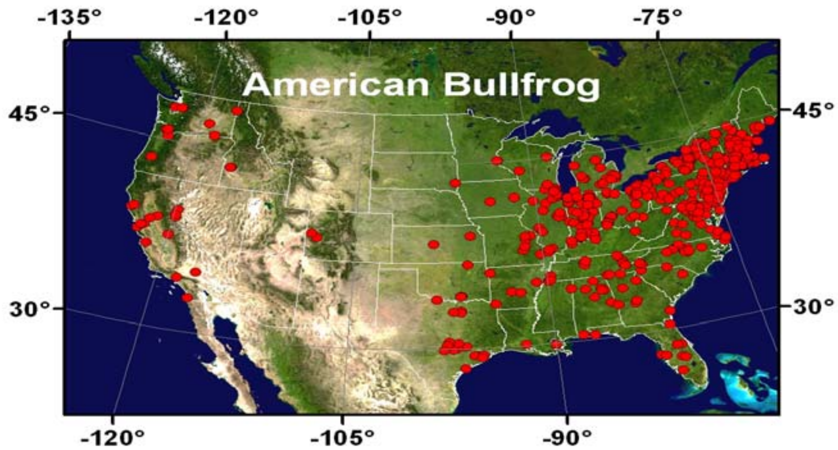
FINAL REPORT
ASSESSMENT OF UTILITY OF FROGWATCH USA DATA
1998-2005



October 31, 2006

by

Douglas B. Inkley, Ph.D.
Senior Science Advisor
National Wildlife Federation

for

U.S. Geological Survey
(Grant 05HQGR0106)

EXECUTIVE SUMMARY iii
ACKNOWLEDGEMENTS v
INTRODUCTION 1
Frog Monitoring 1
Purpose 3
ASSESSMENT OF AND RECOMMENDATIONS FOR FROGWATCH DATA COLLECTION 4
Volunteer Recruitment 4
Data Quality 6
Expertise of Frogwatch Volunteers 7
Accuracy of Data and Data Entry 8
Appropriateness of Analytical Processes 12
USE OF FROGWATCH DATA 14
Species Observed 14
Range Assessments 16
Population Trends 17
Probability of Detection 19
Species Diversity 20
Habitat Preferences 23
Seasonal and Temperature Assessments 23
Intraspecies Assessments 24
Interspecies Comparisons 24
Climate Change 25
FROGWATCH AND OTHER FROG MONITORING PROGRAMS: COMPETITIVE, COLLABORATIVE OR COEXISTING? 26
Data Use 26
FrogWatch Canada 28
Data Availability 29
DISCUSSION 31
CONCLUSION 33
LITERATURE CITED 34

EXECUTIVE SUMMARY

Frogwatch USA is a nationwide frog and toad monitoring program in the United States, with sites observed in 49 states. This citizen science monitoring program was initiated in 1998 by the U.S. Geological Survey to report observations of frogs and toads throughout the U.S. Since 2002 the National Wildlife Federation has administered Frogwatch USA by recruiting and assisting volunteers, operating the Frogwatch USA webpage and storing observational data provided by volunteers. Using the 1998-2005 data, this report is the first comprehensive assessment of the utility of Frogwatch in contributing to the science and conservation of frogs and toads. Potential uses of the data are assessed and recommendations made for improvement of Frogwatch USA. This report also assesses how Frogwatch USA can potentially be used in coordination with other frog monitoring programs.

Through 2005 some 1,395 volunteers monitored 1,942 sites. These sites had 19, 253 visits for an average of 10 (9.9) visits per site. During these visits 79 species of frogs and toads were observed, with an average of 1.7 species observed per visit. Species observed over 1,000 times included the spring peeper, green frog, American bullfrog, gray treefrog, American toad, wood frog and Western chorus frog. Another 13 species were observed over 100 times. Using location data for each site, the range distributions of these species were determined. Temperature data reported for each visit were assessed to determine the temperature average and range during observations of each of the commonly reported species.

Based on the first eight years of the program, Frogwatch USA is a valuable tool for monitoring the status of frogs and toads. In addition to providing recent locational and temperature information by species, Frogwatch USA data has the potential to provide fruitful sources of investigation in many areas, including frog and toad species diversity, regional variation in species temperature preferences, long-term range changes, and seasonal changes in activity. Although the method of site selection limits use of Frogwatch USA for population assessments, there is nonetheless potential for determination of population trends by assessment of changes in the percent of sites at which a species is observed over time. Because of repetitive sampling of the sample site, Frogwatch USA is particularly well suited for determining the probability of detecting a species under differing environmental conditions, as well as optimal dates to detect specific species and/or the greatest number of species.

Observation data from Frogwatch USA should be coordinated with FrogWatch Canada, and can augment existing species databases maintained by state and federal agencies, as well as private entities. Frogwatch USA can also provide information for stratifying sample sites and identifying optimal survey dates for other frog monitoring programs intended for assessment of population trends. And, probability of detection computations from Frogwatch USA data can provide correction factors for other frog monitoring programs.

In light of current major environmental threats such as global warming, loss of habitat and invasive species, Frogwatch USA can provide critical data for long term assessments of frog and toad status, as well as their adaptation to various environmental stresses.

Frogwatch USA should be continued based on its scientific benefits alone, although it has important environmental education benefits as well. Formation of Frogwatch USA chapters across the U.S. would increase administrative efficiency, increase the number of observation sites and assist Frogwatch volunteers. Changes in the Frogwatch USA webpage data entry program could minimize data entry errors. The Frogwatch USA data set is recommended to be made available on the internet for access and analysis by scientists. The Frogwatch USA name is recommended to be slightly modified to FrogWatch USA, and a national Frogwatch USA Summit is recommended to develop a long-term strategy for continuation of this valuable scientific and educational program.

ACKNOWLEDGEMENTS

This assessment of Frogwatch USA was possible because of the dedicated efforts of the many Frogwatch USA volunteers who expend considerable time and energy to monitor frogs and toads and report their observations.

We thank U.S. Geological Survey staff Lianne Ball, Sam Droege, Steve Hilberger, Rick Kearney and Linda Weir for their support and interest in this project and Heather Andrachuck, Sam Droege, Margaret Fowle, Patty Glick, Amy Goodstine, Courtney Herrell, Melinda Hughes-Wert, Craig Tufts and Linda Weir for their constructive comments on an earlier draft. In particular, the insights of Sam Droege and Linda Weir lead to significant improvement in the population and diversity assessments, respectively. Thanks to former and current Frogwatch staff Amy Goodstine, Emily Gibbs, Sue Zwicker, Gideon Lachman, Courtney Herrell and Melinda Hughes-Wert for their administration of the Frogwatch USA program. NWF volunteer Mike Meyer assisted with data assessment and recommendations through an initial independent assessment of Frogwatch USA.

NWF Information Technology staff Julie Hart lent her expertise in Microsoft Access, thereby facilitating Frogwatch data assessment and analysis. NWF Information Technology staff Don Hoppe and John Hottel assisted in resolving computer technology issues. NWF staff member Brad Nunley kindly produced all range maps.

This specific project was made possible by a grant (Grant 05HQGR0106) from the U.S. Geological Survey and in-kind support from the National Wildlife Federation. Earlier support from the National Fish and Wildlife Foundation (NFWF) facilitated development and growth of Frogwatch USA to its current status.

INTRODUCTION

Throughout history, amateur scientists have contributed immensely to scientific fields of research. While few may experience the thrill and subsequent fame of finding a new planet, as amateur astronomer Clyde Tombaugh[1] did in 1930 when he discovered Pluto,[2,3] millions of dedicated amateurs have contributed to the advancement of science and conservation through their volunteer activities.

Amateur scientists, often referred to as citizen scientists, have played an especially significant role in the monitoring of wildlife populations. The Breeding Bird Survey (Sauer et al. 2005) and Christmas Bird Counts (National Audubon Society 2006) rely primarily on citizen scientists to record bird observations. Scientific studies of these data have been important for assessing avian population trends (see Butcher et al. 1990, Barker and Sauer 1992), as well as range distributions (see Bystrak 1971, Root 1988, Beard et al. 1999) and range changes (see Root and Weckstein 1994). These surveys have contributed to the understanding of avian species diversity and the status of individual bird species, as well as the effects on birds of climate change, urbanization and habitat changes (see Price 1995, Root and Weckstein 1994).

Although birds have been monitored for decades by citizen scientists, there has been relatively low past interest in monitoring and conserving amphibians. Public awareness and interest in amphibians accelerated when scientists began to report on the decline of frog populations around the world (Phillips 1990, Reaser 2000). Concern about worldwide declines in frogs, combined with success of the Breeding Bird Survey (BBS) and Christmas Bird Counts (CBC) were key factors leading to the idea of enlisting citizen scientists for monitoring anurans (frogs and toads). Similar to birds, the loud vocalizations of most frogs and toad species during the breeding season render them readily detectable at certain times of the year.

Frog Monitoring

Potential benefits of successfully monitoring frogs and toads are many. Their permeable skin and specific habitat requirements make them particularly sensitive to environmental change. Therefore, frog and toad monitoring can serve as an early warning indicator of significant environmental change in both terrestrial and aquatic environments which may be otherwise difficult to detect in the early phases. Early detection of environmental

---

[1] After his discovery of Pluto as an amateur, Tombaugh went to New Mexico State University where he established the university's research astronomy department. (www.cbsnews.com/stories/2006/09/05/opinion/main1965478.shtml).

[2] Classified as a planet since its discovery, in 2006 the International Astronomy Union's new criteria for planets excluded Pluto as a planet, instead recognizing it as meteor-like object in the Kuiper Belt. (www.cbsnews.com/stories/2006/09/05/opinion/main1965478.shtml)

[3] www.lowell.edu/AboutLowell/history.html

problems can facilitate addressing those issues before they become severe. As measures of frog and toad status, as well as environmental health, several national programs to monitor anurans have been developed in recent years.

The North American Amphibian Monitoring Program (NAAMP) was developed by the U.S. Geological Survey, with data collection beginning in 1997 (Weir and Mossman 2005). Modeled after the highly successful Breeding Bird Survey, a stratified random block design is employed to select designated routes of ten roadside stops, which are monitored several times annually within specified seasonal dates, time of day and weather conditions. Citizen scientists as well as some professionals monitor the routes after passing a frog call identification test. Monitoring is limited to the sites established by the protocol of the stratified random blocks. The specifications of routes and monitoring are designed to facilitate statistical analysis of the collected data with the intent of yielding scientifically valid information, especially on population trends.

The U.S. Geological Survey also developed and implemented the Amphibian and Reptile Monitoring Initiative (ARMI) to monitor, study and conserve amphibians in the United States (armi.usgs.gov/). Staffed by a small group of dedicated professionals, ARMI has implemented a diverse array of amphibian studies including population trends, life history, habitat requirements and factors affecting their populations.

Frogwatch USA was developed by the United States Geological Survey with initial implementation in 1998. In 2002 the National Wildlife Federation (NWF) assumed management of Frogwatch USA through a Memorandum of Understanding, agreeing to recruit, train and coordinate citizen volunteers and maintain the website. Through the training and involvement of citizen scientists, Frogwatch was also intended to educate and motivate persons about frogs and toads (herein generically referred to as frogs) and our environment, making NWF an ideal administrator of the program.

