Study Design, Data Management, Analysis, and Presentation

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INTRODUCTION

Below, I cover a variety of mandatory, often relatively mundane, and generally not particularly exciting tasks that are required to accomplish meaningful research on raptors. However, attention to research design, data management, implementation of reasonable analytical approaches, and the publication or presentation of research results probably represent the most fundamentally important aspects of the effort to advance science in any area of interest.

The stark dichotomy between the tasks of data collection related to raptors, which often involve working in remote wilderness conditions while engaging in activities characterized as extreme outdoor adventure (e.g., rappelling down cliffs, handling eagles), and sitting in an office managing data sets makes the latter seem banal at times. Our ultimate purpose in conducting research on raptors, however, is to enhance our understanding of these unique animals and their spectacular adaptations, and to ensure their conservation. To accomplish this we must perform the latter as well as the former. To do this effectively, and to allow researchers more time to participate in the more exciting aspects of raptor research, the tasks of data management and analysis and write-up should be executed with maximum efficiency.

Here, I provide guidance in this regard and suggest more in-depth treatments of various aspects of the broad areas of research design, data management, analysis, and presentation of results to aid raptor biologists wishing to increase their efficiency. The chapter is designed to be especially useful for individuals relatively new to ornithological or ecological research (e.g., graduate students), but also may represent a worthwhile read to more experienced researchers who want to evaluate continually and improve their research efficiencies. Specifically, this chapter represents a brief outline of "how to conduct raptor science."

Why Study Raptors?

The first recommendation that I will offer is that you should consider working with another model rather than a raptor! I say this because science is basically the pursuit of new knowledge, and raptors, by their very nature, are inherently difficult to study (i.e., to obtain knowledge about and from). Raptors can be hard to find, hard to observe, in part because they occur in extremely low densities overall (sometimes <1 pair/100 km^2), and in part because many are found in nearly inaccessible situations (e.g., on the tops of the tallest trees or on huge vertical cliffs). By committing to study raptors, one of the greatest challenges is obtaining a large enough sample size from which to say anything meaningful. For many basic questions related to biology or ecology, it would be more productive to study a small, abundant bird or mammal. And, one should at least consider this before investing further in studying raptors. By electing to spend time, or a lifetime, studying birds of prey, raptor researchers "choose" to become inherently challenged scientists.

On the other hand, I also would argue that raptors can and do often make ideal models to study a number of interesting biological and ecological questions. Their appearance, their action-filled and risky life of predation, and the many mysteries of their lives represent intrinsic values that give raptors appeal as research subjects. Moreover, birds of prey commonly are used as national and cultural symbols and mascots, and are of great interest to the public, especially related to bird watching and falconry. Many people simply want to know more about these "cool" birds and are willing to buy books and watch videos about raptors. This public demand for knowledge about raptors provides raptor researchers with a large audience. Certainly the fascination the public has for raptors has led to support for laws (e.g., the Bald and Golden Eagle Protection Act in the U.S.A.) to conserve them. These laws, in turn, require knowledge of raptors to guide the implementation of conservation and management programs.

I would further argue that raptors might provide one of the best models for studying certain questions in ecology. Jaksic (1985), for example, has made a strong case that assemblages of raptors may represent some of the best model systems available to study the influence of competition among species and several additional aspects of community ecology. The lack of predators of many raptors eliminates the potentially major confounding influence of predation when addressing community ecology questions. Also, the fact that many raptors rely on well-studied vertebrates for their food resources allows biologists to more thoroughly document and understand trophic relationships than may be accomplished on many small birds, mammals, and predatory insects that consume smaller insects that are difficult to identify; prey groups for which there is poor consensus on how to assess density effectively. Extensive work on small birds (e.g., Bibby et al. 2000) and mammals (Lancia et al. 2005) has resulted in the development of a variety of methods that may produce reliable estimates of population densities or abundance. As the availability of food resources is key to understanding the ecology of any organism (e.g., Lack 1968), raptors, potentially, may provide a more informative model animal than many alternative smaller organisms.

Another area in which raptors provide a useful research model is in the investigation of brood reduction and sibling interactions. Because raptors represent a group of birds in which nestlings are equipped with weapons (talons) that can kill nest mates, they have the capacity for intense intra-brood aggression that could lead to siblicide, and provide one of the few animal models that may be studied to understand such interactions (Mock and Parker 1997). Other topics in which raptors may provide one of the more effective research models, include predation ecology, migration strategies, reversed sexual size dimorphism in higher vertebrates, and the evolution of various forms of cooperative breeding, especially cooperative polyandry (Kimball et al. 2003). My point is that whereas raptors, in general, make a poor model to conduct research into basic biology, they also may provide one of the better research models to investigate some key and contemporary behavioral ecology questions of substantial interest to science. Moreover, sharing the top of the food chain with humans renders raptors invaluable for research on the biomagnification and impact of various pollutants in our environment (see Chapter 18).

