Handbook for Atlasing
North American Breeding Birds

Edited by Charles R. Smith

Laboratory of Natural Resources and Department of Natural Resources, Cornell University

Originally published in September 1990 by the Vermont Institute of Natural Science.

Original publication of this Handbook and its translation into Spanish was made possible by a grant from The Merck Family Fund.

Contents

Introduction

Charles R. Smith

New York Atlas Project

The volunteer spirit and enthusiasm represented by breeding bird atlas projects continues to grow and spread worldwide. The idea for this handbook originated at a conference held in San Francisco in August 1987. It is intended to be a summary and guide for methods and procedures to be applied in North American breeding bird atlases. Through following the recommendations offered in the chapters which follow, it is the hope of the North American Ornithological Atlas Committee (NORAC) that a degree of consistency and uniformity among North American atlas efforts will result.

Many states and provinces now have completed the field work for their atlas projects, and a few have published their atlases. In New York, the Federation of New York State Bird Clubs has established an endowment fund to provide for the start-up costs of our next atlas, which begins in the year 2000. I think it is important to remember, however, that a published breeding bird atlas is not necessarily the end, but really a means to many ends, one of which is conservation. Those states and provinces that have completed their atlases now have the most comprehensive picture of the distributions of their breeding birds that ever has been compiled. Such information can provide state and provincial wildlife and environmental management agencies with important insights into where rare species occur and where regions of high breeding bird species diversity can be found. With such information, informed conservation action hopefully can be applied in a more effective and efficient manner than might have been possible in the absence of breeding bird atlas information. These and other uses of atlas information should not be overlooked, and the value of atlas information should not be underestimated in landscapes that are increasingly affected by human activities.

The tremendous value of breeding bird atlases only will begin to be realized when each state or province completes their second atlas. At that time, two "snapshots" in time of breeding bird distributions will be available for comparison and conclusions can be reached about the changes in distributions that have occurred. The current cycle of atlas projects in North America witnessed the advent of the microcomputer, which has revolutionized our capacity to manage and *manipulate* information of all kinds. It is very likely that the next cycle of atlas efforts will see a revolution in the ways in which we collect information in the field and transfer it to computers for storage and analysis. Optically amenable computer forms already are in use by many large-scale projects for collecting information and transmitting it directly to computers. It is conceivable that atlas workers at the turn of the century will have hand-held microcomputers for use in the field. Such microcomputers will be useful for collecting and storing information in the field for later transmission to central computing systems, through telephone and microwave relay systems. By communicating with a system of satellites orbiting hundreds of miles above the earth's surface, hand-held microcomputers also may be used to provide future atlasers with very accurate information about latitude and longitude for determining their geographic locations while in the field, rather like the LORAN systems used by ships at a-a today. The future of atlasing could be very exciting, indeed!

I am grateful for the contributions made by the authors of the chapters which follow. Without their hard work, no handbook would have been possible. And I am especially grateful to Sally Laughlin and the Vermont Institute of Natural Science for arranging funding for final production and distribution of this booklet. This handbook has been a long time in arriving. For that I take responsibility, along with any errors that may have crops into the final version. I sincerely hope it is helpful and that it stimulates and facilitates future breeding bird atlas projects.

Standardized Breeding Criteria Codes: Recommendations for North American Breeding Bird Atlas Projects

Sarah B. Laughlin, Janet R. Carroll, and Sally M. Sutcliffe

Vermont, New York, and New Hampshire Atlas Projects

The Working Group on Atlas Codes reached consensus on recommended codes for North American Atlas projects. For the most part this was relatively simple to agree upon; however, the MULTIPLE SINGING MALES issue was difficult and incurred some somewhat heated discussion. It was AGREED that "multiple singing males" is NOT an acceptable code for CONFIRMATION because it is not a hard, factual, biologically valid criteria like the other codes. Now that atlas results are becoming legal criteria for land-use issues and endangered and threatened species lists, it seems especially vital to keep our criteria above reproach. The same arguments hold true for "multiple singing males" as PROBABLE. One side argues that if you have seven singing territorial males on one block-busting trip you should intuitively know that you have a probable breeding species. The other side argues that if there are indeed that number of males behaving in a territorial way that you should be able to achieve probable status with one of the existing codes, and that it's not worth jeopardizing our data by using "sloppy" codes. The Working Group finally voted NOT to recommend it as an acceptable code for PROBABLE either (voting NOT ACCEPTABLE were New Hampshire, New York, Maryland, Quebec, and Virginia; voting YES, ACCEPTABLE were West Virginia and Florida).

Code[1] — Evidence

OBSERVED:

O—Species (male or female) observed in a block during its breeding season, but no evidence of breeding. Not in suitable nesting habitat. Includes wide range of species such as vultures or raptors, or a colonial nesting species not at the nesting colony.

POSSIBLE:

Species (male or female) observed in suitable nesting habitat during its breeding season.

X—Singing male present in suitable nesting habitat during its breeding season.

PROBABLE:

P—Pair observed in suitable habitat during its breeding season.

S—Permanent territory presumed through song at same location on at least two occasions 7 days or more apart.

T—Permanent territory presumed through defense of territory (chasing individuals of the same species).

C—Courtship behavior or copulation.

N—Visiting probable nest site.

A—Agitated behavior or anxiety calls from adult.

B—Nest building by wrens or excavation of holes by woodpeckers.

CONFIRMED:

CN—Carrying nesting material, such as sticks or other material. Please submit full details including location within the block of the observation.

NB—Nest building at the actual nest-site.

PE—Physiological evidence of breeding (e.g. highly vascularized, edematous incubation [brood] patch or egg in oviduct based on bird in hand. To be used by experienced bird banders on local birds during the nesting season).

DD—Distraction display or injury feigning.

UN—Used nests or eggshells found. Caution: these must be carefully identified, if they are to be accepted.

PY—Precocial young. Flightless young of precocial species restricted to the natal area by dependence on adults or limited ability.

FL—Recently fledged young (either precocial or altricial) incapable of sustained flight, restricted to natal area by dependence on adults or limited mobility.

ON—Occupied nest: adults entering or leaving a nest site in circumstances indicating occupied nest. To be used for nests which are too high (eg the tops of trees) or enclosed (eg chimneys) for the contents to be seen.

CF—Carrying food: adult carrying food for the young.

FY—Adult feeding recently fledged young.

FS—Adult carrying fecal sac.

NE—Nest with egg(s).[2]

NY—Nest with young seen or heard.[2]

Notes:

1. The **letter code** is entered by the field workers in the appropriate space on the field report form. **Possible** and **Probable** categories are represented by single letters or a symbol. **Confirmed** by double letters. Letters have been selected as a mnemonic aid, keyed to underlined words in criteria definitions.
2. Presence of cowbird eggs or young is confirmation of both cowbird and host species.

General Recommendations

1. The date the code was observed should be recorded on the recording sheet as on the New Hampshire recording sheets. This is valuable data for timing of breeding activities.
2. A data information booklet on what codes are appropriate for what species within what dates should be prepared by each state and province, as "safe dates" for breeding vary with geographic location. The Maritimes have set an excellent standard for this. Computer proofing programs should be set up to check the entered date against these criteria.
3. Good training of field workers in the use of the codes cannot be over-emphasized.

Planning a Biological Atlas: Reflections on the Ontario Experience

Paul Eagles and David Balser

Ontario Atlas Project

Recently, a number of people have been discussing the possibility of starting a new collection of field data for an atlas of the plants or the herpetofauna of the Province of Ontario. These ideas flow naturally out of the success of the Ontario Breeding Bird Atlas.

Much has been learned about the operation of an atlas project from the Bird Atlas project, which might be of assistance to others who are considering the planning and operation of a biological atlas project. It is essential that preplanning of an atlas be as thorough as possible. There were two years of methodological preparation put into the Bird Atlas (1979 and 1980), but this was insufficient in several ways which we will discuss below.

The major items to be considered are scale, field methodology, institutional structure, administration, staffing, funding, data handling, and analysis.

Scale

Decisions must be made early on the scale of the project: all of the province or only a portion thereof? We are quite thankful now that some people pushed hard for all of Ontario to be included in the Bird Atlas, but the size of the project dictated that different sizes of data collection unit would have to be used in different parts of the province. For example, in southern Ontario, comprehensive coverage was the goal, using the 10 X 10 km UTM grid, while in northern Ontario data were collected from individual 10 km squares within 100 X 100 km blocks. This system is quite feasible for a large area such as Ontario (over 1 million sq. km.), but it does add complexity to the system and requires the use of the two-map format used in the Atlas: one for southern Ontario by 10 km square, and one for all Ontario by 100 km block.

The necessity of keeping the data collection unit consistent across the entire province was not recognized in the initial stages of the project, and as a result we have some data for 100 km blocks without any idea of what 10 km square it was collected in. This problem was largely solved part way through the project.

In Ontario and in Canada as a whole, it is probable that all future atlases will utilize the 10 X 10 UTM grid system for data collection. The UTM grid is printed on all Canadian topographic maps and is being used for atlas projects in Ontario, Quebec, the Maritimes, and Alberta. This helps ensure that data from provincial atlases can be combined into a national atlas data base as it becomes available. It would also be of tremendous research potential to be able to undertake correlations between the data for different life forms, and with physiographic data.

In remote areas individual 10 X 10 squares could be "sampled" within some larger unit of measurement. In the case of rare species the specific 6 digit number UTM code could be used to locate the exact location of specific records.

At the same time it is reasonable to consider the coverage of the entire province in any future atlas. It has been proven that it can be done and the resultant data base is more valuable than if it was only a portion of the province. The resolution of the data in northern Ontario is obviously very coarse, but this must be measured against the vastness of the area and the paucity of data which existed previously.

