Journal of the Lepidopterists' Society
33(4), 1979, 216–231

HOW TO MAKE REGIONAL LISTS OF BUTTERFLIES: SOME THOUGHTS[1]

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ABSTRACT. Procedures are described for making two types of regional lists of butterflies: the state or provincial list, and the "local study" (an intensive, long-term investigation of a small area). The need for such lists, problems in making them, and some of the expectable results, are examined. A logarithmic scale for describing population sizes is given, as is a procedure for estimating total number of species in a local area.

STATE AND PROVINCIAL LISTS

State or provincial lists are important sources of regional information about a variety of aspects of butterflies, the particular aspects being up to the writer. At the least such lists should include distribution records, and they may also provide data on number and timing of broods, habitat choice, rarity, phenotypic and geographic variation, and so on.

As I pointed out many years ago (Clench, 1949), these lists are invaluable to taxonomists, zoogeographers, ecologists, and to researchers concerned with many other types of problems as well. They are also useful to both resident and visiting collectors, showing when and where to look for particular species. An often little-appreciated value of such lists is in their "negative information" content: an omission can inform the collector of needed data—a still unknown foodplant, an unguessed fall brood, as well as the more striking unrecorded species—and thereby encourage him to publish any such newly acquired information.

Methods

It is useful, in gathering and storing data, to keep two loose-leaf notebooks: a species book and a county book.

The species book is the main list and comprises a separate sheet for each species, more eventually if needed. On each species sheet enter the full data for all records of that species that you acquire. Enter the records as received, in no particular order. I always put the

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[1] At the Lepidopterists' Society meeting in Louisville in 1978 I gave a paper on this subject, and several of those attending suggested that the information be made more permanently available. I here comply with that suggestion, amplifying and extending the original paper in a few places.

This paper considers two kinds of regional lists: state lists or their equivalent; and what I call "local studies"—long-term investigations of small areas. Each requires a different approach, and each will be treated separately.

[2] Editor's note: This paper is published posthumously following Mr. Clench's sudden and untimely death in April 1979. A future issue of the *Journal* will be published as a memorial to commemorate his many contributions to the study of Lepidoptera, and to the Lepidopterists' Society.

county name to the left in a column of its own, with the remaining data in full to the right. The county column thus may be scanned rapidly for particular records. Data entered on this sheet should comprise full locality data (including, when appropriate, elevation and mountain range), date, source, as well as any other information associated with the record. Do not omit the source. One of Murphy's Laws is that the record whose source you neglected to note will later become critical.

It is also helpful to add a distribution map for each species. Such a map, even if you only tick off the counties recorded (instead of spotting all records exactly), will give you a good general picture of the range of the species in your state, and the areas from which more information is needed.

The county book contains a sheet for each county, parish, or equivalent subdivision. Simply enter the names of all species recorded from that county (referring to the species book for the full data). An easy way to simplify the procedure is to type up a one page list of all species known or strongly suspected to occur *in the whole state.* With elite type, single spaced, and using three columns, you can get 150 species or more on one side of an 8½ × 11″ sheet. Add a blank line at top right. Reproduce this sheet—by quantity-photocopying or mimeograph—to the number of counties in your state (get some additional copies: they are always useful). For each county, take one of these sheets and write the county name on the blank line. Then simply check off the species you have recorded from that county. On the reverse you can note sources of particular importance for that county: published accounts, resident collectors, etc.

In the far west, where counties are particularly large, it may be advisable to subdivide them into more useful smaller units for data recording, in whatever arbitrary way is most appropriate to your needs, and most easily and accurately described to others. The subdivision preferably should be by linear, objective boundaries, such as a river. Be careful using highways, however: they can be rerouted or renumbered and cause confusion in later years.

Recording your data in these two books allows you to keep records with a minimum of time, and a maximum of utility. You have instant access to what you know about either a particular species, or a particular area.

Sources of Preliminary Data

Earlier lists of one kind or another are already published for many states or provinces, or for parts of them. Such lists have often appeared in obscure journals of limited distribution, and learning about them

can be a problem. An outstandingly useful source is Field, dos Passos, and Masters, 1974. This bibliography, as its authors note, is not necessarily complete, so you should do some extra searching. In addition to earlier regional lists, monographs of various genera and other taxa often contain many locality records.