The volunteer investment required by Frogwatch citizen scientists is less than for NAAMP due to less stringent monitoring protocols. Furthermore, unlike NAAMP, the Frogwatch monitoring sites are determined entirely by the volunteers, providing them with greater flexibility. The less stringent protocol and more flexible site requirements of Frogwatch likely make it more attractive to volunteers, but these same two factors also make it more difficult to obtain scientifically useful information. Despite this shortcoming, Frogwatch information has the potential, in a cost-effective manner, to augment the information available to scientists on the range and abundance of frogs provided by NAAMP, ARMI and other more-localized frog monitoring projects.

Now that Frogwatch has been in place since 1998, an assessment of the utility of the collected data can provide direction for the program to ensure its effectiveness.

Purpose

The purposes of this research project were to:

1) Assess and recommend how to improve Frogwatch data collection;
2) Assess what useful information can be extracted from the data collected through 2005; and
3) Assess how the information available from Frogwatch can best be used in coordination with or to assist other frog data monitoring programs.

Together, these assessments are intended to guide future development of the Frogwatch USA program.

ASSESSMENT OF AND RECOMMENDATIONS FOR FROGWATCH DATA COLLECTION

Purpose one of this project was to "assess and recommend how to improve Frogwatch data collection." This required examining both volunteer recruitment (data quantity) and data quality. Recommendations for improving Frogwatch data collection are summarized in Box 1 and discussed below.

Box 1. Summary of Recommendations for Improving Frogwatch Data Collection

Increase volunteers (and number of sites monitored) by establishing Frogwatch chapters
Encourage competency test for Frogwatch observers
Develop process for regional coordinators to review/verify unusual species reports
Restrict temperature data to Fahrenheit
Implement screen for out-of-range temperature values during data entry
Implement screen for out-of-range latitudinal and longitudinal values during data entry
Cease collection of data on the time at which observation was terminated
Implement collection of duration of observation (should be three minutes)
Require or ask that raw data sheets be submitted after entry via the internet
Create means to flag records that are outside of protocol guidelines

Volunteer Recruitment

Without volunteers to collect data, Frogwatch could not exist. Thus, volunteer recruitment is critical to data collection and the success of Frogwatch. Initially administered by NWF's Conservation Department (2002-2004), in 2005 NWF's Volunteer Program staff in the Education Department took over management. This transition allowed NWF to take advantage of its existing volunteer management staff to recruit and support the volunteers, while also allowing us to provide Frogwatch volunteers with other volunteer opportunities in which they might be interested, such as our Habitat Stewards and Global Warming Ambassadors programs. Under NWF's management, Frogwatch expanded from a primarily Atlantic coastal states program with an average of 167 volunteers annually (1999-2001) to a national program with an average of 390 volunteers annually (2002-2005) (Figure 1, Table 1).

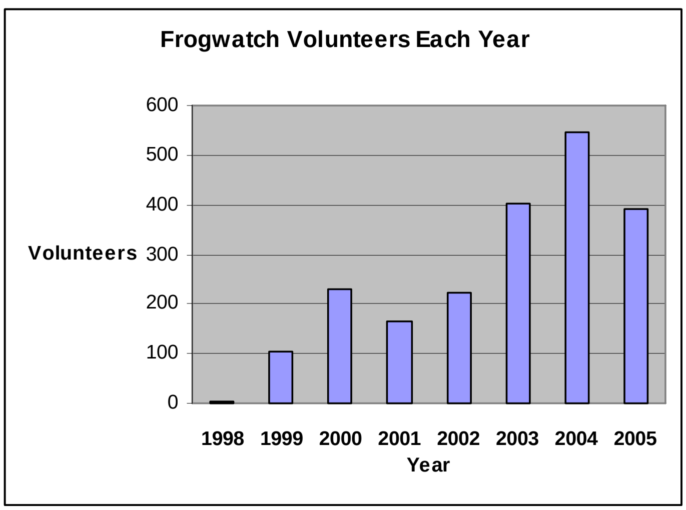


Figure 1. Frogwatch Volunteer Participation by Year

Frogwatch sites are now in all fifty states excepting North Dakota (Figure 2) and the average number of monitored sites has more than doubled from 254 sites (1999-2001) to 657 sites, although the overall number of monitored sites declined in 2005 (Figure 3, Table 2) when staff changes precluded effective management for several months. Frogwatch monitoring is now one of NWF's most popular volunteer opportunities.

Notwithstanding the successes of volunteer recruitment and hence the growth of Frogwatch into a national program, significant challenges remain. Particularly in the plains states, additional volunteers are needed to increase the number of monitored sites (Figure 2). Furthermore, additional effort is needed to motivate registered volunteers to actually monitor sites.

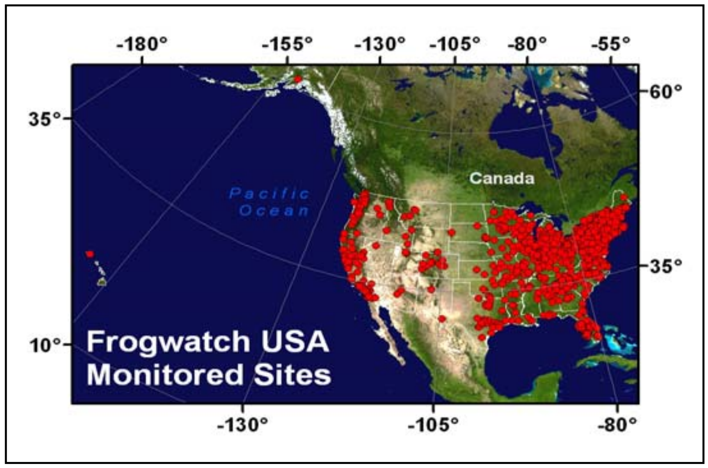


Figure 2. Frogwatch Monitoring Sites (1998-2005)

Through June 2005 a total of 5,031 individuals registered as Frogwatch volunteers, but only 1,365 actually monitored and reported their observations (Gibbs 2005).

Volunteer recruitment and management can be improved to increase the number of qualified and active volunteers (and hence monitored sites), reduce overall administrative needs at the national level, and improve assistance to both interested and active volunteers. Herein are recommendations to restructure the administration of the Frogwatch program to meet these needs.

In contrast to managing all Frogwatch volunteers out of NWF's headquarters in Reston, Virginia, as is currently done, Frogwatch volunteers could be linked to a "Frogwatch USA Chapter" in their state or county with designated Frogwatch Coordinators. This would give volunteers more resources locally while still connecting with NWF on a national level. It would also enable the NWF Volunteer team to recruit volunteers more successfully by leveraging partnerships with local and state

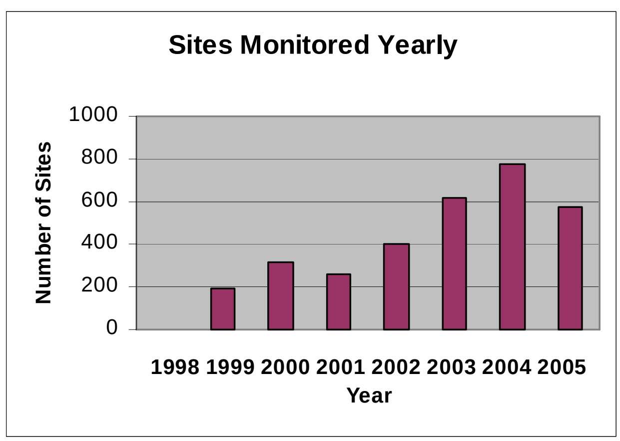


Figure 3. Sites Monitored per Year

organizations such as county park and recreation departments, local nature centers, wildlife refuges, state herpetological organizations and zoos.

The proposed chapter structure would be modeled on a current partnership with the Parks and Recreation Department of Howard County, Maryland. In 2000, Howard County Parks and Recreation took on Frogwatch USA as one of their volunteer programs. Volunteers were provided with localized, hands-on training and support. By creating similar "chapters" throughout the country, NWF will maximize its outreach by providing more thorough local recruitment, community-based training and direct accountability from the chapters. It would also allow the volunteers to connect for training purposes that are geared toward their local area, as well as allow networking between Frogwatch volunteers and experts in the field, leading to more knowledgeable volunteers, higher quality data and improved recruitment and retention of volunteers.

Under this structure, NWF would continue to maintain the Frogwatch USA website and provide support to all chapters. This support would include training the NWF Frogwatch Chapter Coordinators and development of a detailed "How-To" Guide to help chapters achieve success with volunteer recruitment and management. NWF would maintain direct communication with each chapter, including programmatic updates, assessments of data accuracy and regular updates on the data that are collected.

The Frogwatch state or county chapters, through their local Frogwatch Coordinator, would be responsible for recruiting volunteers and providing both classroom and field training three times per season (early spring, early summer, late summer). Chapters would have direct communications with volunteers, assist them with data entry as needed and provide NWF with bi-annual reports. The local Frogwatch Coordinators would perform initial assessments of data accuracy, including verifying records for species outside of their expected range. Appendix A contains Frogwatch training guidelines for volunteers.

Chapter volunteers would be responsible for attending required training programs, learning frog and toad calls, monitoring their wetland site(s) and entering their observations into the NWF Frogwatch web page. They could also be asked to pay chapter dues (vary by chapter) as appropriate to cover costs of training.

Data Quality

Frogwatch USA encourages volunteers to engage in frog monitoring following a protocol of a three minute period of observation about ½ hour after sunset at a location of their choice. Volunteers may monitor the site as often as they wish. Volunteers are asked to record information about the site as well as their frog observations on a data form (Appendix B) provided on the Frogwatch website. Following their observations, volunteers are asked to report their information through the internet, again using the Frogwatch website.

Stated quite inelegantly, an oft repeated phrase in computer data analysis is “garbage in, garbage out.” In other words, the reliability of analytical results is directly related to the quality of the data. In Frogwatch there are three critical stages that ultimately affect the quality of the analytical results. These are:

1) expertise of the Frogwatch volunteers;
2) accuracy of data and data entry; and
3) use of appropriate analytical procedures.

Expertise of Frogwatch Volunteers

Correct identification of frogs can be challenging. To assist Frogwatch volunteers, NWF has provided a limited number of training workshops. A second and more universally available training opportunity is through the Internet. NWF’s Frogwatch has a web page (www.nwf.org/FrogwatchUSA/frogs_state.cfm) wherein a clickable U.S. map is provided which volunteers can use to obtain a list and picture of all frog species in their state. Each species is in turn linked to NWF’s E-nature web site (www.enature.com) for a field guide description of the species. Observers can learn frog calls from the recorded sounds of frogs and toads on the E-nature web site.

Unlike with NAAMP, Frogwatch volunteers are not required to complete a competency test (available online at www.pwrc.usgs.gov/frogquiz/). There have been no trials wherein Frogwatch volunteers were accompanied in the field to assess the accuracy of their identifications. As currently structured, the only method of checking identification accuracy of volunteers is when they report a species significantly out of its known range. Even then, the report could be an actual range expansion of the species, rather than identification error.

