case of expanding the early spring sampling period in 1991, we opted for a needed improvement but may consequently have biased the wood frog data set, at least in the short term. Overall, we believe that current guidelines, training, and sampling procedures are appropriate; cooperators are in general agreement with this impression.

The most important limitation of the WFTS methodology is the subjective selection of listening stations. Thus, although cooperators established routes to represent the range of available anuran breeding habitat in their area, there is no measure of the actual representation of our sample. Nor have we incorporated a measure of the abundance of these habitats across the state. So, for example, when we find that green frogs have a higher percentage occurrence in the Southeast than in the North-central and Eastern Forest regions, we do not know if this reflects a higher density of green frog populations in the Southeast or simply a more complete sampling of its available habitat there.

The subjective selection of stations makes the interpretation of estimated population trends difficult, because we are not certain just what the sample represents (e.g., Krzysik, Chpt. 41, this volume). Adjustments in the route regression analyses help alleviate some of this uncertainty and potential bias by weighting each route according to the coverage in its region, so that, for instance, a species' calculated statewide trend is not influenced inordinately by its trend in the Southeast, where routes are concentrated. However, routes were not placed evenly across each region, so some landscapes remain sampled more than others. Furthermore, if the suitability of sites naturally fluctuates over time (e.g., decades) according to conditions such as drought, flooding, siltation, and vegetational succession, it is possible that observers tended to choose their stations to be at "good" sites—close to wetlands that were near their maximum suitability at that time. If the suitability of these wetlands subsequently declines while the suitability of unsampled wetlands increases, erroneous population declines might be estimated. To complicate the matter even further, habitat changes that decrease a wetland's suitability for one species may improve it for another. The most obvious bias would occur if new wetlands were actually created or restored where they did not exist at the time the route was established.

These potential biases were recognized early in the WFTS program, and we were among those recommending a more representative selection procedure for the NAAMP protocol (Mossman et al. 1996). However, the problem of identifying potentially suitable habitat is difficult and is still being discussed. The currently recommended NAAMP protocol establishes stratified-random roadside routes along which stations are established at minimum intervals, within hearing distance of wetlands regardless of whether anurans are heard there. However, this protocol also involves a subjective identification of potential habitat, and depending on how well the person establishing the route knows the area and at what time of year it is established, some potential sites (especially ephemeral ones) could be missed The use of wetland maps to help identify potential habitat also has its limitations. For example, these maps often do not include small ponds and wet meadows and rarely include ephemeral ponds, where many species breed free from the pressures of fish predation. The only feasible way to obtain a truly representative sample may be to establish stations regardless of their proximity to wetlands, for example, along sections of BBS routes. Wisconsin has seventy of these roadside routes, each comprising fifty stations located 0.8 kilometer apart and located in a stratified-random pattern across the state. This would require no assumptions about the suitability, potential suitability, or abundance of habitat for various species or the minimum distance to breeding habitat allowed for listening stations to be established. But it leads to a logistical predicament because, for many areas of the continent, very few if any frogs would be heard from most random roadside locations. Sampling intensity would have to be increased considerably, and cooperators might have to be paid (however, randomly chosen sites could also provide much-needed monitoring data for night-calling birds, such as nighthawks, whippoorwills, and owls). Even the recommended NAAMP procedure may reduce encounters and necessitate more routes than what we estimated were required to obtain adequate samples in Wisconsin. However, if the routes are more representative, the data returned should be worth the effort.

One advantage of the subjective selection of stations is that cooperators tend to be dedicated to their routes. Cooperators tend to pay close attention to changes in "their" wetlands and frog populations, and this probably contributes to the long and consistent coverage of so many routes in Wisconsin. Indeed, such a commitment produces cooperator continuity and efficiency and contributes to the educational value of the WFTS. The success of any program with a more objective site selection procedure may depend on the extent that this same sort of commitment can be engendered.

Even considering the above discussion, we are confident that the current WFTS has provided valid results on population trends and general abundance patterns over its relatively short tenure. However, we plan to experiment with NAAMP protocols and perhaps BBS-style survey routes while continuing our established routes. We will do this in order to investigate potential biases, both in our program and in the new sampling systems, and to consider how we might change the WFTS without losing the trend information already present in our current database. We hope that these and other analyses of our dataset will provide information useful to the NAAMP and to other states and provinces (see Moriarty, Chpt. 20; Hemesath, Chpt. 23; and Johnson, Chpt. 37, this volume) in terms of developing methodological protocols, analytical techniques, and background information that will help with data collection and interpretation.