Field Methodology

It is essential that the details of field methodology be worked out well in advance of any field data collection. The important factors that need to be considered here are:

- all species in a group or a subset thereof—degree of evidence necessary—use of standardized definitions (where such exist)—timing of data collection
- amount of field time required
- minimum level of expertise of field researcher
- training of field researcher

We assume that all future atlas projects will use largely volunteer labor backed up by certain levels of technical expertise of a more professional nature.

Institutional Structure

The institutional structure of the organization for the operation of the project is of critical importance. Our experience has confirmed our belief that all major groups involved in a particular field must be involved in the planning and operation of a project from the very start. This would include all government agencies, museums, university and college departments, NGOs and major corporations that would have interest in the field. There are many diverse aspects of running a project which require effective management: Who will run the operation? Who raises the money, hires the staff, encourages the volunteers, pays the bills, owns the data, receives requests, answers questions, prints and distributes materials?

The Ontario experience suggests that a non-governmental organization was an excellent choice as administrative home for an atlas project. The Federation of Ontario Naturalists, with the assistance of the Long Point Bird Observatory, played a key role in the Bird Atlas project and would be ideal candidates for any future projects. Governments and universities, as institutional homes for atlas projects, suffer from a number of drawbacks which volunteer groups do not. Usually, the most important advantage of a volunteer group is that of independence. Such a group can act quickly over a wide area and with flexibility. Such factors are often limited in large government or quasi-government agencies. A number of bird atlases in other countries are faltering because they are being operated on too narrow an institutional base with the concurrent lack of potential, profile, and administrative capability.

Administration

The Bird Atlas was basically governed by two committees - the management committee and the technical committee. The former dealt with such items as intergroup cooperation, project structure, funding, staffing, budgeting, and project development. The latter dealt with methodological issues such as data handling, interpretation of field data, field card and instruction booklet design, field work design and error checking. These committees served two vital purposes: project Supervision, and communication back to the institutions represented by each committee member. The committees were very carefully designed so that representatives from a large number of agencies and groups were present.

A worthwhile variation on this type of structure (that of having each project sponsored and administered on an ad hoc basis) is that which has developed in Great Britain, where the national government has established an agency, the Biological Records Centre, to serve as the central repository for all of their various atlas projects. Their staff serve as advisors on all major aspects of new and ongoing projects. We have no similar group in Canada so if an atlas is to run its fullest potential it must raise money to hire a staff.

Staffing

Any atlas project without a permanent staff person will simply not work at all effectively. There is only so much that volunteers can be asked to do and the drudgery of project administration is not one of them. The responsibilities of the hired staff would include:

- overall coordination
- training of volunteers
- data handling
- communication between and among volunteers
- fund raising
- communication among agencies
- mobilization of resources
- hiring subordinates
- production of written materials (newsletters, pamphlets, interim reports)
- methodology development

Our experience with the Ontario atlas was that a minimum of two, and as many as six, full time staff members were required at various stages in the project, with the greatest effort being required in data review and in the production of the book.

Funding

Very little can be done without some funding. The Ontario Breeding Bird Atlas made a decision that a certain level of base funding was necessary for such items as two staff, printing, data handling, office expenses, travel, telephone, mailing and computer time. This base budget amounted to approximately $60,000 per year. Other monies were raised for specific projects such as data collection in remote areas, computer software development and computer equipment. In total, $70,000 of funds and equipment were utilized in the 8 years of the Ontario Breeding Bird Atlas.

If sufficient funding is not available for a basic level of administration, it would be better to hold off on a field project until a later date. This might be preferable to the operation of a sputtering effort which operates intermittently according to the availability of funds or the interest of a volunteer coordinator.

The Bird Atlas was able to raise such excellent levels of support because it was well thought through at a professional level. A hastily conceived project would not have been able to obtain the approval of those in government and industry who are well versed in project administration, especially in these days of fierce competition for funds.

Data Handling

The handling of the data for the Bird Atlas was not at all well thought through when the project started in 1981. But since that time, very hard work by a number of people, including a full-time programmer for the last four years, has resulted in a sophisticated computer-based data handling system. All the data is stored on the IBM mainframe computers at the University of Waterloo. Two microcomputers and three output devices (two printers and a plotter) are dedicated exclusively for atlas use. In addition, large printers and plotters are available at the University when necessary. The computer system is used for:

- editing the data (in flat files using a full-screen editor) - error checking by means of various programs
- integration of new data into existing files
- analysis of data
- output of data in a wide variety of formats, including maps, charts, lists, reports and summaries
- storage on tape and disk
- word processing and typesetting
- specialized data analysis

With over 400,000 records there is no other way of handling the information. Any new atlas must consider its data handling needs well before any field collection should take place. For example, the design of the field card can influence to a large degree the efficiency of data input and determine the information which can be extracted later. The data card used by the Ontario atlas did not, for instance, allow for the recording of the exact date of each sighting, and hence it is often impossible to say just when a suspected migrant was seen.

Another primary consideration is the hardware and software required. The Ontario atlas used SAS as the software package for handling the data base, BASIC for driving a desktop plotter, and custom software for driving the laser scanner-plotter used to produce the publication-quality maps in the Atlas. Since the Ontario project got underway in the early 1980s, more sophisticated relational data base management systems have become available, including some good packages for microcomputers. The value of SAS on the other hand, is that it allows for program development for almost any conceivable purpose, is widely used and well supported, and is available in compatible mainframe and microcomputer versions.

Certainly any project beginning now would want to consider using the very powerful microcomputers which are now available. For some applications, it would be worthwhile to have such a microcomputer connected to a mainframe computer. This would allow access to the powerful data processing capabilities of the larger machine. It would also allow access to the many output devices that are usually attached to mainframes in a large computer establishment. As a relevant example, this paper was composed on a Digital microcomputer in Paul Eagles' office, then edited on a similar machine that was located in Dave Balser's office and connected to the Eagles' machine via a computer network. The finished product then was transferred to a VAX mainframe computer, then to an IBM mainframe computer, both at The University of Waterloo, in Waterloo, Ontario. The paper was then electronically transferred via an inter-university computer network to Charlie Smith 'a computer account at the Cornell Laboratory of Ornithology at Ithaca, New York.

One final cautionary note concerns software development. It might be assumed that most of the programming required would be to develop or implement a mapping system. This is a major task, of course, but at least as much effort was devoted to producing summaries, lists, and specialized reports for regional coordinators, authors, editors, and those scrutinizing the data.

Analysis

One important aspect of any database is its use. The Bird Atlas database is now in active use by a variety of people, and it is hoped that the number of researchers using the data will increase as demonstrations of its utility and potential are provided. For a database to be utilized efficiently there needs to be a basic administrative structure in place. The following items need to be addressed:

- Who has access to the data?
- In what forma are the data available?
- Can unique searches of the data baas be done for the individualized needs of users?
- Is there a person available to answer the telephone, accept mail inquiries and advise on the availability of the data?
- Is there a charge for the information? How fast can the data be accessed?

In summary, we have learned a lot from our efforts in regards to the Bird Atlas. This information could be of use to others who are considering the establishment of new atlas projects. We would like to encourage such initiatives and are willing to provide assistance.

Survey Methods and Mapping Grids

Chandler S. Robbins and Paul H. Geissler

Maryland Atlas Project and Patuxent Wildlife Research Center

Sampling Design

One of the major problems facing most atlas organizers is a shortage of qualified field observers. This requires making difficult decisions as to the best compromise between two extremes: dividing the area into a small number of large blocks, many of which will be poorly covered; or selecting a pattern of small blocks for intensive coverage, while leaving most of the area uncovered. In general, a plan for good coverage of a relatively small percentage of the total area is preferable to poor coverage of large blocks.

Atlas organizers should carefully consider their objectives, and then design a sampling plan that will meet those objectives. If the main objective is to generate species range maps, regular coverage by systematic sampling is effective. If an objective is to estimate frequency of occurrence (percentage of blocks) for each species or to detect future changes, stratified random sampling should be used to permit greater sampling density of rare or disappearing habitats.

Several options for selecting those blocks to be covered have been used successfully. Here are some examples:

Total Coverage. Standard procedure in western Europe, the Maritime Provinces, and several northeastern states. Examples: Maritime Provinces, Maine, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, Maryland, Delaware.

Two-level Sampling. Coverage of all blocks in populated areas and of portions of much larger blocks in roadless areas. Examples: Australia and Ontario.

Systematic Sampling. This is widely used in the United States for convenience: the Priority Block is in the same position on every quadrangle; hence, every field worker knows which blocks are to be covered. Theoretically, the position should be determined at random, then applied throughout (example: Colorado). In practice, most atlas committees have selected the priority position for practical reasons: some chose one of the two center positions (center west or center east), because block boundaries and access are easier to determine when 3 of the 4 adjacent blocks are on the same map; some atlas committees select the lower right block, because the adjacent margin shows the scale of miles and the name of the quadrangle. Examples: Virginia, West Virginia, Illinois.

Random Sampling. Random selection of one Priority Block within each sampling unit (7.5-min. quadrangle or township). Other, non-random, blocks may be designated for coverage for special biological or political reasons, but those are not used in statistical comparisons. Random sampling is a good statistical procedure, but has not been used in atlas studies for two reasons: (1) Because the sample is not evenly distributed, the maps would show holes in coverage, and some of these gaps would fall at limits of species distribution; and (2) Field workers who travel to other parts of the state or province would not know which blocks other than their own were designated for coverage.

Modified Random Sampling. Similar to the above, but with the stipulation that if a selected block shares a aide with a block already selected, it is rejected and a replacement block is picked. Examples: Vermont and New Hampshire. This procedure prevents clusters of Priority Blocks surrounded by large unsampled areas, and so largely solves the first problem under Random Sampling. From the statistical point of view, however, it introduces a new problem in that all blocks do not have equal opportunity of being selected; selection of each block automatically eliminates the possibility of four adjacent blocks being sampled. For most practical purposes this makes no difference, but if atlas results were subsequently to be used in litigation they might be challenged on statistical grounds.