Notwithstanding the unknown competency of Frogwatch volunteers in identifying species, range maps developed from observed species reported by Frogwatch volunteers are remarkably similar to the respective species’ range as known from other sources. Although these similarities lend veracity to the conclusion that Frogwatch observers are reasonably competent in their identification skills, one might expect that uncommon species could be entirely missed or under-reported as a volunteer may be less skilled at recognizing uncommon calls.

Despite the apparent competency of Frogwatch volunteers in species identification, a higher level of confidence in the species observations (especially less common species) would follow if volunteers complete a training course such as required for NAAMP volunteers. Accordingly, Frogwatch volunteers should be strongly encouraged to complete the Frogwatch USA quiz available on the internet (www.pwrc.usgs.gov/frogquiz/). Absolutely requiring completion of the quiz could discourage potential volunteers, who later may be able to pass the quiz as their skills develop. In lieu of requiring all observers to take the quiz, data analyses could be restricted to use only the data collected by volunteers who have completed the training.

The reported data could be further refined by having a herpetologist or regional Frogwatch coordinator familiar with distributions, review the data. Questionable data can be followed up with the observer to either verify the report or correct the data.

Accuracy of Data and Data Entry

Reliable analysis of Frogwatch data requires that the data are entered into the database correctly. Frogwatch data observations are entered on-line by the observer into the Frogwatch database through the Frogwatch web site (www.nwf.org/FrogwatchUSA/). There are two distinct concerns:

1) data may be incorrectly entered by the observer; and
2) without a central system for filing hard copies of the original data forms, verifying the data and reassessing questionable data are not feasible.

Frogwatch internet data entry for most parameters is designed to minimize errors by providing boxes to check to indicate if observations fall within a range of values (for example, call intensity), rather than having to enter a numerical value. Obviously, this method is not suitable for recording latitude, longitude and temperature, which are reported as actual values, rather than in defined categories.

The data analyzed in this report were carefully scrutinized to reveal data entries that were missing or clearly wrong, and then changed to null or corrected if verifiable. Based on this review of the data, we make a number of recommendations to improve data collection (Box 1).

Temperature

Volunteers record air temperature at the time of their observation. Data entry currently allows the observer to enter temperature in Fahrenheit or Celsius, which is automatically converted (if indicated as Fahrenheit) to Celsius, and recorded in the database. Because the system is programmed to automatically make the conversion if temperature data are reported to be in Fahrenheit, all temperature data in the database should be in Celsius. No data field was retained in the database regarding whether the temperature was originally entered by the observer in the Celsius or Fahrenheit scale.

Values above 38 degrees Celsius would not be expected in most of the U.S., with the exception of the Southwest. At temperatures below -1 degrees Celsius, the likely formation of ice would essentially preclude frog mating activity. However, temperature values greater than 38 and less than -1 were found in the database. Values between 38 and 100 would occur if the temperature value was entered in Fahrenheit but was indicated to be Celsius, so the program made no conversion. Thus, values in this range were assumed to be Fahrenheit and were converted to Celsius. Only 13 of 19,253 temperature records (.07%) were converted in this manner.

Another possible source of temperature data error, although likely also infrequent, would be entry of actual Celsius temperatures with indication that they are Fahrenheit. This would trigger the program to convert the numbers to Celsius, thus incorrectly applying the conversion to Celsius formula to values that were already Celsius. Entry of reasonable Celsius numbers (-1 to 38) with incorrect application of the conversion formula would yield numbers ranging from -19 to 3, respectively. By reversing the conversion, these values can be corrected. But, because numbers ranging from -1 to 3 could also be expected to be reasonable on the Celsius scale, only values from -19 to -1 were reversed to correct the erroneous conversion. This affected 0.21% (41) of all temperature records. To avoid inappropriate corrections, other site data (location, date and time) were used to ascertain that the correction was appropriate. In 13 cases (0.07%) where the temperature was -1 or just below that, conversion was not applied because the site location, date and time indicated the value was appropriate on the Celsius scale.

Three values (.01%) greater than 100 were illogical whether Fahrenheit, Celsius or even with an inappropriate conversion applied. These values were changed to null to preclude their use in analyses where temperature could be a variable. Similarly, eight values (.03%) less than -19 were also illogical in either scale, and converted to null. Because these values were well outside of even extreme environmental temperatures, it is most likely they were data entry errors.

Separate from these few corrections described above, a large number of values in the 38 to 100 numerical range were discovered between the dates of April 4, 2003 and May 4, 2004 (inclusive), apparently when the Frogwatch webpage was transferred from USGS to NWF (Amy Goodstine, personal communication). Close examination of the data, and other concurrent changes in the database, revealed that during this period the conversion of Fahrenheit temperature data to Celsius was apparently either disabled or working only intermittently, resulting in numerical values that could be either Fahrenheit or Celsius, depending upon which scale the volunteer used. Although corrections could be applied as described above, it is difficult to determine the actual degree scale of numerical values between 29 and 38 because they could reasonably be either Fahrenheit or Celsius. However, even for these values, the correct temperature scale could likely be determined by checking an official weather station in close proximity to the observation site at the time and day of the reported observation. This potentially arduous task was not performed for these analyses. Instead, to minimize errors and potential biases in analyses, all temperature data during this 13 month period were changed to null to avoid potentially incorrect values in the 29 to 38 range. Thus 27% of all temperature data were converted to null. However, researchers could also convert the data during this time period, with the exception of the 29 to 38 range, and use weighted averages when assessing temperature data to avoid biases from absence of data in the 29 to 38 range.

In conclusion, there is a high degree of confidence in the temperature data except during the period of April 4, 2003 through May 4, 2004 when the data were recorded in the database in both scales. In fact, temperature data have few obvious errors beyond this one major exception. Nonetheless, accuracy of temperature data entry can be improved in several ways, thereby enhancing quantitative analyses when temperature is a variable.

Instead of reporting actual temperature, it could be reported in a range of 10 degree (Fahrenheit) categories, thereby allowing temperature data to be entered by checking the appropriate range. Although this would preclude values out of range, it would also reduce the precision of temperature data and thus the sensitivity of statistical analyses wherein temperature is a variable.

Temperature data accuracy could also be improved by using only the Fahrenheit system, with which nearly all observers are familiar, rather than allowing data entry in either Celsius or Fahrenheit. Because Canada operates its own Frogwatch program, restricting temperature data to the Fahrenheit scale in Frogwatch USA should not be a problem for observers. Despite this investigator's preference for conversion to the Celsius scale in the U.S., restricting temperature data to the Fahrenheit scale would allow observers to use a scale with which they are familiar. It would also essentially preclude observers from reporting a temperature in one scale and wrongly indicating that it has been reported in the other scale.

Finally, the internet-based data entry system can be modified so that as the data are entered, unreasonable temperature values are immediately flagged as out of range, and the observer prompted to re-enter or verify the temperature indicated. Presently, the system only prompts the observer for correction when no temperature value at all is reported. Specifically, the system could instead be programmed to flag the observer for temperature data re-entry when:

1) temperature indicated as Fahrenheit is entered with a value <25 or >100, or
2) temperature indicated as Celsius is entered with a value <-1 or >38.

Furthermore, in the event an observer neglected to record the temperature, there should be an option to enter that the temperature was not recorded. Because the data entry program will not continue without entry of temperature data, an observer is likely to guess the temperature if he/she did not record it.

Although these recommendations are intended primarily to improve the quality of temperature data, their implementation would also simplify data collection and entry for Frogwatch volunteers.

Latitude and Longitude

Latitude and longitude are entered by observers in degrees, minutes and seconds. On the Frogwatch data entry page there is a link to www.topozone.com to assist observers in ascertaining the coordinates for their site. The entered data are automatically converted by the Frogwatch program to a decimal system.

Data entry errors were encountered with latitude and longitude. Data which indicated sites outside of the U.S. were obviously in error and changed to null unless the actual coordinates could be determined from the city, county and state data provided for each site. All site coordinates were also plotted by state, and either corrected or changed to "no data" if outside of the range of latitude/longitude coordinates for the state where the site was located. Corrections were also made in the few cases where latitude and longitude were obviously transposed, as well as the many data entries where longitude was erroneously reported as a positive rather than negative value (all U.S. locations have negative longitudinal value). In a few cases longitudinal or latitudinal values were nonsensical, exceeding the range of possible values (180 and 90 degrees, respectively). These were corrected when it was apparent the decimal place was misplaced. When sites had no longitudinal or latitudinal coordinates reported at all, or recorded only in degrees (no minutes or seconds), coordinates were entered or corrected based on city, county and state information provided for the site.

As suggested for temperature data, the internet data entry system could be modified to prompt the observer for corrections if the reported latitude and longitude are outside the U.S. This should minimize nonsensical entries (impossible latitude or longitude coordinates), coordinates indicating the site is not within the U.S., accidental transposition of latitudinal and longitudinal coordinates, and incorrectly reporting longitude as a positive (rather than negative value). For even further refinement, the entered coordinates could be validated with a program algorithm to verify that they occur within the reported state. Verification of site coordinates could also be done if volunteers provide a map of the site.

Instead of adopting these suggested refinements to determining location coordinates, this procedure could be replaced by the method the Canadian Frogwatch program uses to identify site locations. Therein, when entering data via the internet, observers identify their site from a map, which they zoom in until the map is sufficient to select their site. When their site is selected the mapping application automatically fills in the latitude and longitude for the database.

Time of Observation

Frogwatch instructs volunteers to monitor areas for a period of three minutes at one-half hour after local sunset. Data entry includes time of start and time of finish, wherein PM or AM are to be specified for each numerical entry. Upon entry, the times are converted to military time, and the difference between start and finish time computed as the period of observation.

Entered time data indicate that observations were not always initiated one-half hour after local sunset and/or restricted to three minutes, as the protocol specifies. This indicates that data are either being entered incorrectly and/or observers are not adhering to the protocol. Frogwatch coordinators are aware that there are some instances wherein volunteers simply reported observations when they heard frogs, regardless of time of day and the recommended protocol.

Although date entry procedures currently check to ensure that time of start precedes time of end of the observation, it is possible that instead of entering the time of completion, volunteers may sometimes be entering elapsed time. Possibly frustrated by rejection of the entered data, volunteers may simply enter two times that differ by three minutes (duration of expected observations) to get the data entry program to continue.

Unlike site coordinate information, there is no additional submitted information with which to corroborate the time of day and duration of observation. Absent a clear and consistent way to validate time of day and duration of observation, as well as the confusion associated with entering time of observation data, no data were excluded based on the reported time of data/duration of observations.

The inability to validate time of day data, the potential to incorrectly enter time of day data, and especially the protocol directing observations to appear 30 minutes past sunset, preclude assessments of relationships between time of day and frog activity. Nonetheless, accurate reporting of time observation would help to ascertain that reported observations followed protocols, and facilitate exclusion from analysis any data collected not in accordance with time of day and duration of observation protocols.