The WFTS has produced a valuable database on Wisconsin anuran distribution and has indicated areas and particular sites where documentation should be sought to fill gaps. The data suggest that two species (mink frogs and Blanchard's cricket frogs) reach their range limits in Wisconsin and are restricted to the northern half and southwestern corner of the state, respectively. American toads are the only species relatively evenly distributed across the state. The remaining nine species are essentially distributed statewide but are either absent from scattered sections of the state (pickerel frogs and perhaps bullfrogs) or are less common in some areas than elsewhere. For some species, these regional patterns of abundance are probably due at least in part to being near range limits (chorus frogs in the northeast, wood frogs in the southwest) or to the limited availability of habitat in certain sections of the state (e.g., for wood frogs, eastern gray treefrogs, and possibly spring peepers in the Southeast region or for northern leopard frogs and Cope's gray treefrogs in the North-central Forest region). In other cases, areas of apparently low abundance are more difficult to explain—for example, green frog and Cope's gray treefrog populations in the Eastern Forest region.

We are now using a Geographic Information System (GIS) to study habitat correlations with anuran abundance at each of a sample of WFTS stations. Hopefully, this will explain some species' patterns of abundance. It should also measure the degree to which the various habitat types are sampled in each region and thus help us better estimate the relative abundance of each species among different regions and the representation of the data used to calculate trends.

We have experimented with several methodologies to calculate population trends, most of them modified from the BBS protocol. An analysis of the 1984 to 1995 data suggests that maintaining a variety of such methods provides useful comparisons and a degree of redundancy that is prudent at this early stage in the development of appropriate analytical techniques. We found route frequency regression to be the most useful technique because it accounted for differences in regional sampling intensity and the fact that most routes are not run every year. However, simple annual percent occurrence approximated the route frequency regression trend plots for most species and were almost identical for a few well-sampled species. Route index regression and route adjusted-index regression results were more difficult to interpret because they incorporated the call index into trend estimates by arbitrarily assigning numbers to each index value; however, they were useful for comparison with the trends estimated from frequency alone. Trends estimated from these four methods agreed fairly well. Route regression trends were also similar when calculated using combined-period data for four typically "early spring" species that are sometimes more detectable during the late spring sampling period. The 1984 to 1995 trend analyses indicate that the added complication of comparing early and late spring data for each of these species at each station and the loss of some early spring data from routes in years when the second period is not sampled do not warrant the use of combined-period data. However, the incorporation of data from 1996—an extremely late year phenologically—may prove otherwise.

Population declines estimated by the WFTS should direct researchers' attention to spring peepers, northern leopard frogs, pickerel frogs, and Cope's gray treefrogs. A closer scrutiny of WFTS data is needed to verify these trends and their geographic and temporal patterns; our current evaluation of WFTS and GIS data may also indicate habitat relationships important to the survival of these species. These evaluations should therefore help identify specific management-related research programs and perhaps highlight additional monitoring needs for these species. A look at species' life histories and known habitat requirements may also suggest common factors that might be involved with declines. For example, the fact that all species with significantly declining trends spend considerable amounts of time in upland habitats, while declines were not detected in the three aquatic ranids (mink frogs, green frogs, and bullfrogs), suggests that upland habitat changes may be worth investigating. Research into the causes of cricket frog declines is desperately needed and should occur across state and provincial boundaries in order to incorporate healthy and declining populations in different parts of its range.

Four species were inadequately sampled by the WFTS. It is probably impractical to establish separate monitoring programs for each of them, but such programs are warranted for endangered cricket frogs and probably for pickerel frogs (state special concern status). More adequate monitoring could be accomplished by the addition of auditory survey routes within a species' range (and run only during its calling period) or by other methods that might include some intensive long-term study areas. Regardless, it is important to continue monitoring these four species with the WFTS, which can still detect more extreme population changes and changes over longer periods of time. Most important, our data can be added to those from other states and provinces to obtain adequate sampling over larger geographic areas.

Developing and maintaining a large volunteer-based survey can be difficult, and the WFTS has required considerable time and energy from many dedicated volunteers, as well as from central program staff who must set and periodically review protocols, solicit cooperators, distribute materials, evaluate survey returns for potential problems, maintain communication with cooperators, analyze data, and interpret results. We have found that in order to maintain quality control, continuity, and an adequately large dataset, the program does not "run itself." However, there is probably no other practical way to monitor these populations over the long term. Plus, such programs have the added advantage of being an effective educational tool.

Conclusions

The WFTS has been an invaluable tool for monitoring trends and distributions of Wisconsin's twelve anuran species. It has also provided useful information on the effects of climate and site factors on anuran breeding-call phenology and breeding activity, which has been essential in interpreting trend estimates; however, in this regard there is much more to be analyzed in the dataset. The survey's fifteen-year history, including the recent development of analytical techniques, demonstrates that the WFTS is an appropriate model for use (with other techniques) in the continent-wide amphibian monitoring program being organized by the NAAMP. The NAAMP's efforts to improve on the subjective placement of listening stations is essential; nonetheless, potential biases in trend and distribution estimates need to be investigated for the WFTS and the NAAMP's stratified-random selection procedures.