Stratified Random Sampling. This permits sampling by ecological regions, and the designation of different sampling densities among ecological (or political) regions. For example, one might wish to sample half the blocks containing elevations above 4,000 feet, or all blocks containing tidal wetlands, but only a random one-sixth sample of blocks with less than a 300-foot difference in elevation. This would concentrate field work where it would be most effective. Another example: South Dakota is using the township as their basic unit, and their atlas blocks are one-quarter of a township, or 3 x 3 miles. Townships are grouped into 62 strata (called "superblocks") of 33-39 townships each, and these superblocks are grouped into 17 ecological regions. Two "Standard Blocks. have been selected at random in each superblock. These 124 random blocks, representing about 1 percent of the state, will be used for statistical analysis. In addition, "Special Blocks" have been designated to include unique habitats, and suburban blocks where habitat change is likely to occur; also, "Managed Blocks. have been established on various State and Federally managed lands.

Sampling Recommendations

1. When there are too few observers to visit all blocks, sampling is strongly recommended (rather than using a grid of larger blocks). This is primarily because with a coarse grid it may not be possible to detect future changes in bird distribution. The larger the grid, the greater the chance that some remnants of a habitat (and all of its typical breeding bird species) may still remain after a period of years.
2. Systematic sampling is satisfactory in most instances. A systematic sample may be supplemented with a stratified random sample of blocks containing rare or restricted habitats. However, any special blocks selected to sample specific sites must be excluded from statistical summaries.
3. In jurisdictions that are ecologically diverse or contain extensive inaccessible areas, stratified random sampling should be considered. A classical stratified random sampling design (Schaeffer, et al. 1979, Chapter 25 of Steel and Torrie 1980, or Chapter 21 of Snedecor and Cochran 1980) for detecting changes in bird ranges would start with an inventory of the major habitat types in the state or province and an assessment of their abundance, their relative importance to birds, and their vulnerability to development.

Next, the state or province would be stratified, assigning each block to one and only one stratum. Decide how many blocks to select from each stratum, based on the importance of the stratum. Then select a random sample from each stratum, including 100 percent samples of strata containing rare or critical habitat. The classical design would not provide an ideal arrangement of spots for mapping, and it might be too complex for some applications. An alternate approach would be to use a systematic sample to provide a base for mapping, and supplement this with a random sample of critical ecological areas, stratified by habitat. The two surveys would be analyzed separately, but any blocks from the systematic survey that fell into the critical habitat strata could also be used for the latter because they were randomly selected.

Mapping Grids

The two items for consideration are: (1) the reference base, and (2) the grid size. Ideally, the same reference base should be used world-wide. There are three major problems, however, that have prevented the global standard, the Universal Transverse Mercator (UTM) grid, from being widely adopted either in North America or elsewhere in the world: (1) The UTM grid has major interruptions with wedge-shaped blocks of various adzes every 6 degrees of longitude, (2) the UTM grid does not appear on most detailed U.S. maps (such as standard topographic maps and county maps), and (3) our major topographic maps have latitude/longitude boundaries, so even when the UTM grid is indicated in the margins, as it is in the newest maps, the observers or the atlas organizers must piece together several maps to make up a given atlas block instead of using a single readily available map. Therefore, in most countries the atlas organizers have used their national grid or one based on latitude/longitude rather than struggling with UTM.

Grid size for most atlases is now well standardized as either a multiple of 5 km, a close English equivalent, or a subdivision of a degree of latitude and longitude (L/L). For comparative purposes, a summary of atlas grids in use is given in Table 1, arranged from largest to smallest.

Table 1. Summary of grids that have been used in Atlas work. Grid is expressed as length of one aide unless otherwise specified. Grid base is Universal Transverse Mercator (UTM), latitude and longitude (L/L), a national grid, or a quarter township (3 x 3 ml).

Grid Size (and Base)	Where Used
100 km	Northern Ontario, Northwest Territories
1° latilong (L/L)	Montana, Wyoming, Utah, Australia (out-back)
1/2° (L/L)	Madagascar, Tanzania, Uganda, Turkey
50 km (UTM)	Continental atlas of Europe
50 km (UTM)	West Germany (later re-atlased with 25 km)
20 x 32 km (nat'l)	Portugal
20 x 27 km (nat'l)	France
18.5 x 28 km (nat'l)	Spain
7.5 min. (L/L)	Maine, Texas
10 km (national)	Britain and Ireland, Switzerland, Finland, Czechoslovakia, Italy
10 km (UTM)	Southern Ontario, Maritime Provinces, Poland

10 min. (L/L)	Tasmania, Australia (inhabited regions)
10,000 yd	New Zealand
3 x 5 min. (L/L)	Lower Saxony (Germany)
5 km	New York, Denmark, Netherlands, Sweden
About 5 km (L/L)	Massachusetts, Connecticut, Rhode Island, New Jersey, Pennsylvania, Maryland, Delaware, Florida, Missouri
Random or systematic	Vermont, Now Hampshire, Ohio, Virginia, West
sample, 5 km L/L	Virginia, Illinois, Indiana, Tennessee, Nebraska, Colorado
3 x 3 mi (=4.8km)	Michigan, Iowa, South Dakota, North Carolina
2.5 km l/4 blk (L/L)	DC, 1/6 of Maryland plus 6 Maryland counties
2 km (nat'l)	several British counties
1 km	Berlin, Canton of Geneva (Switzerland)

Grid Base Recommendations

It does not seem practical to insist that any one grid base must be used in North American (or New World) atlases. Therefore, the NORAC Working Group on Survey Methods and Mapping Grids recommends that atlas organizers give careful consideration to the options that are available regarding detailed maps of their state/province/department, especially considering grids used in adjoining jurisdictions, and maps that are most likely to be available 20 or 30 years later when the next atlas survey may be conducted. Computer programs are available for converting atlas records from UTM to lat/long grids and vice versa, so the choice of a grid base is largely a matter of convenience, not a matter of being either right or wrong.

We strongly recommend the 1:24,000 7.5-minute topographic maps of the U. S. Geological Survey (USGS), because they can be obtained and understood by anyone in the world and will be in archives for centurion in the future. Orthophoto maps (USGS), which are becoming available at the same scale, are recommended because they show the key habitat features. For Canada, excellent topographic maps are available in several scales from the Department of Energy, Mines, and Resources, Ottawa. For Mexico we recommend the 1x2-degree 1:250,000 Carta uso del suelo y vegetation, available from Instituto Nacional de Estadistica Geographica e Informatica, Mexico City; these Mexican maps have a 10 km metric grid.

Grid Size

There is a tendency among atlas organizers to think of grid size as being a function of only the size of the state/province/country and the number of prospective observers. More realistically, grid adze should depend on the purpose(a) of the atlas.

If the main purpose is to show approximate distribution of breeding species in an area where distribution is poorly known, a large poorly covered grid will produce valuable information, especially if actual localities are recorded for rarities or birds at their elevational or geographical limits.

If, on the other hand, a major purpose is to show habitat relationships or to establish baseline data for documenting future changes, it is important to select a grid small enough to accomplish these purposes. A 10-km grid is marginal, 5-km is better, and intensive random or systematic sampling by means of a smaller grid such as 2.5 km quarter-blocks, 2 km 'tetrads' or 1 km squares will give much more satisfactory results. The smaller grids are especially recommended for areas that are likely to be altered significantly prior to the next atlas project.

Grid Size Recommendations

- Canadian provinces—10 km
- U. S. States—5 km
- Latin America—10 km
- Lesser Antilles—5 km
- County or local—2.5 km

Options to consider:

- Stratified random, or systematic sampling when not all blocks can be covered.
- Lower density of sampling in large areas of continuous uniform habitat.
- Designation of certain priority blocks (e.g., 1 out of 6 or 1 out of 100) for intensive coverage with a finer grid, to improve capability of detecting future changes.
- Designation of certain counties for intensive coverage with a finer grid (depending on need to detect changes, and on available personnel).

Alternatives:

Optimum grid size may be dictated by availability of suitable maps or by road patterns (e.g., most states use 1/6 of a 7.5-mint topographic map published by the U.S. Geological Survey because these are readily available for the entire country and include green overprint for forest, etc., as well as topography); the area of 1/6 of 7.5 min. decreases from south to north, but is very close to 5 km in the middle latitudes of the country. Many states have a road system based on township lines, with roads at 1-mile intervals; some of these states (Michigan, Iowa, South Dakota) are using a quarter-township, which is a 3-mile (4.8-km) grid, for convenience in the field.

Some large tropical and semitropical countries have opted to use a 1/2-degree block of latitude and longitude.

Other considerations:

Check with neighboring jurisdictions to determine what grid they are using, and why. One of the advantages in using the same grid as your neighbors is that information can be shared from blocks along the border.

Survey Methods

Observers:

Trained observers are fundamental to the success of an Atlas project. They are always a limiting resource, so special efforts must be made to solicit and train observers. Some atlas organizers have placed too much emphasis on coverage by a small number of experts and have given too little attention to the continued training of interested volunteers. Interested beginners can contribute a great deal to an atlas project, and the special efforts required to encourage their training and participation have produced good results. Atlas organizers should recognize that the project itself presents an excellent opportunity for training and developing interested beginners into good field workers, who will go on to become leaders themselves in other survey and conservation work.

Most atlas organizers educate their observers by means of atlas handbooks, training sessions, and newsletters. These concentrate on identification, safe dates, courtesy toward landowners, and finding difficult species. More emphasis needs to be given to improving observer efficiency in the field. It is helpful to hold annual regional training sessions with participants.

Observers can be stimulated through incentive awards such as certificates, plaques, arm patches, pine, or banners, or just through recognition in newspaper or television coverage.