Revision of data entry procedures for observation time of day and duration are recommended to minimize data entry errors so that adherence to protocols can be validated. Specifically, time of start (including whether AM or PM) and duration of observation are recommended to be collected. No longer requiring end of observation time (and if that value is AM or PM) will reduce data entry requirements, potentially reducing overall errors in data entry. Furthermore, the data entry system can be programmed to internally flag time entries that are obviously outside of the protocol of ½ hour after sunset or not three minutes in duration, so that the data can be readily eliminated from analyses if appropriate. The program could also remind observers of the protocol for time of observations and why it is important to follow the protocols, if it is done in such a manner that observers are not tempted to alter the collected data just to fit the protocol.

Data verification

The problems with entered data described above were more challenging to address than they otherwise could have been, due to the absence of hard copies of the original data sheets. Requiring volunteers to mail in their raw observational data sheets after data entry, including a map of site locations, would allow verification of all entered data if desired, or at least facilitate investigation of data that appears in error. However, the inconvenience (time and cost) of mailing in the data forms could discourage either potential volunteers from engaging in the program or long-term observers from continuing if they feel that the process has become arduous. If the recommendations for improving accuracy of the data and data entry are implemented, then the need for sending in hard copies of the original data sheets should be largely negated.

Appropriateness of Analytical Processes

Data must be analyzed and interpreted appropriately to reach valid conclusions. A significant issue in Frogwatch (and NAAMP) is the paucity of monitoring sites in certain areas of the U.S. Figure 2 shows a map of sites at which Frogwatch volunteers actually monitored frogs. Generally, and not unexpectedly, monitored sites were most numerous in highly populated areas such as New England and California. Corresponding with their relatively low human populations, upper Midwest states in particular have very few monitoring sites. A quantitative measure of site density can be obtained by assessing the number of monitored sites in each state, and expressing this as square miles per site monitored (Table 3). Appropriate uses of Frogwatch data are discussed in the next section.

USE OF FROGWATCH DATA

Purpose two of this project was to “assess what useful information can potentially be extracted from the Frogwatch data.” With data in hand for the period of 1998-2005, analyses were conducted using the relational database management system of Microsoft Access.

This first comprehensive assessment of the Frogwatch database reveals a very significant investment by volunteers across the country in observing frogs. From 1998 through 2005 some 1,395 volunteers monitored 1,942 sites, ranging from a low of four sites (1998) to a high of 777 sites (2004) (Figure 3, Table 2). The number of times a particular site was visited ranged from a low of one to a high of 253 with 85 sites visited 50 or more times (Table 4). There were 19,253 visits for an average of 10 (9.9) visits per site, with most sites observed in spring (Figure 4). The average number of species reported per visit was 1.7 while the total number of species reported at each site ranged from a low of none to high of seventeen, with the vast majority of sites reported to have only one or two species (Table 5).

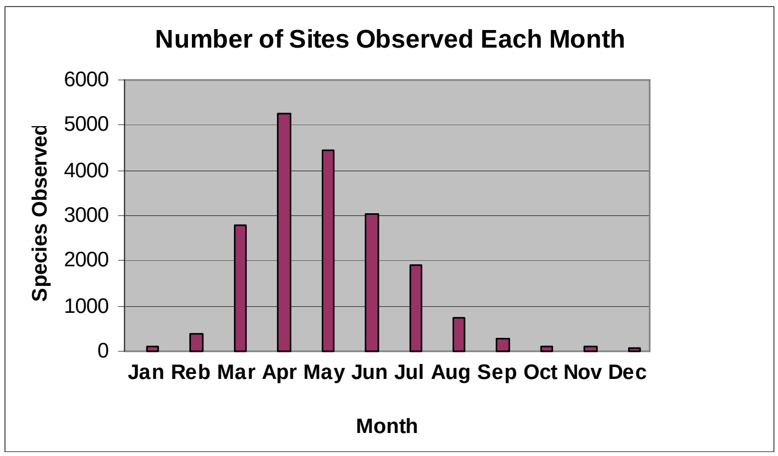


Figure 4. Number of Sites Observed Each Month

Species Observed

While it is instructive to assess the number of sites where each species has been reported, comparisons among species do not reflect relative population levels. The probability of detecting different species with Frogwatch procedures is variable, being affected by many factors (Table 6). An abundant and widely distributed species could be seldom observed if secretive, while a decidedly uncommon species could be frequently observed if easily detected wherever it is present. This issue is discussed further in the section “Probability of Detection.”

Table 7 reports both the number of sites and visits of observation for each of the 79 species (1998 through 2005). Species observed over 1,000 times included the spring peeper, green frog, American bullfrog, gray treefrog, American toad, wood frog and Western chorus frog (Figure 5). Another 13 species were observed over 100 times (Table 7).

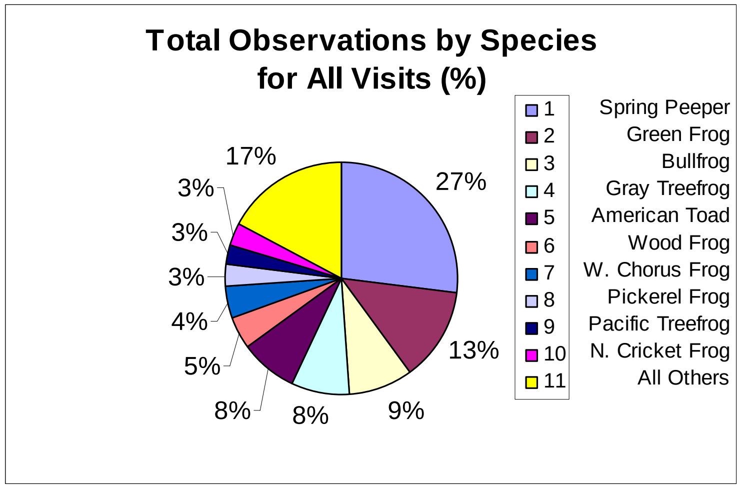


Figure 5. Total Observations by Species

Frogwatch can also yield information about species with relatively small ranges. In fact, despite the relatively low number of observations, they could be very important for knowing the location and status of these species. Many species with smaller geographic ranges, such as Brimley's chorus frog and the California treefrog, were detected by Frogwatch observers.

The data reveal that not all the species in a state were detected, but that the proportion of existing species detected in a state, as expected, is directly correlated with the sampling intensity (number of observations) (Figure 6). The number of species expected in a state was determined from the NatureServe Explorer data base of species distributions. In some states more species were observed by Frogwatch volunteers than actually reported to be present by NatureServe, indicating that further investigation of the species' presence is necessary and, if verified, updating of the NatureServe Explorer Data Base.

The one noticeable anomaly in the strong relationship between percent of species detected and number of observations is in California. However, as the nation's second largest state with considerable environmental diversity, it would be expected that more observations would be required to detect all species than for other smaller and/or less diverse states. Furthermore, California has more federally listed anurans than any other state (three species) and three candidate species. These species would be unlikely to be encountered by Frogwatchers due to their small range and sometimes remote habitats. Excepting California, about 500 observations appear necessary to detect most or all frog species in a state (Figure 6).

It is important to realize that while this report reveals many uses of Frogwatch in assessing frog species status, it is not likely suitable for monitoring all frog species in the United States. Of the 103 frog and toad species reported to be in the U.S. by the NatureServe Explorer Data Base, only 79 species were observed and reported by Frogwatch volunteers. As an overall impression, although not quantitatively assessed, toads appeared more likely to be unobserved than frogs. Not detecting a species must not be mistaken for the species being absent from the sample area. In other words, while detection of a species indicates it is present (assuming correct identification), a species could still be present if not detected. For species difficult to detect, other means of assessment will need to be employed to monitor their status.

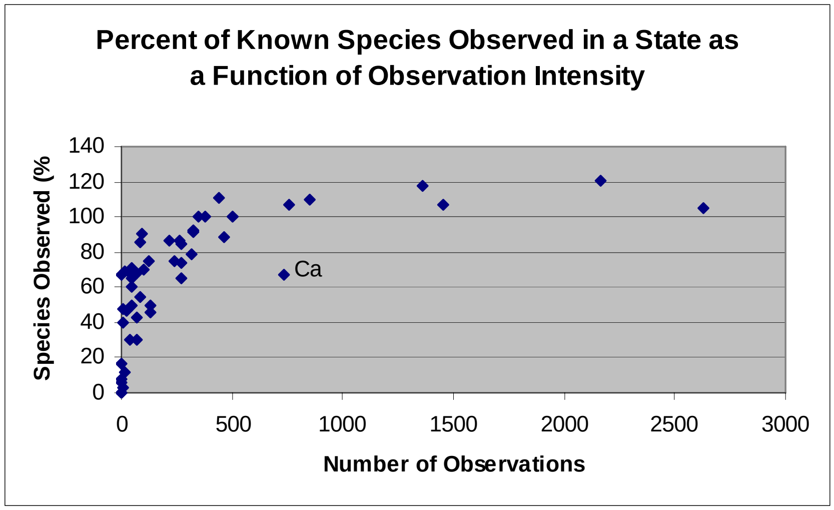


Figure 6. Relationship between Species Observed and Observation Intensity

Range Assessments

The ranges of frog species were mapped based on Frogwatch observations and qualitatively compared to frog ranges reported in the Peterson Field Guides to Reptiles and Amphibians (Stebbins 2003, Conant 1998) and the online ARMI National Atlas for Amphibian Distributions (www.pwrc.usgs.gov/armiatlas/). Mapping was done by first identifying all sites at which a species had been reported. Then, for each of the 69 reported species, site coordinates were plotted (Appendix C) by using ArcGIS 9.0 with background map data provided by Environmental System Research Institute, Inc.

Assessing changes in the ranges of frogs is potentially one of the most useful scientific benefits of Frogwatch. The large number of monitoring sites relative to other national frog monitoring programs likely makes Frogwatch more sensitive to detecting range changes, simply because the resolution of data sites across the landscape is much better.

Frogwatch sites have been most common in New England, Florida, along the Pacific Coast and in states including and immediately south of the Great Lakes. Fewer Frogwatch sites were located between the Mississippi River and the Pacific Coast (exclusive). Although species diversity is generally lower in this region, detection of range changes in this area will be difficult unless the number of Frogwatch sites is increased here.

Frogwatch distribution data can be screened for anomalies, such as when a species is reported at locations outside its known range. By contacting the observer and/or following up with additional observations, there is the potential to identify new areas that a species may be occupying. This could be valuable for detecting the spread of nonnative invasive species such as the bullfrog in the western U.S. and the Cuban treefrog, which is currently confined to peninsular Florida.

Frogwatch observations could also be important for finding species that are rare. In one case, a Frogwatch volunteer in Texas reported the possibility that she was observing the endangered Houston toad. The Texas Parks and Wildlife agency followed up on this report and determined that it was a case of mistaken identification. Nonetheless, the case illustrates the potential for observers to find locations of rare species where professionals might not be aware of their existence.

Population Trends

The suitability of various observation programs for trend analyses is determined in large part by the method of site selection. The BBS and NAAMP essentially use stratified random blocks to select observation sites. Because the sites observed each year are not determined by the presence/abundance or likely presence/abundance of the species being observed, the random design should yield unbiased results regarding population trends. But, in the Frogwatch program there is no control of the sites observed each year; they are chosen entirely by the observer and may be changed as they wish. If observers consistently move from sites where frogs have disappeared to where the frogs are, Frogwatch would be unlikely to identify a population decline because they are observed only where present.