Collections. (a) Large museums have at least some material from almost every state and province. (b) Small museums, state colleges and universities, state museums, nature centers, etc., often have local and/or student collections. These may prove to be a gold mine of early or otherwise unusual records, but watch for poor data. (c) Private collections and collectors are probably your richest source of information outside your own efforts. The local collector has often been active for many years and may have exceptionally complete data on the species in his area: identities, broods, timing, larval foodplants, and so on, information of the utmost value and not duplicated elsewhere. I have found such collectors to be extremely helpful and invariably more than willing to share their hard-won knowledge.

Problems. (a) Misidentifications. With experience you soon learn which are the problem children: among them *Erynnis, Hesperia,* and other hesperiids; *Euphydryas, Speyeria,* some lycaenids, *Calephelis.* You may want to borrow specimens to confirm an identification, or send your own to a specialist. In any event, do not hesitate to query or even omit a dubious record, or you can assign it to the "hypothetical list" (see below). "*Thorybes* sp." is much preferable to "*Thorybes bathyllus*" which is actually *Thorybes pylades.* The famous early Cuban naturalist, Felipe Poey, has a wise saying: *Más vale ignorancia que error* (Ignorance is worth more than error).

(b) Stick to what you know. Do not assume any species—even *Pieris rapae*—to be anywhere. Even common species may have gaps in their ranges, and this would be important and interesting information. If you find what seems to be a gap in the range of a species that "shouldn't" have such a gap, go check it out. It may be real.

Procedure in Fieldwork

Ideally your fieldwork should be conducted in two concurrent phases: (1) an intensive, prolonged study of a small, easily accessible area (see under "local studies" below); and (2) field trips to farther places within your state or province.

The principal goal of the latter is to add as many distributional data as possible, expressed (or summarized) in terms of county records. Your aim is to acquire as much information as you can in the time at your disposal. Initial efforts should be directed at simply adding as many county records as possible. Pick the season when the most

species are flying (often June and July, but not always or everywhere), and visit as many counties as time and funds permit. A fairly respectable list of species and county records eventually will be amassed, and your attention may then gradually shift to intensified efforts at more specific goals: a county still poorly represented; a species that ought to be present but of which you have few records or none. The search for such a species is more efficient if you first familiarize yourself with available information about its habits, larval food, flight periods, and so on. Remember, some species fly only in particular seasons, especially the spring, so seasonal collecting should be added to your field exploration program.

Although you can think of the task as one of accumulating county records, always remember that that is not the *real* goal but merely a simplified accounting procedure, useful for record-keeping and statistical treatment. With that in mind, it may help to discuss some possible patterns you may observe.

Every county has some upper limit to the number of species in it. In a reasonably diversified state some counties will have relatively many species, others fewer. If the counties are more or less uniform in size and range of habitats, then the number of species in them should be distributed in a Gaussian or normal curve, as in Fig. 1B.

Before you have begun to accumulate records, all counties in the state have precisely zero species known from them: they would all be ranged in a single bar at the extreme left of such a curve. As you acquire records the counties begin to move up the graph to the right. A single visit to a hitherto uncollected county may result in a dozen or so species records, shifting that county up one class interval to the right. With more visits the number will gradually increase. In Pennsylvania, a state I know well, a reasonably well-worked county—several visits in different seasons—will have records of some 20–60 species. To increase the number beyond that point takes far more effort, generally possible only by residence or intensive local collecting.

After some years of work, both on your part and on the part of earlier workers as well as collaborators in various parts of the state, the distribution of counties according to number of species will look something like Fig. 1A, which shows the current state of knowledge of Pennsylvania butterflies. Note that the curve at this time is essentially three-humped: (a) a group of 25 counties (37% of the 67 counties in the state) with fewer than 20 records each, representing those either collected in briefly or not at all; (b) a group of 28 counties (42%) with between 20 and 60 records each, representing those visited a number of times and in different seasons; and (c) a group of 12 counties (18%)