THE TWO KEYS TO SUCCESS IN RAPTOR RESEARCH

If you do decide to conduct raptor research, you should do it in a way that maximizes your potential success. I submit that there are two primary and fundamental elements to successful research in raptor science, and that these elements also apply to success in any ecological study. These are (1) an innovative research idea, approach, or both and (2) sample size, sample size, sample size.

To advance the discipline, new and novel ideas are required to guide the collection of data and to move our paradigms (i.e., basic scientific theories and methods) and general knowledge of raptors forward. Science by its very nature and emphasis on replication forces us all to conduct mostly normal science (*sensu* Kuhn 1962). There always will be a need to replicate studies on firmly held paradigms or conduct an investigation on a local question that has been investigated thoroughly elsewhere. Some examples of normal science would include: (1) comparing the diets of two or more species of raptor co-existing in a specific area, (2) determining the "habitat requirements" of a species of conservation concern, and (3) examining most aspects of raptor productivity or nesting biology. In such cases, raptor scientists are using long-held paradigms and are filling in small gaps in our knowledge base. I maintain that conducting normal science is productive and necessary, and as such is a worthwhile endeavor for all raptor biologists. As raptors are generally poorly known in many parts of the world, much of our work requires careful description of their natural history, and this, clearly, is normal science. I would classify most undergraduate and Master's theses as normal science.

By successfully conducting normal science, a biologist does achieve some level of success. However, truly major advances in the discipline require novel ideas that challenge long-established paradigms and that stimulate cutting-edge and exciting investigations by the scientific community. This is revolutionary science (Kuhn 1962). To be most successful in science and to advance our disciplines most dramatically, we all should try to participate in revolutionary science as well as normal science. Recent examples of thinking "outside the box" that could be classified as revolutionary science include Brandes and Ombalski's (2004) use of laminar fluid-flow models to understand and predict migration pathways used by Golden Eagles (*Aquila chrysaetos*) and Ellis and Lish's (2006) ideas on specific adaptations of the patterns and pigment deposition in eagle rectrices. In my own thinking, I am beginning to question our heavy reliance on the importance of habitat features (which are usually taken to mean vegetation features) to the population viability of several raptors. An alternative paradigm may involve the fact that raptors are highly site-faithful and that their population viability and success may be more tied to gaining experience and improving hunting skills (see Dekker and Taylor 2005) on one given territory regardless of specific habitat features there, and that our long-held paradigm that habitat (i.e., vegetation, topography, etc.) is vitally important to conservation of raptors may not be true in all cases (also see Ahlering and Faaborg 2006). Another interesting idea that warrants investigation is the long-term influence of sibling interactions and competition in raptor nests—does the alpha chick enjoy the lifelong benefits of being a "winner?" Is the runt in each brood destined to be a "loser," evolutionarily and otherwise? Importantly, I would encourage all biologists alike to strive to conduct revolutionary science in raptors by testing long-held assumptions, challenging conventional wisdom, employing innovative tests of hypotheses, developing new paradigms, and thinking outside the box.

Scientific Method

Designing a well-reasoned study is vital to the effective completion of any fieldwork and subsequent data analysis. Although there are many ways of acquiring knowledge (Kerlinger 1973), the most commonly accepted approach in the ecological sciences is use of the hypothetico-deductive method. This approach was developed through the 1900s and was popularized through the works of Popper (1959, 1968) and others. In brief, the hypothetico-deductive approach involves identifying a research problem or question, developing alternative explanatory research hypotheses, deriving logical and testable predictions from the hypotheses, and then implementing the experimental test. Tests of hypotheses may be either observational or manipulative, although manipulative experiments generally are more powerful (see Diamond 1986). There are several excellent review papers (Romesburg 1981, James and McCulloch 1985, Eberhardt and Thomas 1991, Sinclair 1991, Ford 2000, Garton et al. 2005, and others) that describe the scientific method as it applies to raptor research and related disciplines, and I will not repeat that information here. I recommend that all raptor researchers read Romesburg (1981) and Garton et al. (2005) at a minimum. Raptor biologists have been slow to adopt the hypothetico-deductive method into the practice of raptor science (see Guthery et al. 2004); perhaps, in part, because there is still much basic natural history to describe in raptors worldwide. However, I advocate that the use of the hypothetico-deductive approach is long overdue in raptor biology, and that all raptor scientists should be conducting problem-based research by testing research hypotheses. Descriptive natural history data should and can be easily collected simultaneously by taking detailed observation notes while testing both basic and applied hypotheses related to raptor biology and conservation.

In implementing this scientific method, I find that there often is confusion, especially among students, between research hypotheses and statistical hypotheses (Guthery et al. 2001). Good explanations of differences between these terms are provided by James and McCulloch (1985) and Ratti and Garton (1996). Specifically, a research hypothesis is an explanatory answer or conceptual model that answers the research question. A statistical hypothesis is a derived testable prediction that guides the collection of specific data. For example, we may hypothesize that human disturbance is the cause of low reproductive success in a population of Ferruginous Hawks (*Buteo regalis*). A derived testable prediction that may be used to evaluate this hypothesis might be that experimentally applied pedestrian intrusions at a random sample of nests would result in significantly lower reproductive success (i.e., fledglings per nest) than at a comparable control sample of nests. The null statistical hypothesis in this case would be the expectation of no statistical difference in the mean number of fledglings produced between experimentally disturbed and control nests. In both their understanding and presentation of research results, biologists should clearly distinguish between research hypotheses and testable predictions or statistical hypotheses.