Population increases could also be difficult to detect because it seems unlikely that observers would continuously monitor areas without frogs, and therefore would not be present to report observations when frogs begin to increase there. Although inferences may be made about population trends at the monitored Frogwatch sites, the lack of a random sample procedure requires caution if one wishes to make inferences about population trends as a whole.

Another complicating factor in monitoring population trends is that abundance information in frog calling surveys are not actual counts of observed animals. In Frogwatch, species abundance is categorized as "0" for "No frogs or toads can be heard calling", "1" for "Individuals can be counted; there is space between calls," "2" for "Calls of individuals can be distinguished but there is some overlapping of calls," and "3" for "Full chorus, calls are constant, continuous and overlapping." With the exception of category 0, the actual abundance reported is not a numerical count, but an index within which the numbers of frogs present can vary considerably.

Despite these constraints, it is reasonable to expect that if rapid large-scale changes in amphibian populations are driven by climate change or other factors potentially affecting large regions, these would be discerned with Frogwatch observations. This occurrence could alert biologists to implement more intensive studies.

To overcome the difficulty of assessing population size or trend with frog calling surveys without counts of actual animal numbers, the USGS Amphibian Research and Monitoring

Initiative (ARMI) employs a measure of the percent of area occupied (Bailey and Adams 2005). Presumably, with higher populations a larger percent of potential habitat will be occupied. Declines or increases in percent area occupied over several years could be indicative of overall population trends. Frogwatch data could be used to assess trends in the percent of sites within a species range at which a species is detected. However, because sample sites are not randomly distributed, inferences can not be drawn range-wide, but only to the Frogwatch points themselves.

An assessment of percent area occupied (PAO) for the wood frog was completed for 1999-2005 with Frogwatch data. All sites at which the wood frog had ever been reported were identified to determine the overall range of the wood frog, and then a list of all sites ever monitored within this range was compiled. For each year, the percent of all observed sites which reported the wood frog was computed. Potentially applicable to most species reported in Frogwatch, the wood frog shows no overall discernible trend in PAO from 1999-2005 (Figure 7).

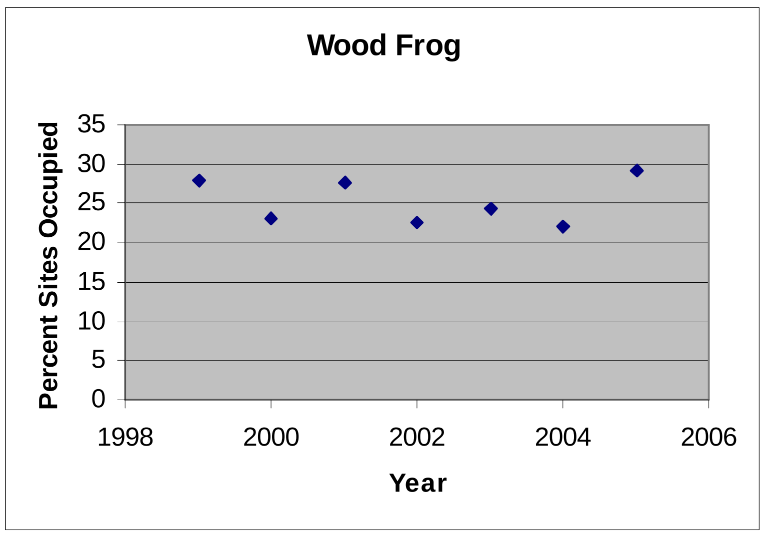


Figure 7. Wood Frog Range Density PAO

Because this method assesses the percent of all sites within the observed range of a species which are occupied, it is henceforth referred to as "range density PAO."

While assessing a trend in the range density PAO is useful, additional insight to potential population trends could be gained by examining activity levels within only the sites where a species was ever observed. That is, separate across year trends in the percent of sites at zero, one, two and three activity levels could indicate population changes early, even when the range density PAO may not yet have changed. For example, if a species has a marked decline in the percent of active sites which reach level three activity level, one could conclude that breeding intensity is declining. Conversely, an increase in the percent of active sites reaching activity level three for a species would indicate increased breeding activity. In essence, assessment of "activity level PAOs" can be an early indicator of a potentially increasing (or decreasing) population status before it results in any changes in the range density PAO.

There are two main differences between range density and activity level PAOs. One, range density PAO is based on all sites within the observed range, while activity level PAOs are confined to sites of known activity for a species over the course of the assessment (in this case, 1999-2005). Two, range density PAO is computed based on presence/absence of the species, while activity level PAOs are computed for each activity level, thereby revealing the percent of active sites at each activity level. Therefore, range density PAO is an occupancy indicator, while activity level PAO is a breeding activity indicator. Both methods assume similar sampling methods across years.

Activity level PAOs were determined for the wood frog from 1999-2005 (Figure 8). Throughout the study period about 80% of the sites annually reached activity level three, and about 10% reached a maximum observed activity level of two. The wood frog showed no marked trend in activity level PAO over the course of the study period. It is not surprising then, that range density PAO showed no significant trend. Continuation of Frogwatch would be expected to show first a decline in activity level PAO followed by a decline in range density PAO, if there is ever a range wide event (climate change, pollution, etc.) that decreases the population and/or breeding intensity.

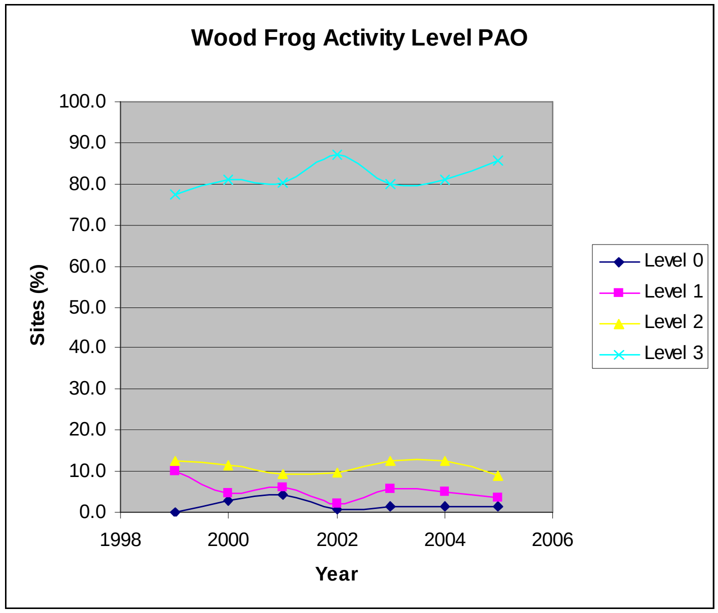


Figure 8. Wood Frog Activity Level PAO

Probability of Detection

The repetitive monitoring of the same sites by dedicated Frogwatch volunteers should be particularly useful in estimating the probability of detection for different species and conditions. It is well known that even when a species is present, the probability of detection is less than one. In other words, when a species is positively identified it is known to be there, but a species will not always be detected even when present. Recently, MacKenzie et al. 2002 developed a technique to determine detection probabilities from repeated observations at the same sites, which they used to compute with Frogwatch data a correction factor when assessing PAO for the spring peeper and American toad. With 85 Frogwatch sites now monitored more than 50 times each, their methods (available on-line at armi.usgs.gov/paoEstimator.asp/) could be used to ascertain detection probabilities for these and other species under varying environmental conditions (see also MacKenzie 2005). Potentially, detection probabilities may now be possible to assess for a species in different geographic areas and in different seasons.

Species Diversity

As previously noted, Frogwatch site locations are not randomly selected, and are biased towards areas with high human population densities. Therefore, it would be difficult to conclude that diverse sites are likely the most highly diverse within an entire geographic sampling area. But, Frogwatch observational data can at least identify the sites of highest species diversity among the sites which were sampled. And because it seems likely that observers could be biased towards high diversity sites within areas they frequent, Frogwatch data are potentially useful in conservation programs which identify and protect areas of high species diversity.

A measure of species diversity that can be determined from Frogwatch data is species richness at observed sites. However, the number of species reported at a site would be expected to be affected by sampling intensity. Although one can conclude that sites with observed high species richness are indeed diverse, sites with low measured species richness could be due to either in-fact low species richness or inadequate sampling. Therefore, to accurately assess species richness at a site, one should take into account sampling intensity, which leads to the question: how many visits are adequate to detect most species at a site?

Two approaches were used to assess the relationship between sampling intensity and reported species richness. In the first assessment, all sites were grouped by the number of times they were observed. The average number of species detected was determined for each group of sites and plotted as a function of number of visits (Figure 9). Sites sampled between one and about six times showed marked increase in species, reaching nearly a five species average. After about six visits the increase in number of species observed was small, with a gain of only about one additional species after about 20 total visits. Thus, more than a tripling of sampling intensity

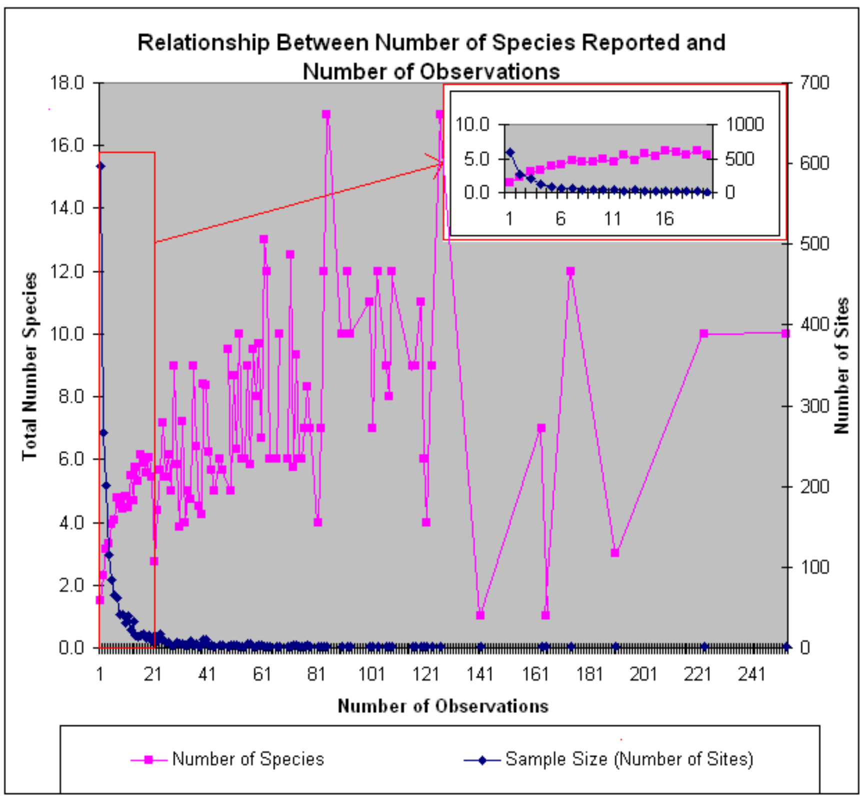


Figure 9. Total Number of Species Observed as a Function of Number of Observations at a Site

from six to twenty observations increased species richness detected by only about 20%. Ideally, when determining species diversity, as many samples would be taken as possible. But, the cost of each additional unit of sampling returns less in species diversity. Six observations appear adequate to assess species richness at a site, although 20 or more would be ideal.