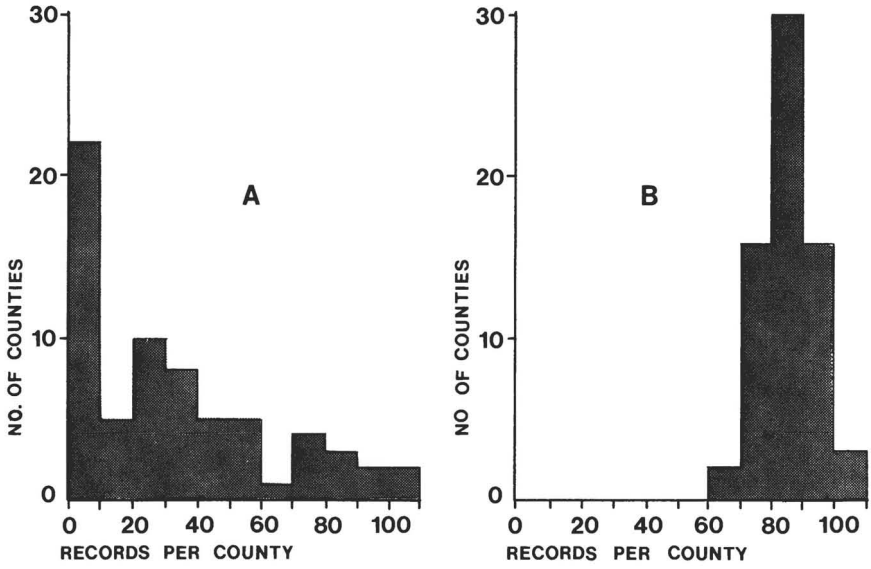

FIG. 1. **A.** Present state of knowledge of Pennsylvania butterflies. Note the three humps in the curve: a group of counties with fewer than 20 records each; a group with between 20 and 60 records each; and a group with 60 or more records each. **B.** If all Pennsylvania counties were completely known, the curve would probably look essentially like this.

with 60 or more recorded species each. These last are counties with a long history of collecting (Allegheny and Philadelphia counties); or with collectors long resident (Lancaster Co. [George Ehle], or Tioga Co. [George Patterson]); or in which especially intensive, long-term collecting has been done (Westmoreland Co., where Carnegie Museum has a field research station). The distribution of collecting intensity in Pennsylvania as measured by the number of species known from each county, is shown in Fig. 2.

If the curve in Fig. 1B is summed (midpoint of each class interval times number of counties in the class interval, and these totalled), we have a theoretical maximum possible number of county records for Pennsylvania of about 5,715. The total number now actually known is 2,215, or 39% of those possible. Although this seems like a small number, it is the result of many thousands of hours spent in the field by collectors over more than a century. It shows dramatically how difficult it is to get truly thorough knowledge about even one state. I should add, however, that because several areas have been intensively studied, about 145 species are now known from Pennsylvania,

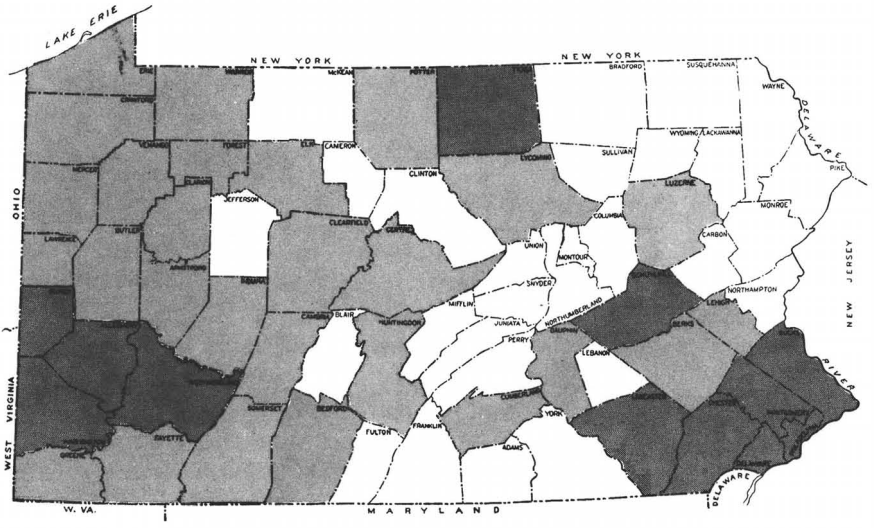

FIG. 2. Distribution of collecting intensity by counties in Pennsylvania. Counties with no shading have 20 or fewer records each; those with light shading have between 20–60 records each; and those with dark shading 60 records or more each.

and this total is not likely to be much increased in the future: perhaps by no more than about 10.