Training Sessions:

Any steps that can be taken to improve the efficiency of observers will help them bring their home block up to satisfactory coverage in a shorter time and stimulate them to tackle additional blocks. We suggest the following topics for training sessions:

1. Purposes of the project.
2. Responsibilities of the participants; goal for each block.
3. A quick course in map reading, so observers will be able to locate unique habitats such as marshes, or ponds that may not be visible from a road. Where possible, use the new Orthophoto (Topographic) 7.5-minute series (Geological Survey), USDI. There is a quantity discount, so if you are sending a small order, consider combining your order with that from another state.
4. Discussion of importance of habitat in limiting the distribution of each species; examples of habitat requirements.
5. Resources, such as bird song records and tapes, Stokes' (1979, 1983, 1989) guides to Bird Behavior, guidebooks for bird nests (Harrison, 1975, 1979), Ehrlich, Dobkin, and Wheye's (1988) guide to bird natural history, and local field lists showing dates of occurrence and nesting, and habitat requirements. If your state/province does not have such a local field list, use one from a neighboring area.
6. Atlas codes, with examples of their use, and other information from Atlas Handbook.
7. How to fill out the field card and summary sheet; explanation of forms cosigned for computer entry; what not to do.
8. Identification and habitat hints. Species with similar appearance, songs, or habitat Use colored slides if available (or consider use of study skins if a small group).

9. Discussion of bird behavior by groups of birds. Misleading code possibilities. Pair formation (year-round, during migration); singing during migration; feeding far from the neat (gulls, herons, vultures); mobility of fledglings (gulls, ducks). Importance of safe dates.
10. Instructions about Rare Bird Documentation forms and Nest Cards.
11. Cautions about neat disturbance. Predation rates are high, especially for nests on and near the ground. Avoid beating a trail directly to a neat; walk by at a safe distance. Preferably use a mirror on the end of a pole.
12. Getting permissions (don't trespass). Report findings to landowners.

Field Methods:

Always encourage feedback and sharing of experiences. Nothing takes the place of field experience. Even seasoned observers can benefit from field trips on which an experienced atlaser interprets behavior and tells what codes to use. Time is of the essence! Although many observers take their birding very casually (and some will not change their habits), they should be encouraged to work efficiently, if not vigorously. Their help can always be used in another block in the future, after they obtain satisfactory coverage of their first assignment. The following suggestions are based on experiences of active atlasers in the Middle Atlantic States.

Preliminaries:

1. Become familiar with your block before the atlas season begins.
2. Study topographic maps; find streams, ponds, marshes, large woodlots, access trails.
3. Contact important landowners. Each County Assessors Office has tax maps showing ownership of all lands in the county. A single permission may provide access to large tracts of interesting habitat.
4. When contacting landowners for permission, ask if they have seen quail, grouse, turkey, or pheasant nests, woodcock or hummingbirds, whether pigeons, phoebes, swallows, or Barn Owls neat in their barn, and whether they hear other owls at night. You may wish to verify their answers if you have any doubts. Knowledgeable farmers can save an enormous amount of time finding and confirming difficult species.

Principles:

1. Concentrate on early morning coverage when the birds are most active.
2. Sample all habitats; topographic maps are essential for locating off-road habitats.
3. Space trips throughout the season. If one waits until all species are within safe dates, the activity peak for woodcock, owls, and many other birds will have passed. Confirmation of late nesting species such as waxwings and goldfinches may be missed unless there is some late-season effort.
4. Some experienced observers prefer to begin their field work by laying out a "Miniroute" of 15 (or more) 3-minute roadside stops along secondary roads that have little traffic; they set the stops about one-half mile apart at strategic locations such as habitat boundaries and stream crossings so as to maximize the number of apecioa that may be encountered. (Less experienced birders cannot be expected to contribute to a highly structured study of comparative abundance based on Miniroutes, but they can use the

technique effectively for Atlasing if they ignore the 3-minute time restriction). Keep a separate tally of birds at each of these numbered stops. Go back a week later, observing from these same stops; this will automatically upgrade many species from Possible to Probable status (as soon as the spring migration is over and the various species are within the summer "safe dates"). Timed stops can also provide valuable information on relative abundance. Return to these same stops later in the summer (not restricting subsequent visits to 3 minutes) to upgrade additional species that were either missed or "unsafe" on one of the previous visits. It helps to highlight ahead of time those species that you hope to upgrade at each stop. After completion of Miniroute coverage, visit other portions of the block to search for other habitats and for additional species.

Extra Effort:

1. By the second year (or the first year if one gets organized early enough), concentrate on early spring birds such as owls and woodcock that may be much harder to find later in the season. Nocturnal and crepuscular species require special effort. Early mornings average better than evenings in areas where traffic or frog noise is a problem. A moonlit night is generally more productive than a dark or rainy night. Use tapes if necessary to stimulate response; playing tapes once or twice at a given location will cause a minimum of disturbance to the birds.
2. Although roadside coverage may give the most rapid initial results, off-road coverage is essential for access to other habitats. Railroad rights-of-way, power lines, pipelines, and sewer lines should be considered as means of easy access to off-road habitats. Be sure to obtain permission, especially when lands are posted.
3. Work as efficiently as possible during the first years of the project. Every atlas project has a near crisis in its final year because observers have neglected to keep on schedule or have moved out of the area. By the final year, new residential development and shopping centers have wiped out nesting areas where some species would have been easy to find and confirm in earlier years.

Assessing Adequacy of Coverage

Setting Total Species Goals:

It is taken for granted that observers must be given goals toward which to work. Goals are hard to define, however, in a large diverse state or province with varied landscape. It might be easy to find 80 species in some blocks, but impossible to find as many as 50 in others.

Adequacy of coverage has been defined in various atlas projects as finding 75% to 90% of the species suspected of being present in a block and confirming 50% or more of these species. The 75% of species believed present has been generally accepted in most North American projects. This 75% rule has been criticized by Kibbe (1986) as being inadequate for future comparisons, and ho correctly shows this to be true when only a single block is compared; but when hundreds of blocks are compared the problem disappears.

The coverage goals represent a compromise with respect to the allocation of limited resources. For example, from experimental work in England, Sharrock (1973) found that in 400 hours an experienced observer could obtain atlas data for either 63% of the species in 80 10-km blocks, 75% of the species in 40 blocks, 87% of the species in 25 blocks, 92% of the species in 4 blocks, or 94% of the species in 2 blocks.

The problem with setting goals too low, such as 63% of the expected species, is that only the more familiar, most vocal, and most widespread species may be recorded, while rare, local, and habitat-specific species will be missed. On the other hand, setting goals too high may discourage some observers, and will seriously limit the number of blocks that can be visited. Whatever the specified goal, it is important to point out that regional differences exist and that blocks in urban areas, blocks with extensive agriculture, and blocks with little diversity of habitat will have small species totals. It should also be specified that blocks with extensive wetlands or a rich variety of habitats may have well in excess of the regional goal.

Most North American atlas organizers agree that 75% of the expected species is a legitimate goal, but that if the number of expected species is later found to have been underestimated the goal needs to be raised accordingly.

Estimating the Number of Expected Species:

In some states preliminary field testing is done in the year prior to launching the atlas. This gives an excellent opportunity to test adequacy of estimates of expected species in various environments. When the luxury of actual field experience is not available, data from nearby states or provinces may prove helpful.

Experienced field ornithologists can usually make fairly reliable estimates with the use of topographic maps. After the first full year of field work, estimates can be revised as necessary. Raynor (1982) described a method of estimating the number of species in each Long Island block based on his personal knowledge of the birds and the habitats present and on the lists submitted by the observers.

A method that proved very helpful in Maryland after the first year of field work was providing county coordinators and observers with a computer-generated list of expected species that were missing from each block. This list was obtained by comparing species lists from the eight surrounding blocks with the list for each target block and printing the names of those species not listed for the target block, together with the number of surrounding blocks in which they had been detected. Such a list, when added to the list for the target block, and adjusted for species whose habitat is completely lacking from the target block, gives a good estimate of the potential for the target block.

Confirmation Percentage:

In western Europe, where habitats are more open and birds easier to confirm, it was not unusual to have 70% or more of the atlas records confirmations. In Switzerland (Schifferli, et al., 1980), for example, the average number of species per block was 86, and 76% of the records were confirmations. In North America, many eastern states and provinces began with a goal of 50%

confirmations. Some states later dropped this goal in favor of better species counts; their emphasis became directed toward more Probable or Confirmed records rather than just confirmations. Confirmation of rare species remains a high priority. Everyone agrees that confirmations are important and that they should continue to be emphasized on the atlas maps. A confirmation rate of 50% is still a desirable goal but should not be a prerequisite if it will jeopardize adequate coverage of all habitats.

Judging Adequacy of Reports from Individual Blocks:

This is best done by comparison with results from neighboring blocks that have a similar mix of habitats. Some observers may have hearing problems and miss birds with high pitched calls, some may have neglected wetland habitats or failed to include nocturnal coverage. More often, songs of some species may not have been recognized. Failure to detect a species is generally a greater problem than misidentification.

Hours Afield as a Measure of Adequacy:

It is dangerous to rely too heavily on total hours spent in an atlas block because so much depends on the capability of the observer, the time of day, the distribution of effort through the season, the accessibility of habitats, and even weather conditions. The Ontario goal of 16 hours per square was later changed to 75% of the expected species.

In Spain, de Juana (1980) spent 12 hours per 11-km block, finding 70% of the species present, but confirming very few. In Switzerland (Schifferli, et al., 1980), it took about 9 days to find 80-90% of the species in a 10-km block and confirm 80% of them.

For experienced observers, 16 hours proved adequate in New York (Carroll 1986); they hired 2-person teams to blockbust by spending one day in each block, camping there at night.