The increase in variation at the higher sampling intensities (Figure 9) is due to a combination of low sample sizes (very few sites were observed many times) and some of those sites observed many times appear to, in fact, have low species diversity.

The second assessment refined the first approach by examining the cumulative average of the percent of sites at different species richness levels (rather than the average for total number of species detected) as a function of number of observations (Figure 10). This reveals that 20% of sites had no observed species with just one visit, which dropped to less than 10% of sites with two visits. After eight observations all sites had at least one or more species (it is doubtful observers would continue to monitor sites without frogs). Up to about six visits, the number of species observed increases rapidly. Specifically, for sites with one to six visits the percent of these sites with just zero, one, two or three species drops quickly while the percent of sites with more than three species rapidly increases. After about six visits the percent of sites at species richness one, two and three becomes relatively stable, although showing slight decreases through 20 observations. As with the first assessment, six observations appears minimal for an adequate measure of species richness, but species richness continues to increase to a lesser degree as observations increase.

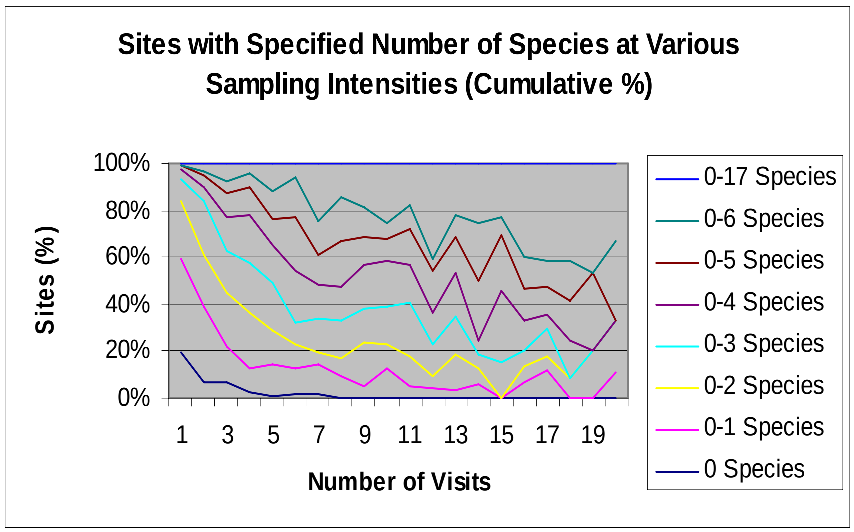


Figure 10. Proportion of Sites with Specified Number of Species at Various Sampling Intensities

From these two assessments it is apparent that Frogwatch can give some indication of species richness when a site is sampled six or more times. To identify sites of low species diversity, sites sampled six or more times and with only one species reported were mapped (Figure 11). Only 6.5% of sites (44 of 678) observed six or more times reported just one species observed. Low diversity sites were most frequent on the West Coast with the other sites scattered infrequently across the U.S. The species most often reported (43%) when only one species was observed was the Pacific treefrog (Table 8).

The Pacific treefrog is quite common and may occupy some areas less favorable to other species, which would not be surprising given that Pacific treefrogs frequent dry land when not breeding. A total of fifteen species occupied single species sites although spring peepers and bullfrogs were observed at single species sites more frequently than might be expected. It is likely that the extremely loud chorus of spring peepers inhibits detection of other species and the known depredation by bullfrogs of other species could extirpate or reduce populations of other species.

At the other end of the diversity scale, sites with high species diversity were identified by mapping sites with eight or more species present (Figure 12). Based on known species richness patterns for Anurans, one would expect sites of highest species richness to be concentrated in the Southeastern U.S. The most diverse sites reported through Frogwatch were located in the eastern United States.

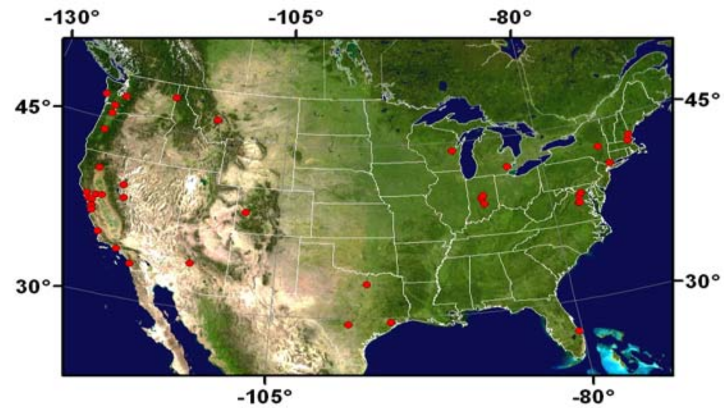


Figure 11. Sites with Species Richness of One

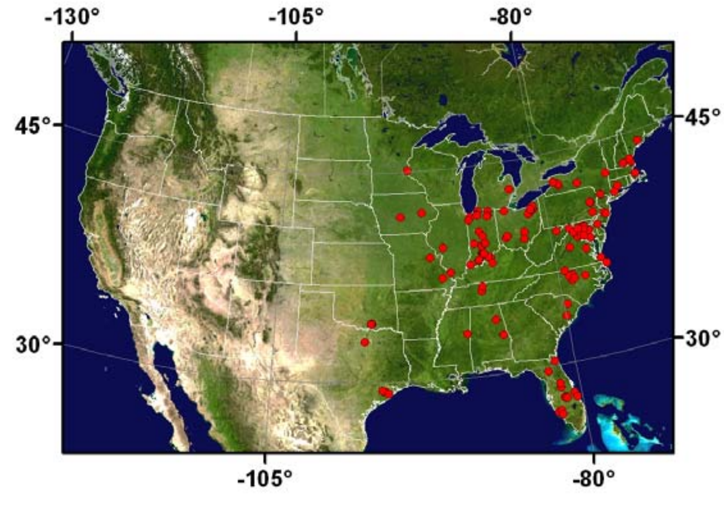


Figure 12. Sites with Species Richness of Eight or More

Overall, species diversity for all sites, regardless of number of observations, ranged from a low of zero to a high of 17 (Table 5). Assessments of species richness through Frogwatch, as discussed above, are most accurate when sites are sampled six or more times. However, multiple methods of detection are better for assessing species diversity than just one or few methods (Hutchens and Depemo 2006). More intensive methods of surveying to supplement the relatively passive methods of Frogwatch should yield more accurate measures of species diversity for a site.

Habitat Preferences

A variety of descriptive information is asked of volunteers to be reported for each site. Potentially, quantitative analyses can be performed to identify habitat conditions preferred or avoided by various species based on their presence, absence or abundance at different sites. However, NWF Frogwatch Coordinators have found through direct communications with volunteers that many have difficulty sorting out the variety of wetlands types to describe their site(s) and completing the fairly extensive site descriptions. Due to these difficulties, this assessment did not examine species presence/abundance as related to descriptions of the sites.

We recommend that the number of descriptive variables asked of volunteers to characterize their sites be reduced. For example, habitat descriptions could be simplified to rural, urban, city and industrial while wetland descriptions could be simplified to pond/lake, stream, or wetland. This would simplify the site descriptive process for volunteers while also simplifying quantitative analyses by reducing the number of variables. In addition, site coordinate information could be used to identify land use coverage, including possibly predominate wetland types, from available GIS data bases.

Seasonal and Temperature Assessments

Frogwatch data can yield information about temperatures and dates of greatest activity for a particular species. Table 9 shows the average temperature at which each species was reported observed. Although instructive, this table does not take into account the differential observation effort at various temperatures.

To account for different observation effort, weighted averages can be calculated for each species with sufficient sample size. For example, the simple temperature average of actual observations for the wood frog was 12.5 degrees Celsius (n=891). But, from 0-10 degrees Celsius the wood frog was detected 33% of the time, and at 10-20 and 20-30 degrees Celsius it was detected 29% and 12% of the time, respectively. By weighting the average based on these observational frequencies, the average temperature at which the wood frog was detected was 11.7 degrees Celsius, compared to the simple average of 12.5 degrees Celsius.

Average peak dates of activity are more difficult to assess than the average temperature of peak activity for a species, simply because of the delayed onset of spring as latitude increases. Nonetheless, there is potential to identify dates of peak activity if latitude (and potentially altitude) is accounted for. Alternatively, one could identify optimal survey dates by first assessing the average temperature of peak activity for a species and then at any location determine from historic weather records when that temperature occurs. This assumes (reasonably) that at different latitudes the preferred temperature of maximum activity does not vary within a species.

Intraspecies Assessments

The large number of sample sites and observations potentially allows for assessment of variation within a species. An assessment of the standard variation within a state of the dates of activity level three for the spring peeper reveals a relationship with latitude (Figure 13). The more northerly states generally had a narrower range of peak activity dates than more southerly states, which is not surprising in light of the compression of spring and summer duration as latitude increases. Frogwatch data may also permit assessment of variation in other factors within a species. For example, there may be geographical changes in a species' preferences for calling temperatures or different population levels across the range of a species.

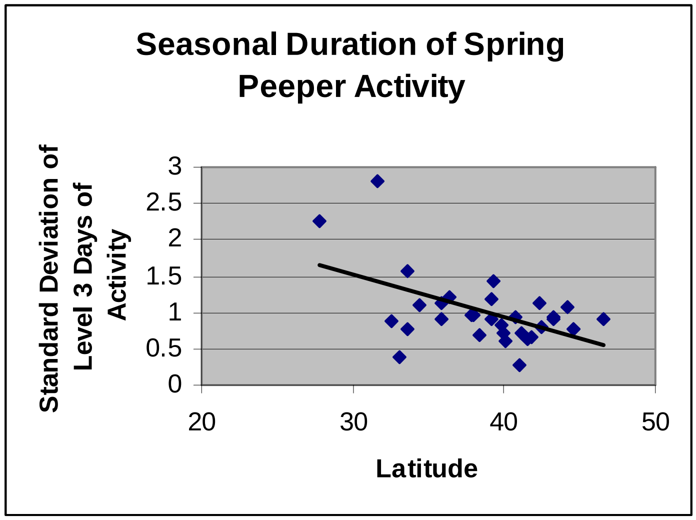


Figure 13. Seasonal Duration of Spring Peeper Activity by Latitude

Interspecies Comparisons

The use of a single technique to monitor various species facilitates some comparisons across species, such as season and temperature preferences previously described. Frogwatch can also be used to ascertain other differences among species. For example, the standard deviation of the temperatures on which category three ("full chorus, calls are constant, continuous and overlapping") activity was detected was computed for all frog species observed more than 50 times (arbitrary selection of 50). Standard deviations of calling temperatures were lowest for the Pine Barrens treefrog, southern toad, squirrel treefrog, Eastern narrow-mouthed toad and Southern cricket frog (Table 10). Large standard deviations of calling temperatures were observed for the Northern leopard frog, upland chorus frog, southern leopard frog and carpenter frog. Analyses such as this have potential value in assessing a species ecological niche, as well as the potential plasticity of a species in response to ecological changes such as climate change.