Special Matters

Wherever you may be, you can help other lepidopterists. Perhaps a taxonomist revising a group needs material or information from your state; or a geneticist may want to find a colony of a particular species in your area, or someone working on Monarch migration might need local dates of immigration or emigration. For all such people the special knowledge you have acquired could be of great value. And do not forget reciprocity: his (or her) special knowledge may be of particular value to you someday as well.

Be aware of research that already has been done and that is relevant to your area, and make an effort to extend the results. One frequent problem is the nature of the boundary between two wide-ranging subspecies. If that boundary passes through your state, and the material you have acquired is adequate, you are uniquely situated to add precision to what is known.

You may discover new problems. No general rule applies here. Keep an inquiring mind, and be alert for things that "don't fit." Perhaps you know of a local population with a different flight period than

the species has elsewhere, or with a higher-than-usual frequency of some dimorphic form. Or you might have noticed a persistent and anomalous absence of some species from areas where it should be found. A new species turning up in your area might represent a range expansion, something we know little about.

The Goal

The objective in preparing a state list is the accurate record of conditions in a particular place—your state—at a particular time or times, and in as much detail as you are capable of.

Accuracy is vital. Rumored occurrences and sight records are admissible *only* if they are clearly so reported. Misidentifications, ideally, should never occur. Some few are bound to, but make every effort to eliminate them completely: submit doubtful specimens to a specialist; record any uncertain identifications as such. Be meticulous with specimen data, and ultracareful in recording the information.

Data on brood numbers and timing, on larval foodplants, and other attributes, should be clearly identified as to geographic source. If you have no local data it is proper and even wise to copy from the literature (because it will provide clues for future users of your list), but you should clearly indicate that the information was not locally obtained.

Be aware of old records not recently duplicated; of species common now but not mentioned by "the old boys." Such things may seem unimportant but could fit in with data from other areas to demonstrate a pattern. A recent instance of this began with the account of *Nathalis iole* by Kimball (1965). He remarked on the absence of early records from the state and concluded that it might have established itself in Florida relatively recently. I became interested, checked two large museum collections and other early literature and concluded that *iole* indeed previously was absent from Florida, that it reached the state in 1913 or shortly before, and spread north from its probable original landfall in the Keys (Clench, 1976).

Miscellaneous

A state list may invite a zoogeographic or ecological analysis, or other derivative study. If your interests lie in these directions, so much the better: a list can only be improved by such work. But these "extras" are not *necessary*. What *is* necessary is a careful, accurate compilation of reliable information. If you provide this, then your list will be a valued and respected contribution to our science, useful and used for a long time to come.

The *"hypothetical list."* Ornithologists are familiar with this term; lepidopterists are not. In your published list itself, include only species with established reliable records. Save the rest for the "hypothetical list" at the end. It is the perfect place for the doubtful species, the "possibles," those previously reported in error. Anything dubious can go in. This device allows you to avoid the difficult decision of what to include in, and what to exclude from, the main list. Amplify and discuss the entries as you will. The "hypothetical list" is a wonderful place for the reader to browse when your paper is eventually published.

The work of assembling a state list is never done. Information always remains to be learned, and always will. The trick is knowing when you have reached the point when you can properly say, "This is now worth publishing." Eventually the time comes when you have a reasonable picture of the butterflies of your state, embodying a satisfying quantity of new data. If at this point the influx of new information slows, then the time clearly has come to put it all together and get it into print.

As the foregoing should have intimated, preparing a state list is not a simple task. It requires experience, knowledge, and judgement, as well as diligence. It is not really a job for a beginner. If you are a beginner, however, and you really want to undertake such a task, then you should seek as much advice and help as you can from those with more experience. If you do that, then there is no reason not to produce an excellent and valuable piece of work.

LOCAL STUDIES

A *local study,* as I use the term here, is an intensive, long-term investigation of a small area: perhaps one or two thousand acres, about as much as can be covered reasonably well on foot in a single day.