Numerical Treatment

In the early years of atlasing, much discussion was devoted to various means of obtaining meaningful estimates of abundance. Trained professionals are often willing to participate in an activity involving standardized counts, but the average atlaser is not. The options are:

1. To make no attempt at numerical estimates;
2. To compute grid frequencies, the proportion of blocks in which a species was found, preferably done by physiographic regions as in Laughlin and Kibbe (1985);
3. To urge only those participants who feel comfortable about making estimates to do so (through either standardized surveys of relative abundance, counts of birds actually observed while atlasing, or estimates of the number of pairs nesting within an entire atlas block); see Adams (1986);
4. To rely on the regional coordinators to make estimates for their regions;
5. To have a special committee make estimates of abundance for all species on the basis of whatever information is available to them (primarily published sources);
6. To use existing Breeding Bird Survey data to show the mean number of birds detected per 50 3-minute roadside stops. This information is available for the U.S.A. from the

Office of Migratory Bird Management at the Patuxent Wildlife Research Center, Laurel, Md. 20708, and for Canada from the National Wildlife Research Center, Canadian Wildlife Service, Environment Canada, Ottawa, Ontario K1A OH3);
7. To supplement BBS data with additional routes in order to increase the data base, especially for rare or local species, or to provide data from areas not adequately sampled by the BBS; and
8. To establish a special network of standardized counts, such as Miniroutes, to be run by hand-picked experts.

The greatest value of numerical estimates is to serve as a basis for future comparisons. Consider carefully whether future changes in bird population will be detectable by the method selected. A population index that is repeatable will probably be preferable to estimates of actual abundance, unless the latter are made in a highly standardized fashion.

Recommendations for numerical Treatment

1. At a very minimum, State/Province means from BBS should be used as indices of abundance for any U.S. or Canadian Atlas (except in the Arctic where not available). For common species you might also consider separate means for the physiographic regions within the state or province. In requesting these (from Breeding Bird Survey, Patuxent Wildlife Research Center, Laurel, MD 20708), you must specify the years you want included in the means. If the State/Province is well saturated with BBS routes, it would be preferable to use means based only on the Atlas years; otherwise, you might select a longer span of years.
2. If (willing) observers or coordinators are asked to provide estimates of total number of pairs of each species in their blocks, we recommend the estimates be in powers of 10 (1, 2-10, 11-100, etc.) as used successfully in the French and Ontario Atlases and proposed for the atlas of all of Europe. A simple check to determine whether such estimates are in the right ballpark is to consider that if the BBS means were based on 100% efficiency of all observers in detecting all birds within 1/4 mile of each of the 50 stops on every route in every year, the mean would represent the number of birds per 25.42 km2. In other words, the area theoretically sampled by a 50-stop BBS route is essentially the size of a 5-km Atlas block (25 km2). It is safe to say that BBS efficiency never reaches 100%. For conspicuous open country birds it might reach 50%; for most species, and especially those in habitats poorly sampled by the BBS, it would be under 10%. Possibly estimates for some species in certain habitats may be available within the next decade.
3. Another option is to have observers time all their early morning counts. If an efficiently large number of timed counts are available from experienced atlasers, the number of birds per hour can be calibrated, species by species, and adjusted to a standard observation time (e.g., 6-hour day) as was done successfully in the British Winter Atlas (Lack 1986).
4. Systematic Miniroute (Bystrak 1980) coverage by experienced participants such as BBS observers is recommended as an ideal way to obtain a large sample of data on relative

abundance. Either actual counts or frequency (percentage of stops) can be used as an index (Robbins and Dowell 1986).

Monitoring Bird Populations with Atlas Data

An important potential for breeding bird atlases is to monitor long-term changes in populations of rare species. Robbins et al. (1989) noted that standardized roadside surveys such as the Breeding Bird Survey (BBS) poorly sample nocturnal and rare species and those found in habitats such as mountain tops and marshlands that tend to be avoided by roads. They considered the use of breeding bird atlases to supplement the BBS. Unless atlases are designed for monitoring bird populations, it is not valid to use them for this purpose. Techniques to monitor special groups such as raptors have been developed (e.g., Fuller and Mosher 1987).

To monitor rare species and those found in habitats poorly sampled from roadsides, atlases must have a random or systematic sample of these species' habitats. It is likely that many of these habitats are rare and thus poorly sampled by random or systematic samples of blocks selected from the whole state or province.

Arbitrarily selected "Special Blocks" that may be added to include these habitats should not be used for monitoring, because one cannot know whether population changes in these hand-picked blocks are typical for the state or province. Instead, it is necessary to list all the blocks that contain each special habitat of interest and then draw a random sample from each habitat (stratum) or visit a 100 percent sample of the rarest habitats. For the rarest species it would be highly desirable to document numerical abundance and to record time and methodology used in counting these species so the effort could be duplicated in the future.

It is also possible to estimate the number of blocks in which a species was present but not found (Geissler and Fuller 1986, White et al. 1982). This method requires observers to make a separate list of the species found on each trip to their blocks, by habitat (excluding trips made explicitly to look for particular species). Statistical methods can then be used to estimate the probability of finding each species that is present.

In addition, for monitoring even the more common species it is necessary to standardize procedures so that effort can be matched, or at least compared, in the future. The number of blocks in which a species is recorded cannot in itself be used to monitor change, unless the results can be adjusted for differences in effort. Not having an accurate record of hours of coverage, Robbins et al. (1989) used the ratio of total volume of atlas quarter-block records in Howard County, Maryland, for 1973-75 and 1983-87 to compensate for differences in coverage during the two periods. They were able to show that dramatic changes in bird distribution had taken place in a single decade.

For species common enough to be monitored along roadsides, a network of timed Miniroute stops that can be repeated in the future either during a future atlas project or as a special monitoring program would be ideal. Another method would be intensive ("saturation") coverage of a random sample of blocks, with a special effort made to search all habitats where the species of interest might occur.

Literature Cited

Adams, R. 1986. Relative abundance and the Michigan Breeding Bird Atlas. Pp. 41-43 in Sutcliffe, S.M., R.E. Bonney, Jr., and J.D. Lowe. Proc. Second Northeastern Breeding Bird Atlas Conf. Lab. of Ornithology, Ithaca, N.Y. 192 pp.

Bystrak, D. 1980. Application of Miniroutes to bird population studies. Maryland Birdlife 36:131-138.

Carroll, J.R. 1986. Adequate coverage: New York Breeding Bird Atlas. Pp. 16-17 in Sutcliffe, S.M., R.E. Bonney, Jr., and J.D. Lowe, Proc. Second Northeastern Breeding Bird Atlas Conf., Lab. of Ornithology, Ithaca, NY.

Ehrlich, P.R., D.S. Dobkin, and D. Wheye. 1988. The birder's handbook. Simon & Schuster, New York. 785 pp.

Fuller, M.R., and J.A. Mosher. 1987. Raptor survey techniques. Pp. 39- 65 in B.A. Geron Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird, eds. Raptor Management Techniques Manual. Nat'l Wildlife Fed., Washington, D. C. 420 pp.

Geissler, P.H., and M.R. Fuller. 1986. Estimation of the proportion of an area occupied by an animal species. Proc. Sect. On Survey Research Methods of the American Statistical Assn.: 533538.

Juana de, E. 1980. Atlas Ornitologico de la Rioja. Instituto de Estudios Riojanos, Logrono, Espana. 658 pp.

Harrison, H.H. 1975. A Field Guide to Birds' Nests. Houghton Mifflin, Boston. 257 pp.

Harrison, H.H. 1979. A Field Guide to Western Birds' Nests. Houghton Mifflin, Boston. 279 pp.

Kibbe, D.P. 1986. Determining adequacy of coverage in statewide breeding bird atlas projects: when enough is enough. Pp. 18-22 in Sutcliffe, S.M., R.E. Bonney, Jr., and J.D. Lowe, Proc. Northeastern Breeding Bird Atlas Conf., Lab. of Ornithology, Ithaca, NY.

Lack, P. 1986. The atlas of wintering birds in Britain and Ireland. T & A.D. Poyser, Calton, England. 445 pp.

Laughlin, S.B., and D.P. Kibbe. 1985. The atlas of breeding birds of Vermont. Vermont Inst. of Nat. Science, Woodstock. 456 pp.

Raynor, G. 1982. Evaluation of breeding bird atlas survey data. Pp. 66-69 in Laughlin, S.B., ed. Proc. Northeastern Breeding Bird Atlas Conf., Vermont Inst. Nat. Sci., Woodstock, VT. 122 pp.

Robbins, C.S., and B.A. Dowell. 1986. Use of Miniroutes and Breeding Bird Survey data to estimate abundance. Pp. 28-40 in Sutcliffe, S.M., R.E. Bonney, Jr., and J.D. Lowe. Proc. Second Northeastern Breeding Bird Atlas Conf. Lab. of Ornithology, Ithaca, N.Y. 192 pp.

Robbins, C.S., S. Droege, and J.R. Sauer. 1989. Monitoring bird populations with Breeding Bird Survey and atlas data. Ann. Zool. Fennici 26:297-304.

Scheaffer, R.L., W. Mendenhall, and L. Ott. 1979. Elementary Sampling Theory. North Scituate, Mass. Duxbury Press.

Schifferli, A., A.P. Geroudet, and R. Winkler. 1980. Atlas des Oiseaux Nicheurs de Suisse. Station ornithologique suisse de Sempach, Sempach. 462 pp.

Sharrock, J.T.R. 1973. Rate of species-registration in atlas work. Bird Study 20:88-90.

Snedecor, G.W., and W.G. Cochran. 1980. Statistical methods. Iowa State Univ. Press, Ames. 507 pp.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York. 633 pp.

Stokes, D.W. 1979. A guide to the behavior of common birds. Little, Brown, Boston. 336 pp.