Additional years of Frogwatch data collection should significantly enhance the ability to make interspecies comparisons. In the above described analyses, the entire data set was used, regardless of range size and other factors. With a larger data set, it should be possible for researchers to control for various variables (latitude, altitude, etc.) and still retain a sample size large enough to refine interspecies assessments.

Climate Change

Continuation of Frogwatch could allow the data collected to be used to monitor changes in seasonal timing of peak activity for a species. For example, over several decades it should be possible to ascertain if there is a trend for peak activity dates to occur earlier for a species and if those peak activity trends are correlated with temperatures occurring earlier. In a study of six species in New York from 1900 to 1999, Gibbs and Breisch (2001) reported four species shifted to calling 10–13 days earlier, none were calling later, and two were unchanged during the 20. In light of on-going and projected climate change, Frogwatch can potentially reveal climate change impacts on anuran calling activities, ranges and populations.

FROGWATCH AND OTHER FROG MONITORING PROGRAMS: COMPETITIVE, COLLABORATIVE OR COEXISTING?

Purpose three of this research project was to “Assess how the information available from Frogwatch can best be used in coordination with or to assist other frog monitoring programs.”

Data Use

As discussed previously, the relatively uncontrolled method of site selection in Frogwatch makes it less useful for determining population trends than monitoring programs which use random samples. However, Frogwatch can potentially assist in identifying geographic areas for other monitoring programs. For example, if a monitoring program is intended to yield information on the population of a particular species, Frogwatch data can identify the range of the species across which monitoring sites could be randomly distributed.

Frogwatch can identify areas of the country with different species richness. Potentially, based on this information, areas with very low species diversity could be sampled less intensely than areas with high species diversity. Furthermore, a potential major benefit of Frogwatch already discussed is to determine species detection probabilities to use as correction factors in other survey programs.

Separate from population trend assessments, Frogwatch has greater potential to ascertain range changes of amphibians over time than either NAAMP or ARMI because of the relatively large number of sample sites. Frogwatch’s larger number of sample sites leads to detecting smaller changes in a species’ range than would occur with the lower resolution of NAAMP and ARMI. Furthermore, Frogwatch sites are distributed more broadly than NAAMP or ARMI, and thus sample broader geographic areas.

Frogwatch data can be very useful for identifying optimal dates for other frog studies, such as NAAMP, in a given area. Temperatures and dates of peak detection can be ascertained from Frogwatch data for species in a particular area. Based on dates/temperatures of peak activity for the various species, optimal monitoring dates for

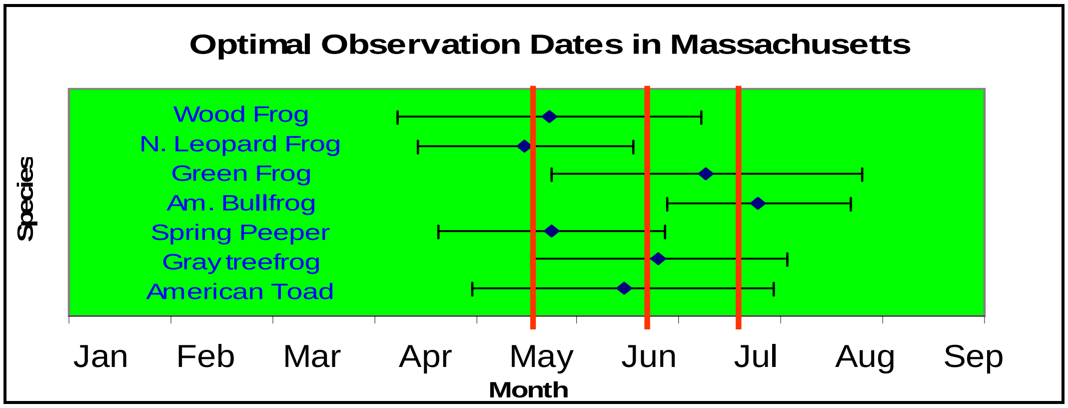


Figure 14. Mean and Standard Deviation of Level Three Frog Activity Dates in Massachusetts

other studies of chosen species could be selected with the highest probability of detecting the species with minimal effort. For example, in Massachusetts the dates of highest activity (level three) were assessed for each species detected. By plotting the average date and standard deviation (Figure 14), the optimal date(s) for monitoring each species were ascertained. Weighted averages based on search intensity (number of observations over a given time period) could be computed for greater accuracy.

Plotting of optimal observation dates can also help ascertain the optimal monitoring date(s) that will likely detect the greatest number of species. In this case, it is obvious that confining sampling to just one or several close days is unlikely to detect all species that could be present. Whether monitored by Frogwatchers or other survey programs, observers in Massachusetts would be best advised to sample at least three times over several months, with optimal dates being about April 25, May 20 and June 15, to increase the likelihood of detecting the various species that are likely present. A potential downside of this would be if observers restricted their future observations to a narrow range of optimal dates, thereby reducing samples at other periods of time when other previously undetected species may be active.

Although the above procedures can help identify the most suitable average survey dates, there is still considerable inter-annual variation in peak calling dates for various species due to inter-annual variation in weather and season progression, to which frogs are particularly sensitive. Frogwatch data could be used to provide an annual calibration for other surveys, such as NAAMP, based on each year's phenological calling window for each species.

The ARMI program has a conceptual framework of a multi-tiered or pyramid structure (armi.usgs.gov/programbackground.asp) (Figure 15) which relies on partnerships for extensive measurements at "many monitoring sites across the country" for the pyramid base to assess the status of amphibians (USGS Pamphlet). Frogwatch USA fits perfectly into this model at the base level, as well as the second of the pyramid's three levels by providing information about study areas, detectability, PAO and ranges. By utilizing the Frogwatch USA data, the ARMI program can better meet its goal to "provide the first nationwide assessment of the current distribution and status of amphibian populations" (armi.usgs.gov/programbackground.asp).

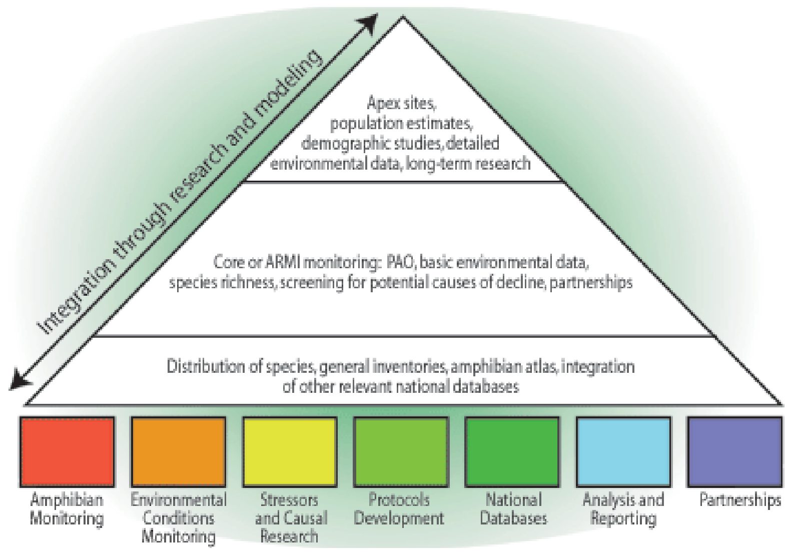


Figure 15. ARMI Conceptual Model (armi.usgs.gov/programbackground.asp)

FrogWatch Canada

Combining data from Frogwatch USA with other frog monitoring programs has the potential to increase the density and range of monitored sites, thereby increasing the sample size and scope of analyses. In cooperation with the Ecological Monitoring and Assessment Network of Environment Canada (www.eman-rese.ca/), the Frogwatch program in Canada is administered by the conservation organization Nature Canada (www.naturewatch.ca). Frogwatch USA and FrogWatch Canada, although not identical, are sufficiently similar that the data can be combined, thereby enabling assessments on a North American basis rather than restricted to the U.S. (or Canada). Combined assessments results in the only frog monitoring program that encompasses both the U.S. and Canada, and yields a broader and more complete picture for species which range across both the U.S. and Canada.

FrogWatch Canada data are available on-line (www.naturewatch.ca/english/download.html) and although it was the beyond the objectives, capacity and scope of this project to complete a comprehensive analysis of FrogWatch Canada, the data set (1998-September 17, 2006) was downloaded and an initial assessment made. As with the Frogwatch USA data set, data were screened to verify that the latitude and longitude occurred within the reported geographic area (province or state). Sites for which no province was listed in the data set were not included in this overview.

FrogWatch Canada abundance categories are similar to Frogwatch USA with the exception that FrogWatch Canada differentiates between no frogs heard and no frogs seen (or heard), whereas Frogwatch USA does not. These two categories were combined into the single Frogwatch USA category of no frogs heard (Table 11).

FrogWatch Canada reported 24 species (Table 12) at 719 sites, which were monitored 4,810 times with the number of observations per site ranging from one to 378 (Table 13) . As an example of the potential for combined assessments, the range of the wood frog was mapped with the combined Frogwatch USA and FrogWatch Canada data sets (Figure 16). Frogwatch USA and FrogWatch Canada could establish a cooperative relationship to share information and coordinate planning to ensure that the two programs continue to be compatible and the maximum benefit returned for assessment of the frog and toad species with ranges which cross the U.S./Canada border.

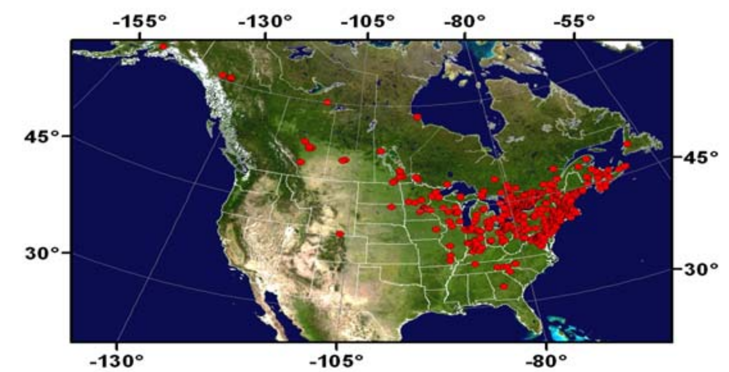


Figure 16. Wood Frog Distribution as Observed by Frogwatch USA and FrogWatch Canada

Data Availability

The Frogwatch data can and should be used to augment existing species databases such as those maintained by NatureServe and ARMI (National Atlas for Amphibian Distributions). The annual observations of Frogwatch volunteers provide up-to-date information on frog status which could be integrated into either or both of these species distribution information systems.

The contents of the entire Frogwatch USA database are not currently available on line for distribution to other databases and interested researchers. Precluding this are two factors. First, prior to this project there was no comprehensive screening of the data for accuracy. This is now completed through 2005. Second, while NWF has facilitated volunteer training and maintained the data repository site, there have been no resources available to make the database available on line.

As has been done with BBS, CBC, NAAMP and FrogWatch Canada data, scientific assessment of Frogwatch USA data could be enhanced by making the Frogwatch database available online on to all interested scientists. Potential options for making the data available on-line include development of the capability within NWF’s Frogwatch web site, NBII (National Biological Information Infrastructure), NAAMP and/or NatureServe.