Studies of this kind have been undertaken so seldom that wherever you choose to do so you will be rewarded with significant data, well worth publishing. Because it requires no extensive collections and no large reference library this kind of study is particularly suited to the serious lepidopterist in a rural area. Bear in mind that much of the information you acquire, even though it seems of little interest in itself, will gain greatly in value when added to similar information from elsewhere. Among the most important eventual results of such work will be establishing geographic patterns of variation in brood numbers and timing, larval foodplant choice, abundance levels, and other things about which we are still totally, or almost totally, ignorant.

Define or enunciate what you want to do at the outset, and give it careful thought. One important aspect of a local study is time variation, for which you need data extending over as long a time as possible. The earlier you start keeping records, the longer your time-span of useful information.

Do not make your goals too many or too complicated or you will defeat your own purposes. Know about how much time you will have for the work and plan accordingly. After your first month or two, review your program and your goals. Perhaps you have bitten off more than you can chew; or perhaps you could easily do more than you first thought.

The place: what to look for. Frequent visits are important. The nearer your chosen spot is to your home, the more often you can visit it.

The study area you choose should be reasonably representative of your region; with enough habitat diversity this should be so. In a pinch, however, almost any area will do: even a vacant lot in town, if you cannot get to anything better. Nevertheless, in a day's survey you can record useful data on a large number of species, so (within reason) the more diverse the area the better.

Your study area should have—and have had—no pesticide spraying. It should be free from any abrupt, major change in land use: you do not want the place bulldozed for a shopping center a year after you begin! And it should be as free of people as possible. When you are hard at work in your area you need to concentrate, to be free to follow this or that butterfly, to observe what it does. People, even the best intentioned, interfere with this work.

If you are lucky, a weather station (government or private) may be located in or near your study area, and you can arrange for copies of the data. Failing this, then look for a weather station as near as possible, and in as similar a habitat as possible, and record what you can in your own area on your own visits. This is not as satisfactory, but some idea of the regional climate is necessary.

State or local parks, perhaps even a national park, if they fit other requirements of your study, may include suitable sites. If permits are required, you must get them. In any event you should get permission. The personnel of the park may even be able to help you locate the best place for your study, if you explain your needs and aims.

Universities and other institutions often have their own study areas, designed for investigations of just this kind. If so, they are ideal: they are stable in land use, free of insecticides, often have climatic records, and frequently have background data on vegetation, land use history, maps of habitat types, and so on. They may also have a policy of

limiting the area to their own personnel. Sometimes, however, they are only too happy to let you use the area, if you ask first, explain your aims, and don't mistreat the area.

Private lands often have ideal places for such a project. Again, ask the owner and get his permission first. In recent years the land owner has gotten much more hard-nosed about strangers on his land. He or his neighbors may have been victimized by careless or malicious campers, wanton vandals, drunken or stupid hunters, and who knows what else: his attitudes can hardly be faulted. In most cases, however, if you can satisfy him that you are serious, and that you will not trample his crops or leave trash behind you, he will willingly let you use his property.

In using any land ordinary courtesy is necessary. Do not litter; do not walk on crop plants; do not leave gates open if they were closed, and vice versa, follow paths as much as possible. If the area is already in use by other researchers, familiarize yourself with what they are doing and be careful not to interfere with their projects. Respect fully any ground rules that may be in force. Regardless of who owns the land, it is good public relations to keep them informed, if only in a general way, of your progress. If you find a rarity, or make an important or unusual discovery, tell them. Land owners or managers like to hear that their place is "special." And when you publish, acknowledge them by name, and give them a reprint of your paper.

Methods

I assume that you have chosen an area, and that you will be making periodic visits, perhaps once a week or so. As in state lists, I keep two books of records:

(1) Log book. This need not be loose-leaf, as it is strictly chronological: on each visit enter date, time you begin fieldwork, and time you finish. Record weather data (temperature, cloud cover, wind; and any important changes during your visit). List the species you take or observe in the area, where you see them, how common they are, their condition: these three matters are discussed more fully below. Record any special observations, such as territorial behavior (time of day, territorial activity, size of territories, and so on), predator attacks (details), mating or courtship behavior (nature of activity, time, sex of the flying partner in copulating pairs, and so on), unusual numbers, oviposition records, flowers serving as adult food, etc.