Stokes, D.W., and L.Q. Stokes. 1983. A guide to bird behavior, vol. 2. Little, Brown, Boston. 334 pp.

Stokes, D.W., and L.Q. Stokes. 1989. A guide to bird behavior, vol. 3. Little, Brown, Boston. 396 pp.

White, G.C., D.R. Anderson, R.P. Burnham, and D.L. Otis. 1982. Capture-recapture and removal methods for sampling closed populations. Los Alamos Nat'l Laboratory, Los Alamos, N. Mex. 235 pp.

Computer Guidelines: Recommendations for North American Breeding Bird Atlas Projects

Daniel W. Brauning, Pennsylvania Atlas Project and

Linda Ann Payzant and L. Peter M. Payzant, Maritimes Atlas Project

Introduction

Most of the NORAC Working Groups were formed to establish recommendations which, if adopted, would lead to a degree of uniformity among atlas projects. Although uniformity is not necessarily our goal, the Working Group on Computers suggests the following guidelines primarily to assist those projects now in the planning stages.

Some of the terms used may be unfamiliar to you if you do not have a computer background. We recommend that a person familiar with computers be persuaded to take part in the planning stages, at least.

General Guidelines

1. Don't underestimate the time and costs of computerization. If possible, model your system after another atlas project which meets your needs.
2. Identify technical support people with an interest in birds to help implement your computer system. Include a "computer person" on your advisory board. Ideally, this person should be available to help for the life of the project.
3. Atlas personnel should have direct control of the computer system. Be wary of offers of "free. time on a mainframe. Technical assistance may be lacking and your work may become low priority. For these reasons, we recommend that you budget for and buy a microcomputer. They are the most coat effective (you don't need to pay for time or communications) and you maintain control.
4. If possible, buy and program your computer system before the first field season. Your software may influence the format of the field card you use.
5. Ensure careful data processing and backup procedures. Your data are extremely valuable and represent many hours of volunteer time. Your atlas project should be able to survive almost any kind of computing disaster with little loss of data.
6. Consider providing data security to limit access to sensitive species.

Hardware Configuration

1. The following minimum configuration is recommended:
    a. A microcomputer equivalent in power to at least an IBM/PC-AT.
    b. 640 kilobytes of RAM.
    c. One diskette drive (5 1/4 or 3 1/2 drives are available).

    d. One 40-megabyte hard disk drive.
2. Some means of backup other than the diskette drive should be provided if possible. Diskettes are slow and may discourage regular backups. Options which should be investigated include "Bernoulli. drives, streaming tape cassettes, and aerial links to mainframe computers with large amounts of storage space available.
3. Many varieties of plotters are available. An inexpensive plotter can be very valuable in producing interim maps during the data collection phase of your project and should be sought after if your budget permits. Another, more versatile, option is to use a Laser printer with plotting software. A plotter capable of producing publication quality maps would be uneconomical to purchase. Final maps should be prepared on a drafting-quality plotter, i.e., one with a resolution of better than 0.002 in., and using India ink pens with Mylar or polyester media. This service can usually be obtained from government agencies or commercial facilities and should not be too expensive for a "one-shot" occasion.

Software Design Considerations

1. Software development invariably takes more time and effort than anyone ever expects. If at all possible, copy a working system from another atlas project.
2. If you must design a system from scratch, try to obtain assistance from someone with system design (as opposed to simply programming) experience.
3. Design data forms to correspond to database structure. Forms should require minimum hand transcription of data.
4. Keep data handling and fill structures as simple as possible to reduce errors.
5. Store data efficiently. Disk usage will expand beyond your expectations in any case. An efficient structure will also speed data retrieval.
6. Minimize repetition. Use codes when possible for species and locations. Numeric codes are fastest to enter; however, alpha codes are less error-prone and result in more readable files.
7. Structure data for quick access. However, complicated structures which may prove difficult to maintain should be avoided.
8. Maintain descriptor files for each set of codes, e.g., to translate species codes to full species names, etc. Each code should be defined at only one place (one file) in the system. This makes maintenance simpler and prevents ambiguity.
9. Keep the annual data entry process separate from the multiyear database. Annual data should be entered, proofed, and summarized before incorporation into the multiyear database. This is faster and safer.
10. Each data record should have a comment field at least two characters wide, and more if possible. These can be used for flagging records requiring documentation, records which have been cancelled by your approval committee, and so on.
11. Reports should avoid the use of codes where possible, i.e., use full species names, block names, etc. This is particularly true for reports being sent outside the atlas organization.

Typical File Contents

The following list of files is suggested as one way to implement an atlas data base:

New Data File: Contains region, block, species, breeding code, abundance code (optional), and field card number for one year. Other information may be included in this file such as atlaser number(a), visit dates and hours, and error/documentation flags.

Master File: (same as New Data File plus year field) for combined years data.

Block File: Information on each block such as code, name, county, coordinator, map coordinates, etc.

Species File: Contains species code, English (or French) names, scientific names, taxonomic order number, status designations (e.g., does this species need documentation when reported?)

Documentation File: List of records currently requiring documentation, including species, breeding code, block, atlaser, and documentation status (outstanding, received, approved, etc.). Note: this may not be a separate file, but rather just flagged records in the Master File.

Address List: Including flags for participants, officials, interested parties (but not active atlasers), etc.

Data Entry Procedure

A well thought out data entry procedure can speed up the entry of the data, catch certain errors, and save a lot of problems later in the data manipulation. We recommend the following features:

1. Use a "friendly" data entry screen.
2. Enter coded information to reduce the number of keystrokes. These should be printed directly on the field card.
3. Include as much error checking as possible at this stage--is the species code legal, are the species in the same order as on the field card, are the visit dates and block numbers reasonable, etc.
4. Data should be entered twice by different persons, and the two raw files compared, and differences resolved before the raw file is added to the Year file. This will eliminate virtually all keying errors.
5. Before the raw data are appended to the yearly data file, the raw data file should be rigorously checked by a program designed to flush out errors that the data entry program couldn't catch.

Reports

The following is a list of reports that you may have to develop. Ideally, these should all be ready to go before the end of your first field season. See pp. 72-73 in the Proceedings of the Northeastern Breeding Bird Atlas Conference (1981) for additional suggestions.

1. Raw Data Report—lists data as they exist in Yearly data file. Very useful for checking other reports.
2. Regional Detail Report—sent to Regional Coordinators. Lists all records for each block in region, sorted by block.
3. Regional Block Summary Report—for each block in the region, lists the number of species reported in each breeding category, the number of visits, total atlaser hours, and atlaser numbers.
4. Regional Species Summary Report—for each species in a region, lists the number of breeding reports in each breeding category, highest breeding code, status of documentation, etc.
5. Documentation Status Report—lists (by region) status of each documentation request: not received yet, received, sent to committee, final disposition (accepted, accepted with change, rejected).
6. Species Status Report—lists number of reports of each breeding code for each species for complete a/ate/province.
7. Mapping Report—lists squares and breeding codes for each species. Useful for producing interim maps.
8. Statistics Report—lists by year and region: number of species possible probable, confirmed, and total; total atlaser field time, number of blocks "completed", number of doc forma outstanding, etc. A good tool for the management committee.

Interim Mapping

Micro-computer mapping is a rapidly developing technology. Currently several software packages are available that will produce very nice interim maps on a plotter or laser printer. Interim maps are highly recommended. They provide significant feedback to volunteers and are an invaluable management tool. The main components include:

1. Mapping software, available commercially or custom written. ATLAS-GRAPHICS mapping software (STSC, Inc., Rockville, Maryland) has been successfully used by some states.
2. State/Province and county coordinates (available from software manufacturer).
3. Block coordinates, generated by user.
4. Database management system to produce reports of block coordinates for each species.
5. An output device, either laser printer or plotter. Laser printers, using plotting software, can produce excellent interim maps more quickly than can a plotter.

Two types of maps can be produced: a coverage map showing the number of birds per block and species distribution maps. When producing maps, select breeding code symbols in advance and use them consistently for each species.

Conclusion

Although these guidelines will not answer every question you will have in setting up your computer system, we hope that it will be of some assistance. A wide range of approaches has been tried. If you are setting up a new system or modifying an existing one, find a project of similar adze and hardware availability to use as a model. Contact that project and obtain as much information as possible before designing your system. Remember, a well-designed computer system will greatly facilitate your atlas project.

Publishing the Breeding Bird Atlas

Janet R. Carroll

New York Atlas Project

A multi-authored publication, like the New York Breeding Bird Atlas, is considered to be the most difficult type of book to publish. Those of us who have edited an atlas can attest to that fact. The following discusses the publishing process for a hardcover book and makes recommendations based on the experience of the New York Atlas.

Choice of Publisher

Publication of the atlas can be done by any publishing company, but in only a few cases can it be done without an initial outlay of money. Neither New England Press, nor Cornell University Press, publishers of the Vermont and New York Atlases respectively, required money up front to publish the book. Other publishing companies in New York, such as Syracuse University Press and the New York State Museum, required as much as $10,000. Most commercial publishing companies are not interested in publishing books like an atlas which will have limited sales.

The Ontario Breeding Bird Atlas handled all aspects of their publication except for the printing. This approach gives complete control and responsibility for the publication to the editors. Editing, copy-editing, and proof-reading expertise are essential to the use of this method.

Publication Staff

The publication staff could potentially consist of the following: Editors, reference editor, managing editor, authors, art editor, and artiste. If at all possible, the book staff, particularly the editors, should work together in one location.

The number of editors should be small, keeping in mind that the more people editing the more distinct styles are affecting the final product. A separate editor for references is extremely useful for that most tedious and time-consuming task. The managing editor is responsible for the financial and legal aspects of the book, including negotiating contracts and obtaining and budgeting funds.