DISCUSSION

The popularity of birds and long history of the Breeding Bird Survey and Christmas Bird Counts have attracted many thousands of citizen (and professional) scientists as participants. Initiated in 1966 with 600 survey routes, approximately 2,900 Breeding Bird Survey routes (Figure 17) are now conducted annually (Sauer et al. 1997). Similarly, Christmas Bird Counts have expanded from 25 counts by 27 participants in 1900 to nearly 2,000 counts (Figure18) with over 52,000 participants in the 102nd year (2001-2002) (LeBaron 2002). The BBS and CBC have contributed immensely to the scientific knowledge of birds with literally hundreds of scientific publications from each (see Peterjohn and Pardieck 2002 and National Audubon Society 2006).

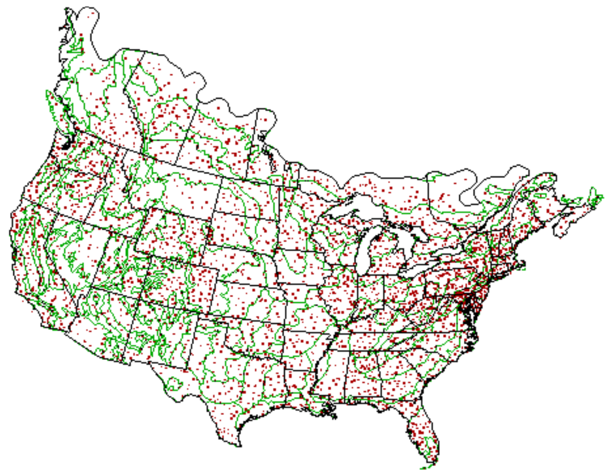


Figure 17. Breeding Bird Survey Route Locations

Frogwatch is currently in a nascent stage relative to the BBS and CBC for birds, with 1,395 volunteers at 1,942 Frogwatch sites in the first eight years. Frogwatch has the potential to contribute significantly to the scientific knowledge of Anurans, but only if appropriate attention is devoted to continue the program. The most important aspect of the BBS and CBC programs, which should be replicated for Frogwatch, is their longevity. While comparison of trend data from several successive years in Frogwatch may not be very instructive, the comparison of a group of years early in the program (for example, 1998-2005) to data collected at years 20-25, would very likely be instructive regarding species range changes and dates of peak calling activity (in light of ongoing climate change), as well as other aspects.

The value of Frogwatch is not in the scientific data alone. NWF agreed to manage the program not only because of its scientific benefits, but also because of its use to educate and motivate persons about frog conservation and our environment. Participation by citizen scientists in Frogwatch has averaged 259 volunteers annually, with a total of 1,395 different volunteers over eight years. The number of visits to the Frogwatch website by the public is also a measure of its educational value. From April 26, 2006 to August 9, 2006 (3.5 months), the www.Frogwatchusa.org page was visited by 83,520 unique individuals (actually, unique ISP addresses) who viewed 206,166 pages with averages of 2.5 pages viewed by each user. This averaged 23,862 unique visitors each month and was more than a 50% increase from the period of February, 2004 through January, 2005 when the NWF Frogwatch website received a total of 188,878 visits, for an average of 15,740 visits each month (Gibbs 2005). Furthermore, a Google search on "Frogwatch USA" returns approximately 53,000 hits(!).

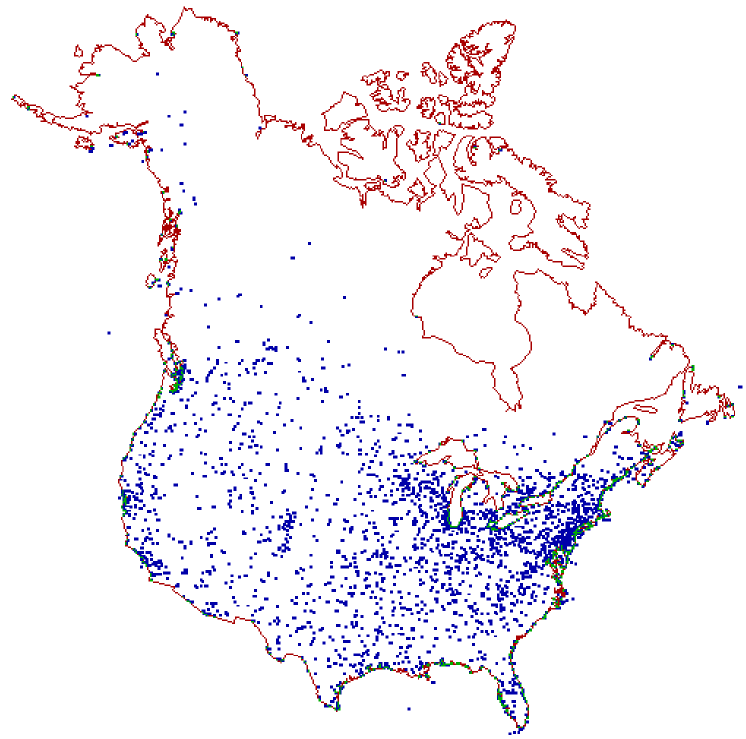


Figure 18. Christmas Bird Count Locations

Another measure of Frogwatch educational value is the media coverage it has received. Efforts of NWF Communications and Education Departments staff to promote the program in 2004 alone resulted in significant national, regional and local media coverage of Frogwatch (Appendix D). Articles also appeared in NWF's National Wildlife magazine and, just recently, USA Weekend (Appendix D).

The Frogwatch USA name is intended to brand the program with a distinctive title to facilitate promotion, and is trademark protected. Branding and logos are complicated issues and it is hard to know what will appeal. Nonetheless, because it seems that a minor change to the title would enhance its image, it is recommended that the title of this program be modified from "Frogwatch USA" to "FrogWatch USA" and also be trademark protected. The FrogWatch Canada program is already titled in this manner.

CONCLUSION

Frogwatch USA is truly national in scope and has the potential to yield information on frogs and toads comparable to that for birds from the Christmas Bird Count program. Like this program, continuation of Frogwatch USA would enable citizens to contribute to valuable scientific research not only about amphibians, but about environmental change. Box 2 summarizes programmatic recommendations for Frogwatch USA to gain its full scientific and educational returns in the years ahead.

We strongly recommend continuation of Frogwatch USA based on its scientific value alone, notwithstanding its ancillary benefits of cost-effectiveness (for scientific data gathering) and environmental education. Accordingly, every effort should be made to fund continuation of the Frogwatch USA program. Toward this end, USGS and NWF should host a Frogwatch Summit of interested parties to develop a viable strategy for long-term operation of Frogwatch USA.

Box 2. Summary of Programmatic Recommendations for Frogwatch

Implement Data Improvement Recommendations (see Box 1)
Provide researchers with access to Frogwatch data through a web site
Provide Frogwatch data to other species data bases
Collaborate with FrogWatch Canada
Change “Frogwatch USA” name to “FrogWatch USA”
Convene “Frogwatch USA Summit” of interested parties to develop/implement plan to continue the Frogwatch Program

LITERATURE CITED

Bailey, L. and M. Adams. 2005. Occupancy Models to Study Wildlife. USGS Fact Sheet 2005-3096.

Barker, R.J., and J.R. Sauer. 1992. Modeling population change from time series data. Pages 182-194 *in* D.R. McCullough and R.H. Barrett, eds. Wildlife 2001: populations. Elsevier, Amsterdam.

Beard, K.H., N. Hengartner, and D.K. Skelly. 1999. Effectiveness of predicting breeding bird distributions using probabilistic models. *Conservation Biology 13:1108-1116*.

Butcher, G.S., M.R. Fuller, L.S. McAllister, and P.H. Geissler. 1990. An evaluation of the Christmas Bird Count for monitoring population trends of selected species. *Wildl. Soc. Bull*. 18:129-134.

Bystrak, D. 1971. How to prepare a winter range map from Christmas Count data. *Am. Birds* 25:952-956.

Conant, R. 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. The Peterson Field Guide Series. 3rd Edition.

Gibbs, E. 2005. NWF Final Programmatic Report to the National Fish and Wildlife Foundation.

Gibbs, J.P. and A.R. Breisch. 2001. Climate warming and calling phenology of frogs near Ithaca, New York, 1900-1999. Conservation Biology 15(4):1175-1178.

Hutchens, S. and C. Depemo. 2006. Efficacy of sampling techniques to inventory herpetofauna in a species richness study. Abstract for The Wildlife Society 2006 Annual Meeting. Anchorage, Alaska. Sjhutchi@ncsu.edu

LeBaron, G.S. 2002. The 102nd Christmas Bird Count, December 14, 2001, to January 5, 2002 *American Birds – the 102nd Count)* (National Audubon Society (2002). The Christmas Bird Count Historical Results [Online]. (www.audubon.org/bird/cbc)

MacKenzie, D.I. 2005. What are the issues with presence-absence data for wildlife managers? *Journal of Wildlife Management 69(3):849–860; 2005.*

MacKenzie, D.L., J.D. Nichols, G.B. Lachman, S. Droege, J.A. Royle and C.A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. *Ecology 83(8):2248-2255.*

National Audubon Society. 2006. The Christmas Bird Count Historical Results [Online]. (www.audubon.org/bird/cbc/biblio.html)

Peterjohn, B. and K. Pardieck. 2002. A bibliography for the North American Breeding Bird Survey. (www.pwrc.usgs.gov/infobase/bbsbib/bbsbib.pdf)

Phillips, K. 1990. Where have all the frogs and toads gone? *BioScience* 40(6):422-424.

Price, J. T. 1995. Potential impacts of global climate change on the summer distributions of some North American grassland birds. Dissertation, Wayne State University, Detroit, Michigan, USA. 419 p.

Reaser, J. K. 2000. Amphibian declines: an issue overview. Federal Taskforce on Amphibian Declines and Deformities, Washington, DC.

Root, T. L. 1988. Atlas of Wintering North American Birds: An Analysis of Christmas Bird Count Data. University of Chicago Press, Chicago and London.

Root, T. L., and J. D. Weckstein. 1994. Changes in distribution patterns of select wintering North American birds from 1901 to 1989. *Studies Avian Biol*. 15:191-201.

Sauer, J. R., J. E. Hines, and J. Fallon. 2005. The North American Breeding Bird Survey, Results and Analysis 1966 - 2005. Version 6.2.2006. *USGS Patuxent Wildlife Research Center, Laurel, MD*

Sauer, J. R., J. E. Hines, G. Gough, I. Thomas, and B. G. Peterjohn. 1997. The North American Breeding Bird Survey Results and Analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, MD. (www.mbr-pwrc.usgs.gov/bbs/genintro.html)

Stebbins, R. C. 2003. A Field Guide to Western Reptiles and Amphibians. The Peterson Field Guide Series. 3rd Edition.

USGS. Amphibian Research and Monitoring Initiative (ARMI). Pamphlet. (ami.usgs.gov)

Weir, L. A., and M. J. Mossman. 2005. North American Amphibian Monitoring Program (NAAMP). Pages 307-313 *in* M. Lannoo (ed.) Amphibian Declines: the conservation status of United States species. University of California Press, Berkeley, California, USA.