(2) Species book. This should be loose-leaf, to allow additions. A separate sheet (or more) for each species, entering dates, particular places, and other information from your log. It will be repetitive, certainly, but this accumulation of data is the core of your whole project.

You will need to accumulate a voucher collection, either keeping it yourself, or giving it to some inititution. It should comprise reasonable series of each species, and of each brood, and of any problem groups or unusual specimen for which documentation or later study may be necessary. After this, collect as little as possible: the job is primarily one of observation and recording. With a little familiarity, most species can be identified without capture. Certain groups, such as *Polygonia, Erynnis,* or some of the smaller hesperiids, may need to be captured for reliable identification. Many can then be released, but some must be kept for more careful identification later. Be alert for the rare species that in the field looks much like some common species.

The following procedures can improve the accuracy and detail of your observations, and hence their later utility. Your study area can be divided into a number of "microlocalities." It is important to be able to specify these, in order to localize observations on habitat choice, colony locations, and so on. Two basic methods are used:

(1) A grid system, in which the whole area is marked off by a rectangular grid. In one type of grid the squares are identified, "B-6," for example, referring to the square in row B, column 6. In the other type of grid the lines are identified, so that a square may be specified by the intersection of some standard corner, or a point identified by a fractional designation such as "5.6 E, 6.1 N," meaning 0.6 unit east of line 5 and 0.1 unit north of line 6. A grid system can be particularly precise, but it requires more than just drawing the lines on a map: you must have some means of identifying them on the ground, too, or they are of little use. Survey markers along trails or at grid line intersections is one method. Generally, if the area you use does not already have a grid system, it is too involved and expensive to set one up.

(2) Place names. Sometimes an area under study will have them, or some of them already. If so, use them. If they do not exist, then you will need to make them up. Do so with thought. It is tempting to use such terms as "Idalia Meadow" or "Hypaurotis Scrub," but such names may sometimes cause confusion in your notes. The same may be true of botanical adjectives. Other kinds of names can be more practical, sometimes even silly ones. One of our places at Powdermill is called "Elephant Walk." I'm not sure why, but it is certainly easy to remember. "*Typha-Acoris* Marsh" is there, too, and poses no problem, for that combination of plants occurs at Powdermill in only one place. However you do it, keep a record on a map of the locations, and document them with photographs.

Recording the condition of the specimens you see is extremely use-

ful, particularly when visits to the area are at weekly or greater intervals, because they give a valuable clue to how long the species has been flying. I use a series of five lower case letters: *a*, perfect and unblemished; *b*, showing slight wear; *c*, definitely worn; *d*, extremely worn; and *e*, a complete rag, the wings so rubbed that identification may be difficult. The important thing in this scale is wing wear, and it increases with age, so record tears in the wings separately. A tear (or bird or lizard bite) can happen in a fresh specimen and means little in this connection. Remember, you are using the scale to estimate the relative age of the individual since eclosion, *not* to describe an exchange item! When you see a number of individuals of a species on a particular day your notes might read, "all *a*" (suggesting quite recent emergence), or "*b–d*, most *c*" (suggesting about the midpoint of the flight period or a little later), or "most *d*, one *a*" (suggesting a second flight beginning as an earlier flight is ending), and so on.

Words like "common" or "scarce" convey a poor idea of numbers; mark-recapture techniques can give accurate population figures, but the procedure is far too time-consuming for routine use. Some years ago I devised a compromise system, more accurate and objective than words, less tedious than population estimation; it is easily used, as subsequent experience with it has shown. This abundance measure is a logarithmic scale much like that of stellar magnitudes used in astronomy, after which it was patterned. The scale records numbers seen per hour, or the equivalent, as follows:

Scale	Numbers
0	125–625 individuals seen per hour
1	25–125 " " " "
2	5– 25 " " " "
3	1– 5 " " " "
4	0.2– 1 per hour, or 1 seen per 1–5 hours
5	1 per 5–25 hours
6	1 per 25–125 hours
7	1 per 125–625 hours
8	1 per 625–3,125 hours

The scale can be extended in either direction if needed (it rarely will be): −1 would be the next commoner scale unit, and so on. Each abundance unit represents ⅕ the abundance of the preceding unit, and a difference of one unit is about the minimum that can be accurately perceived in routine observation.