Since a book with multiple authors presents special problems, experienced editors should be selected. It would be preferable if your editor(s) had previous experience working with a multi-authored book, but at least considerable book editing experience is very important. The advantages to choosing an experienced editor are obvious, but in addition to being familiar with such things as style sheets, editorial marks, style manuals, and copy-editing, an experienced editor will have much less trouble dealing with authors.

The original state atlas coordinator, if that person has good writing and editing skills, is one choice as an editor. There is probably no one in your state who will know as much about atlas data and its distribution statewide. She or he has handled the data on a daily basis and has information useful to its interpretation. I would even suggest that the atlas coordinator draft the paragraphs regarding distribution for all species accounts as an aid to the author. This will allow for consistent interpretation parameters. Your authors will presumably know much about the birds in the region where they live but often do not have a statewide perspective.

Selecting Authors

The decision on the number of authors to use is a difficult one. The more authors, the greater the style variation, the more people you will have to deal with on deadlines, the more good writers you will have to find, and the more personalities you will have to get to know. The fewer the authors the more you will have to be sure of their writing ability, longer deadlines will have to be established, the writer may find the writing tedious and mistakes may occur from burnout, and the authors may not be as knowledgeable about some of the species. The most interesting species accounts are those written by individuals who have either done research on the species or have a particular knowledge of the bird through considerable experience. Naturalists tend to want to write of the more colorful aspects of the species; scientists the more technical--there should be a happy medium.

No matter how many authors you select, be sure you have seen unedited (by someone else) writing from the candidates because bad writing will be a major problem. Have writing samples submitted if possible. If you encounter an author who doesn't write well eliminate that person from your writing staff. If you don't you will end up rewriting the accounts yourself. You will be unhappy, the writer will be unhappy, and time will be wasted.

The information provided to authors before they begin to write is critical. See Proceedings of the Second Northeastern Breeding Bird Atlas Conference (1986) for material provided to New York and Ontario authors. No matter how clearly you feel you have made the guidelines to the writers, their interpretation will be different from yours in many cases. Be prepared to get the first draft of the first species accounts back to the writers quickly so they can see what they are doing right and what they are doing wrong. Be firm about content and deadlines.

Selecting Artists

Someone knowledgeable about bird art should be appointed to coordinate the artwork for the book. Ask for samples of the type of art to be in the book from as many artists as you can and choose as many as your art coordinator feels she or he can manage. The artists will have deadlines to meet and more artists are preferable to fewer. A committee should be formed to review and comment on the initial sketches. It will be necessary in most cases to prepare a contract with each artist to specify deadlines, size of drawings, ownership of original artwork, and other details.

Selecting Reviewers

It would be best to select technical reviewers who have done research on a species or family. This may not be possible, however, but you should be able to find reviewers who are knowledgeable in general. Individual reviewers are very different in their approaches--some don't say much, some do mostly editing, some make comments about content, and some thoroughly review the content for accuracy and make extremely useful comments. You, of course, want the latter.

Working with the Publisher

The publishing company staff can be very helpful to you in the preparation of your book. You must first agree upon the type of book you want to produce which can run the gamut from a flashy, colorful, and expensive book to a basic black and white version. The publishers will want to produce a book on which they will not lose money. You have to negotiate a contract with them (the publishing company usually has a standard format it uses). The contract will specify content, number of pages, your responsibilities, and the publisher's responsibilities. Your publisher must determine the number of words of each species account, size of the original artwork and reduction size for the book, quality and design of maps and overlays, format, and deadlines. The publisher makes several decisions some of which you can probably influence, some are completely at their discretion. Show the publisher a sample of a book similar in layout so they know what you are expecting the final product to look like. They will have their own opinion about such things as adze of artwork and style and adze of type based on what type of presentation they think will sell; their opinion may not be the same as yours so don't let this be a surprise.

Even with very careful preparation and discussion with them, unexpected complications will occur. These are examples of some of the problems experienced by the New York Atlas: the number of words specified by the publisher was too many and several accounts had to be shortened after the manuscript was submitted; some of the computer produced maps were not of a quality acceptable to the publisher--some had to be redone and some had to have hand corrections paid for by the project (quality control of 238 computer plotted maps is difficult); the word processing software used for the text and references cited could not be used by the typesetter and all disks had to be converted to ASCII format.

The publisher should deal only with the editors of the book. Direct contact between the publisher's staff and artists, writers, or others should be avoided.

Sample species accounts should be given to the publisher early on for their comments and suggestions. For example, you don't want to find out after you submit the manuscript (as they did in Vermont) that your publisher will not accept anecdotal information in the accounts.

The publisher will hire a copy editor to go over the entire manuscript. The copy-edited manuscript will be an improvement over the original, and you will be grateful for this fresh look at the manuscript. By the time 238 accounts have been edited for the third time, the editors will no longer have any idea whether the writing is good or bad and will be glad to be rid of it for a while. The copy editor will look in particular for inconsistencies and no matter how careful you have been, more style decisions will be necessary.

Proofreading of the page proofs would best be done by a professional who will probably have to be paid by the project, not the publisher--someone who has not read the manuscript previously. The editors will also check the page proofs carefully, and you may want your authors to read them as well if the manuscript has changed considerably from the one submitted. Changes to the page proofs cost money, so the only changes made should be corrections of errors of fact or typos. This is not the time for revisions. One person should be in charge of putting all corrections on one set of page proofs.

The number of copies produced and the price will not be determined until the end, but the publisher will give you an estimate. The New York Atlas sells for $29.95 plus $12.95 for map overlays, which are sold separately, and 3,500 copies were printed.

Matters of style

In addition to having species accounts that are written similarly, there are many matters of style that have to be decided for consistency. The list below includes some style questions that must be decided upon. Authors should be made aware of all style decisions.

1. Decide on a standard reference for the following: bird, and other animal names, plant names, place names, plant community names, physiographic region names, forest type names, etc. Decide if you want to use only English names or both English and scientific names. When you use a place name such as a town, include a locating name such as a county, so individuals not familiar with your state will have a better chance of figuring out what part of the state you are referring to. As part of the editing process all names should be checked against the appropriate standard reference.
2. Decide which common names you want to capitalize--only those bird names which are current AOU names, former AOU English names, names of other animals and plants?
3. What abbreviations will you use--keep a list? CBC, BBS, USFWS, BBA, NWR, DDT, mm, km, ha, ft. in, mi, a.
4. Are you going to use the terms atlaser, atlasing, birder or birdwatcher, blockbusting or block busting.
5. Do you want to capitalize or put in quotes words like endangered species, possible, probable, confirmed, blue list?
6. Numbers--what is spelled out and what is in figures; 1,000 or 1000; 1980 to 1984 or 1980-84; % or percent; 4 July 1980 or July 4, 1980. Do you want to use metric with a conversion to English in the text; if so, provide the authors with the conversion figures to be used and advise them how to round off--whole numbers, one decimal?
7. Refer to birds either in the singular throughout or plural, but do not mix; e.g. "The gray jay is a bird of the spruce-fir forest," or "Gray Jays are birds of the spruce-fir forest.

Your publisher will recommend a style manual. Be sure each author has access to the style manual and all standard references. As you edit, other style decisions will continually have to be made. Make up a style sheet as you go along and each time you make a style decision, write it down so the next time the situation arises your style sheet will tell you what to do. Give your style sheet to the copy editor.

References

Provide your authors with a printout of current references which can be obtained from a retrieval service. Spot check references and quotes used in the text for errors and if a particular author is making mistakes advise her or him.

Decide whether you want a References Cited section or Bibliography and advise the authors. Both New York and Vermont used only references cited, since there were such a large number of references.

Decide on your reference style and prepare a form for the authors to fill out for each reference used. Include all the information needed for each type of reference and prepare your form in such a way that your typist will be able to type everything in the correct order from the form with minimal instruction. Have your reference editor check each reference as it comes in with the species account drafts to make sure it is complete, have the typist enter the reference on the computer, and then have the reference editor check the typing. In addition to the master list of references cited, in New York a list of references was prepared for each species account so the authors could check for errors. Only the master list is printed in the book. WARNING: Keep up with the references. References can become a nightmare if they are not kept up to date. Since some references get eliminated as the editing progresses, when you do your final check of references against the species accounts, make a note beside each reference of the corresponding species account(a). A copy editor will check your references against the text and for style.

Timetable for Preparation and Publication of New York Atlas

Contract with Cornell University Press signed 6/85 Atlas field work completed 8/85

- Information sent to authors 8/85
- Atlas data clean-up completed 12/86
- Final distribution maps given to authors 2/87
- Manuscript submitted to publisher 6/87-8/87
- Copyediting completed 11/87
- Typesetting completed 12/87
- Prepublication ion advert is ing 1 / 88
- Proofreading completed 2/88
- Book available for sale 6/88

Uses of Atlas Data

Paul F. J. Eagles

Ontario Atlas Project

Atlas data are primarily collected for the purpose of assessing the geographical distribution of species in an area. The wide movements of many bird species make the location of their relatively sedentary breeding stations guise important. Therefore, bird atlases usually concentrate on breeding. However, other atlases have been developed for many other groups. In Britain, over 30 atlas projects have been completed or underway, dealing with life forma as diverse as dragonflies, mammals, and marine dinoflagellates. Therefore, in the discussion of the uses of atlas data it is important to recognize that it is possible to undertake analyses with information for a wide variety of life forms.

C.S. Robbins (pers. comm.) suggests that atlas data can be used for three general types of activities: conservation, monitoring and research. This paper will discuss these three activities while exploring six different types of uses.

Determination of Geographical Distribution

Atlas data are valuable for the original determination of the geographical distribution of a species. This fine degree of resolution, the wide geographical distribution, and the large amount of field time result in the production of a picture of the range of a species for the province or state. In Ontario, the breeding bird atlas work resulted in the addition of three new confirmed breeding species and ten possible or probable breeding species to the provincial list (Cadman, Eagles and Helleiner 1987).