Based on several trend analyses conducted on WFTS data, three of the eight adequately sampled species underwent significant population declines during the period 1984 to 1995. Declines had been otherwise suspected for spring peepers and northern leopard frogs—two of the most widespread species in the state—but not for the less common Cope's gray treefrogs. One species (wood frogs) had significantly increasing trend estimates, which may have resulted in part from improvements in observers' abilities to time their surveys for this species' early, explosive breeding season. Three adequately sampled species (American toads, eastern gray treefrogs, and green frogs) exhibited stable to increasing trends. The four inadequately sampled species have limited distributions in the state: bullfrogs and mink frogs showed no indication of decline, but pickerel frogs did. The endangered Blanchard's cricket frog is too poorly sampled for WFTS data to suggest any trends, other than to document its rarity and extreme losses since the 1950s.

Whereas further attention is warranted in Wisconsin to investigate what may be long-term declines in spring peepers, leopard frogs, Cope's gray treefrogs, and possibly pickerel frogs, Blanchard's cricket frogs need to be studied primarily in nearby states where declining populations are larger.

WFTS data have quantified regional distributions of all twelve anuran species and have filled gaps in the known distributions of several species. However, additional documentation is needed for some calling records.

The program has helped educate hundreds of cooperators about the existence, ecology, and conservation of amphibians and the habitats on which they depend, while simultaneously contributing to amphibian conservation. Cooperators have also disseminated to the public information on amphibian population trends and conservation issues, and many have increased the public's involvement in other cooperative projects, such as the Herp Atlas.

Quality control and communication with cooperators are important factors for newly developing volunteer survey programs such as the WFTS, especially during the years before any results from trend analysis become meaningful; these factors have remained essential throughout the tenure of the WFTS. We have modified the program in a number of ways over the years and are now considering minor changes, such as the addition of monitoring night-calling birds, targeting documentation needs, improving the instructional materials, and identifying regional contact people who can help volunteers time their surveys. We will begin establishing some routes using NAAMP standards. These routes will be compared with our traditional routes, and we will be investigating additional uses of the large WFTS dataset, for example, regarding the effects of climatological factors, geography, and habitat on species distributions and trends.

Summary

Suggestions of widespread declines in amphibian populations have encouraged various agencies to initiate long-term monitoring programs, including auditory surveys for anurans based on the Wisconsin Frog and Toad Survey begun in 1984. The Wisconsin survey consists of approximately 120 permanent roadside transects, each comprising ten nocturnal listening stations. Volunteers survey each station in early spring, late spring, and summer, recording an index of abundance for each species based on the general frequency of breeding calls. The survey has been an important educational tool. Results have helped elucidate the breeding phenology, status, distribution, and short-term population fluctuations of Wisconsin's twelve anuran species and suggest that some species are in decline. Most new distributional records need further documentation. Several species apparently suffered short-term declines during the drought years of 1986 to 1989. Spring peepers (*Pseudacris crucifer*), northern leopard frogs (*Rana pipiens*), Cope's gray treefrogs (*Hyla chrysoscelis*), and possibly pickerel frogs (*Rana palustris*) are experiencing more long-term declines. Most species are currently sampled well enough to detect a 3 percent mean annual change over a twenty-year period at $p < 0.10$. Potential biases resulting from the subjective selection of listening stations and the limitations of alternative methods of selection warrant investigation.

Acknowledgments

This survey program would not exist except for the hundreds of cooperators who have volunteered their time, expertise, and travel expenses since its inception. Nor would it have been initiated at such an early date without the foresight of WDNR researcher Ruth Hine and the creative work of Debra K. Jansen and Ray Anderson, then of the University of Wisconsin-Stevens Point. Phenological data were collected and shared by cooperators Ron Eckstein, Karen Voss, Karen Etter Hale, and Carol Rudy. Lisa Dlutkowski, Kelly Kearns, Charlene Gieck, Ricky Lien, and others have helped coordinate the survey or summarize returns. John Huff established the computer database, wrote and modified initial analytical programs, and produced some of the early summaries and analyses. Paul Rasmussen helped with data transfer between the WDNR and the USGS. Janel Pike and Ron Gatti produced the distribution maps. Sam Droege of the USGS helped conduct the power analysis. WDNR supervisors Ruth Hine, Randy Jurewicz, LeRoy Petersen, and Jerry Bartelt helped to ensure the survey's continuation through the lean times.