In recording abundance take due note of highly localized species (count only time spent in suitable habitats) and of flight periods (count only time spent in appropriate months).

If you know your average rate of movement through an area, and the average width of your "sweep"—the distance you can effectively survey on either side of your path (which will vary with the terrain as well as your vision and knowledge of local butterflies)—then the measure can be converted into a rough density measure of so many per acre, or hectare, or whatever.

When only a single specimen is seen, its abundance should be entered as "4 or rarer," "5 or rarer," etc., because catching one individual cannot establish a time span.

The measure is crude, but about as accurate as possible in the circumstances. Remember, too, that any measure based on visual sighting will generally underestimate true numbers.

Persistence pays. The whole idea is to continue observations for a long time—several to many years—in all seasons. The following kinds of data should be expected and sought:

Species list. The list will never be complete—something often not realized—but with enough time you can approach completeness about as closely as you wish. If you record the total accumulated number of species you have found (S), and the total accumulated time (in hours) you have spent observing (N), then the following relation (Clench, 1968) will describe your results quite closely:

$$S = Se \frac{N}{K + N}.$$

Se is the theoretical total number of species in your area, and K is an adjustable constant, related to "collectability."

Powdermill Nature Reserve (of Carnegie Museum of Natural History) is an area of about 2,000 acres, located 9 miles south of Ligonier, Westmoreland Co., Pennsylvania. Since its establishment in 1956 I have worked on its butterflies as time allowed (little in recent years, but intensively in the 1960's). A total of 820 hours has been logged, and 73 species recorded in that time: $K = 59$, and $Se = 78$ species. In short, we have found about 94% of the species expected there, with only 5 left to go (see Fig. 3).

Calculating the "best fit" values of Se and K is difficult and complicated, too much so for inclusion here. You can approximate them fairly simply, however: draw a smooth, eye-fitted curve through your graphed data points; pick two well spaced positions on this curve (or

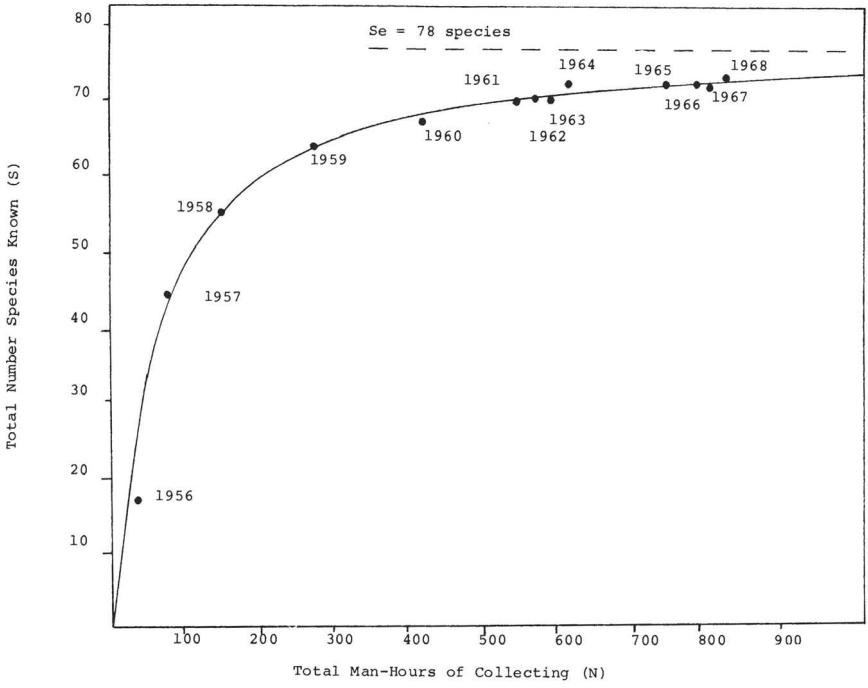

FIG. 3. Collection curve of butterflies for Powdermill Nature Reserve (Westmoreland Co., Pennsylvania). Spots represent cumulative man-hours of collecting (N) and species recorded (S) at the close of each indicated year. The curve follows the formula:

$$S = 78\left(\frac{N}{59 + N}\right)$$

two well spaced data points which touch it), substitute their S and N values in the formula, and solve the two simultaneous equations for Se and K. If your eye-fitted curve was well drawn, the results should be fairly accurate.