The known ranges may change by hundreds of kilometers as the data reveals previously unknown populations. For example, in Ontario it was found that Lesser Yellowlegs breed over 200 kilometers further south than the range shown in Godfrey (1986). New patterns of distribution are often revealed. In Ontario, it was found that there are two distinct bands of distribution across southern Ontario for Cerulean Warbler, a fact previously unknown (Cadman, Eagles and Helleiner, 1987).

Atlas data can provide relevant and important information on the range on every species that is studied. The broad geographical coverage of atlas data allows for correlation with other ecological data bases, such as those of soil surveys, forest inventories, etc. However, it is important to recognize that atlas data can be used for much more.

Determination of Distribution Changes over Time

Atlas data for birds are usually collected within a finite period of time. These data are then coalesced into a group and published as if from one point in time. However, it is possible to break down the data to specific periods of time. For example, Dunn (1987) has shown the significant changes in the distribution of House Finches in Ontario over the 1981 to 1985 data collection period of the bird atlas. Lumsden and Smith (1987) discuss the importance of having year by year data with the interpretation of the distribution of the irruptive crossbill species. If the data are stored in the computer with files for each year, it is possible to undertake analyses of these types.

In Ontario, six species of birds that had bred in Ontario were not found during the atlas period. This almost certainly means that they are now no longer present as native breeders in this area.

In some cases atlas data have been collected continually. For example, the Provisional Atlas of the Mammals of the British Isles (Arnold, 1978) includes historical as well as more current information. The maps for most species have three types of records, those before 1900, those between 1900 and 1959, and those between 1969 and 1976.

Historical information is prone to bias due to the under collection of data in some areas. However, if used judiciously, it can still be used to show changes over time. This is most certainly the case for those species that were once found in an area but were found more sparingly during more recent data collections.

C.S. Robbins (pers. comm.) has suggested that there are four important conservation questions that can be partially answered by atlas data:

- What species are declining in distribution and numbers?
- Why are they disappearing?
- What can be done about it?
- What land needs to be conserved?

Determination of Rarity

Atlas data show the geographical distribution of a species. This information can be used to give a rough idea of the relative rarity of an organism. Certainly, if a species is found in a majority of the squares in a province it cannot be considered rare. However, it is often necessary to have some abundance data for the species in a square to provide a more complete picture.

It is possible to have a widely and well distributed species considered to be rare. Loggerhead Shrike in Ontario was found in 145 squares, which is a reasonably large number, but the number of individuals in each square was low. It is possible to have a locally distributed species considered to be common. This can be the case where there are large numbers of individuals in the locations where the species occurs. Some colonial waterbirds could be examples of this phenomenon. The determination of rarity is therefore best done by the combination of data on distribution and on abundance.

Atlas data also can be used at local scales, such as for pert a of a province or counties. This can be quite important for the understanding of local populations of breeding birds. It is often found that a species which is common across the entire province is locally rare and therefore deserving of special management in a specific area. If the atlas data are properly computer stored the selection of a variety of scales should be possible (Eagles, 1987).

The Ontario breeding bird atlas data are being used to assist with the assessment of statue under the Ontario Endangered Species Act. As atlases elsewhere in the country come into form, the national status of breeding birds can be much more clearly defined than it is now.

Environmental Impact Assessment

In both the U.S. and Canada there are extensive provisions requiring for the proponents of development to undertake a study that outlines the environmental impact of the proposal. Atlas data can be used in two ways in EIA.

In the early stages of a proposal the EIA specialist needs to know the general environmental features of the area of study. Atlas data can provide an excellent first cut of information. Usually the atlas data are at too coarse a scale to provide specific information on the site in question, but they can still provide knowledge of the local species pool. It is very useful to know if specific important species have been recorded in the local area. The design of the field methodology can then be adapted with the information on the local area in mind. The EIA specialist must then undertake detailed field work in the specific area. These data are then compiled and summarized.

One of the important aspects of EIA is the assignment of importance to an environmental feature that is found on a site. After the field work is complete the EIA specialist can ask for the comparison of the data from the specific site to the general area. For example, it is possible to ask of the atlas data base: In how many squares was species X found in Halton County? or In how many squares was species X found in the 50 squares surrounding the development? Dance and Fraser (1987) provide a detailed discussion of the use of atlas data in EIA.

Assessment of Landscape Change

Landscapes change over time and wildlife populations are excellent indicators of such changes. Eagles (1984) provides a nice example of the impact of large-scale agricultural change on the humble bumble bee of Great Britain. The British Bee Atlas map for Bombus humilis shows that the species has been extirpated from central England in recent decades. This is due to the removal of hedges and forests for the intensification of agricultural land use. The increased use of herbicides also probably played a role.

In the next few years, we should see increasingly sophisticated analyses of the interrelationships between landscapes and wildlife populations. It is now possible to use satellite images of land, databases of soils, land use, forest potential, watersheds, and other phenomena to explore the reasons for the distributions of wildlife.

Basic Biology

The information found in atlas databases provide an unprecedented opportunity to study various aspects of basic biology, most specifically in the areas of au/ecological, gynecological and biogeographical studies.

One of the most interested applications deals with the analysis of species complexes. How often do certain species occur together? Are there breeding bird communities that replicate over broad geographical areas? How similar are the communities between area A and area B? How often does a particular bird species occur in association with a certain mammal species?

Calabuig (1981) has experimented with developing indices of similarity between squares in an attitudinal and latitudinal sense in central Spain. Kwak and Reyrink (undated) used a computer program, TWINSPAN, to divide the breeding bird populations of the Netherlands into 18 different districts. The computer compared the atlas data among different squares and grouped those with similar populations. Taylor and Smith (1987) present a computer analysis of the bird communities in Ontario, using the TWINSPAN program as well. They show that clearly defined breeding bird communities do occur in Ontario and the distributions of these communities do not necessarily follow the biogeographical province boundaries that have been defined on botanical grounds.

Characteristics of Volunteers

Almost all atlas projects are based on the work of volunteer field workers. Hidden in the database are valuable clues on the behavioral characteristics of the volunteers. What was the average number of hours of participation by a volunteer? How were those hours distributed? Where did the volunteers participate? How far did the average person travel from home? All of these questions are answerable by the average atlas database.

Beyond the basic questions of coverage and participation lie questions of motivation. Why do atlasers volunteer? What do they get out of it? What did they not do to make time for atlasing? What rewards were they seeking? What rewards did they get? Why did some drop out with low levels of activity? All of these questions can only be answered by a follow-up study. Such research would be quite valuable for a more complete understanding of the volunteer aspect of atlasing.

Conclusion

Atlas data can be used in many ways, beyond mapping geographical distributions. It is important to recognize that there are limits to the use of this information. The research question must come first, to be followed by the application of the appropriate methods designed to answer the question. In many of the questions discussed above, atlas data are but one way to approach the problem. There are others and they should be used when appropriate.

It is important for the designers of atlas computer systems to be aware that there are a wide variety of research questions that can be tackled by the data. If this fact is recognized early, then the computer system can be designed with this in mind. It is possible to shut out many applications with a narrowly defined computer database.

It is to be hoped that in the next few years we will see the continuing publication of research results from novel approaches to the study of atlas data.

Acknowledgment

Thanks to Dave Balser who read an earlier version of this document.

Literature Cited

Arnold, H.R. 1978. Provisional Atlas of the Mammals of the British Isles. Inst. Terr. Ecol., Abbots Ripton, Huntingdon.

Cadman, M.D., P.F.J. Eagles, and F.M. Helleiner. 1987. Atlas of the Breeding Birds of Ontario. Univ. Waterloo Press, Waterloo.

Calabuig, E.L. 1981. Analisis Y Valoracion Del Metodo Del Itinerario con Estaciones de Escucha, Aplicado a la Elaboracion de un Atlas Ornitologico Regional. Pp 35-56 in Censos de Aves en el Mediterraneo (F.J. Purroy, Ed.), Dept. Zoologia, Univ. Leon, Spain.

Dance, K.W. and D.M. Fraser. 1987. Uses of Breeding Bird Atlas Data for Environmental Planning. Pp 569-471 in Atlas of the Breeding Birds of Ontario (M.D. Cadman, P.F.J. Eagles, and F.M. Helleiner, Eds.). Univ. Waterloo Press, Waterloo.

Dunn, E.H. 1987. Using Atlas Data to Monitor Changes in House Finch Distribution. Pp 574-575 in Atlas of the Breeding Birds of Ontario (M.D. Cadman, P.F.J. Eagles, and F.M. Helleiner, Eds.) Univ. Waterloo Press, Waterloo.

Eagles, P.F.J. 1984. The Planning and Management of Environmentally Sensitive Areas. Longman, London.

Eagles, P.F.J. 1987. The Role of Atlas Data in Determining the Relative Size of Ontario Breeding Bird Populations. Pp 566-568 in Atlas of the Breeding Birds of Ontario (M.D. Cadman, P.F.J. Eagles, F.M. Helleiner, Eds.). Univ. Waterloo Press, Waterloo.

Godfrey, W.E. 1986. The Birds of Canada. Natl. Mus. Can., Ottawa.

Kwak, R.G.M. and L.A.F. Reyrink. Undated. National Breeding Bird Districts and Their Relation to Landscape Features. Unpub. Manuscript.

Lumsden, H.G. and R.B.H. Smith. 1987. Crossbills, Cone Crops and Irruptions. Pp 572-573 in Atlas of the Breeding Birds of Ontario (M.D. Cadman, P.F.J. Eagles, F.M. Helleiner, Eds). Univ. Waterloo Press, Waterloo.

Taylor, P.D. and S.M. Smith. 1987. Multi-species Clusters of Birds in Southern Ontario. (M.D. Cadman, P.F.J. Eagles, F.M. Helleiner, Eds.) Univ. Waterloo Press, Waterloo.