A word of caution: the formula has ramifications and complications that I have not mentioned and it should be used judiciously. By way of example, Se actually represents the size of the "universe" being sampled, and this may vary: a one-day universe is smaller than a one-year universe, and that in turn is smaller than a two- or a ten-year universe. A spring universe may be smaller than a midsummer universe and so on.

How many flight periods are there, and when? In any species the timing, if not the number, of the flights varies from year to year, pre-

sumably because of variation in weather conditions. It takes several years of observation to establish reliable average times.

One of the reasons for a diversity of flight periods among the species of a community is to minimize competition for adult food—normally flower nectar—and a thoughtful examination of your data in this light could produce interesting results.

Population levels. Each species has an average level of abundance: some are rare, others commoner, and some are abundant. In any given area the frequency distribution of species according to abundance is close to log-normal, that is, the frequency distribution approximates a normal curve when abundance is plotted on a logarithmic scale. Since the abundance scale ("0–8") described above is logarithmic, a frequency distribution of the species based on their average abundance according to that scale should approximate a normal curve. The curve is truncated at the rare end, but the degree of truncation diminishes with prolonged study. Most species vary considerably in their numbers from year to year, and again it takes a number of years of observation to establish reliable average values. Some species may have different abundance levels in different broods, and this variation, too, should be looked for.

Cycles of commonness and rarity are often present, but beware of generalizing too much from them. Many cycles are transient, or not truly cycles (having varying periods).

True regular cycles are uncommon. Eventually you should find in some species a "boom and bust" phenomenon. This is a season (or flight) of exceptionally high numbers, followed by a crash, during which you will see only a few individuals, or even none at all. A return to normal numbers soon follows. At Powdermill I have seen this in a few species (*Euphydryas phaeton, Polygonia comma, Epargyreus clarus, Hesperia leonardus*) over about 16 years of observation. In each of these only one eruption was seen, ordinarily about 2 abundance units above normal, followed by a crash of similar magnitude, with a return to normal numbers the year after.

Habitat choices. With appropriate observation and recording, the principal habitat and subordinate habitats of most of the species should be learned in comparatively few years. Watch for species that regularly occupy two or more different habitats, especially (a) for feeding, and (b) for courtship, reproduction, larval growth, and inactive ("sleeping") adult occupancy.

Territorialism. Many butterfly species are territorial. The subject has scarcely been touched, and much remains to be learned. Persistent observation should reveal territorial individuals if you are alert to what the butterflies are doing. Absence of territorialism in a species

is harder to document, for individuals of territorial species are non-territorial part of the time. Some species occupy territories only at certain times of the day (such as *Vanessa atalanta,* in late afternoon). In most territorial species males occupy the territories, and females wander in search of them.

Life history data such as larval foodplants and adult food sources should be noted. If you rear the early stages you can learn much more.

Long observation of an area will often show some transient species that move into an area, live for one or a few seasons, and then die out. At Powdermill, *Nastra lherminieri* arrived, lasted for several years, then disappeared, and has not been seen since. Both *Euptoieta claudia* and *Hylephila phyleus* established colonies that died out after a single brood.

The Monarch, *Danaus plexippus,* is a special transient since it regularly moves into an area in the spring, raises a local brood or two, then emigrates in the fall. The fall southward migration is conspicuous and often spectacular. It is important to keep records of its size, direction, and dates of start and finish. Just as important, however, is the time of Monarch arrival in the spring, a far less documented event because it is so inconspicuous. One can only note the date of first spring sighting.

Inevitably, long-term observation will produce genuine resident rarities, such as the celebrated *Erora laeta,* or strays from outside the area—single individuals of non-resident species.

When you have studied an area intensively for several or many years you are apt to find significant, non-random changes. They may be changes in the trend levels of certain populations, but they could be other things as well. As succession alters a meadow, grassland species may change from common to rare, or perhaps even disappear; a species not seen before may move in and establish itself, perhaps only temporarily, perhaps permanently.

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