In designing studies, all raptor researchers need to be aware and careful of the potential of pseudoreplication and the inappropriate use of inferential statistics. (I recommend a thorough reading and understanding of Hurlbert 1984.) Pseudoreplication is the use of traditional null-hypothesis statistics to test for treatment effects from experiments in which either the treatments are not replicated (although samples are often replicated) or the replicates are not statistically independent. For example, a researcher may be interested in assessing the effects of petroleum exploration on nesting raptors by comparing the reproductive success in an area of development to that in a similar area where there is no development. Use of statistics to compare the reproductive success of large samples of nests in these two areas would be an obvious example of pseudoreplication. In this case, samples are replicated (i.e., nests), but the treatment is not (i.e., one area of development compared to one undisturbed reference area). The use of statistics may be appropriate to compare the impact of this development relative to the single reference area, but it would be inappropriate for the authors of this study to extrapolate their results to other areas of petroleum exploration.

I cannot overemphasize that a well-reasoned and carefully developed study design guides the collection and subsequent management of data. Specifically, the test predictions should clearly identify the key data that should be collected. Also, at this early stage of the research process, investigators should consider the appropriate statistical tests to be used. Are parametric or nonparametric methods more appropriate (see Potvin and Roff 1993, Smith 1995, Johnson 1995)? Often with a clean experimental design, researchers can develop an analysis of variance (ANOVA) model designating specific experimental effects and covariates (ANCOVA) that can be considered in the model before the research is implemented.

For example, below I present a potential ANOVA model associated with a proposed experimental design for a hypothetical study on the effects of pedestrian and ATV traffic on nesting Ferruginous Hawks. For this study, the dependent variable would be the distance from an experimental disturbance at which the hawk flees the nest. The potential effects terms and error term included would be as follows:

$$\mathrm{F} = \mu + \mathrm{A}i + \mathrm{B}j(i) + \mathrm{C}k(ij) + \mathrm{D}l(ijk) + \mathrm{E}(ijkl)m,$$

where F = flee distance from disturbance, A = disturbance type (i = pedestrian or ATV disturbance or no disturbance [control]), B = breeding stage (j = incubation or brood-rearing period), C = nest substrate type (k = cliff nest or tree nest), D = vegetation type (l = open-grassland or shrubland), E = error term, and m = replicates.

Also, at this stage investigators should consider the applicability of using information-theoretic methods in which a set of alternative models are evaluated based on Akaike Information Criteria (AIC; Anderson et al. 2000, Burnham and Anderson 2002). I recommend that in addition to peer evaluation during the research project development stage that a statistician be consulted before field data are collected.

The Magic Window

Once you have a good idea or have developed a new approach to test an old idea, then the other key ingredient for success in ecological or raptor research is to collect an adequate sample size of data. This is especially challenging with raptors because of their inherent attributes: they are wary of human observers, exist at low densities, are wide-ranging, and often occur in inaccessible locations. Moreover, with almost every raptor research project that I have been involved with there is a limited "magic window" during which data can be collected most effectively. That window may be limited to a few weeks during the breeding season or to just a few hours when conditions are right to capture the critical individual(s) for which data are needed. For example, for most temperate stick-nesting raptors there is a critical window for nest finding spanning the period when the hawks begin building their nests and when the trees leaf out. Depending on the species and circumstances, that window may be 3 weeks or less, after which it becomes very difficult to find occupied nests. Thus, the researcher's sample size depends on their effectiveness in that nest-finding window. I also have found, especially during migration, that there are often prime periods to capture and mark raptors. In other words, if the research depends on marked individuals, the researcher must identify those conditions and then take maximum advantage of capturing and marking birds during this window of opportunity. Thus, raptor researchers must be aware of their magic window of data collection and do all they can to take advantage of that period. This requires successful researchers to be extremely efficient and organized and to be willing to work those extra hours (e.g., when raptors are catchable) and those extra days and weekends (when your prime window of collection of key data [e.g., finding of nests] is relatively limited). To my knowledge, raptors never take a holiday, and data-collection opportunities are often lost if the raptor researcher takes a break during the magic window. Simply put, a strong work ethic is required by successful raptor biologists to take advantage of these fleeting periods of opportunity to augment sample sizes.

Finally, in my experience, most raptor science manuscripts are rejected from scientific journals because of "inadequate sample size." The only fix to this problem is to work hard and maximize the efficiency of the available resources during the magic window of data collection. Time devoted to the management of data and maximizing data collection efficiency also will aid researchers in taking the best advantage of the data collection window.

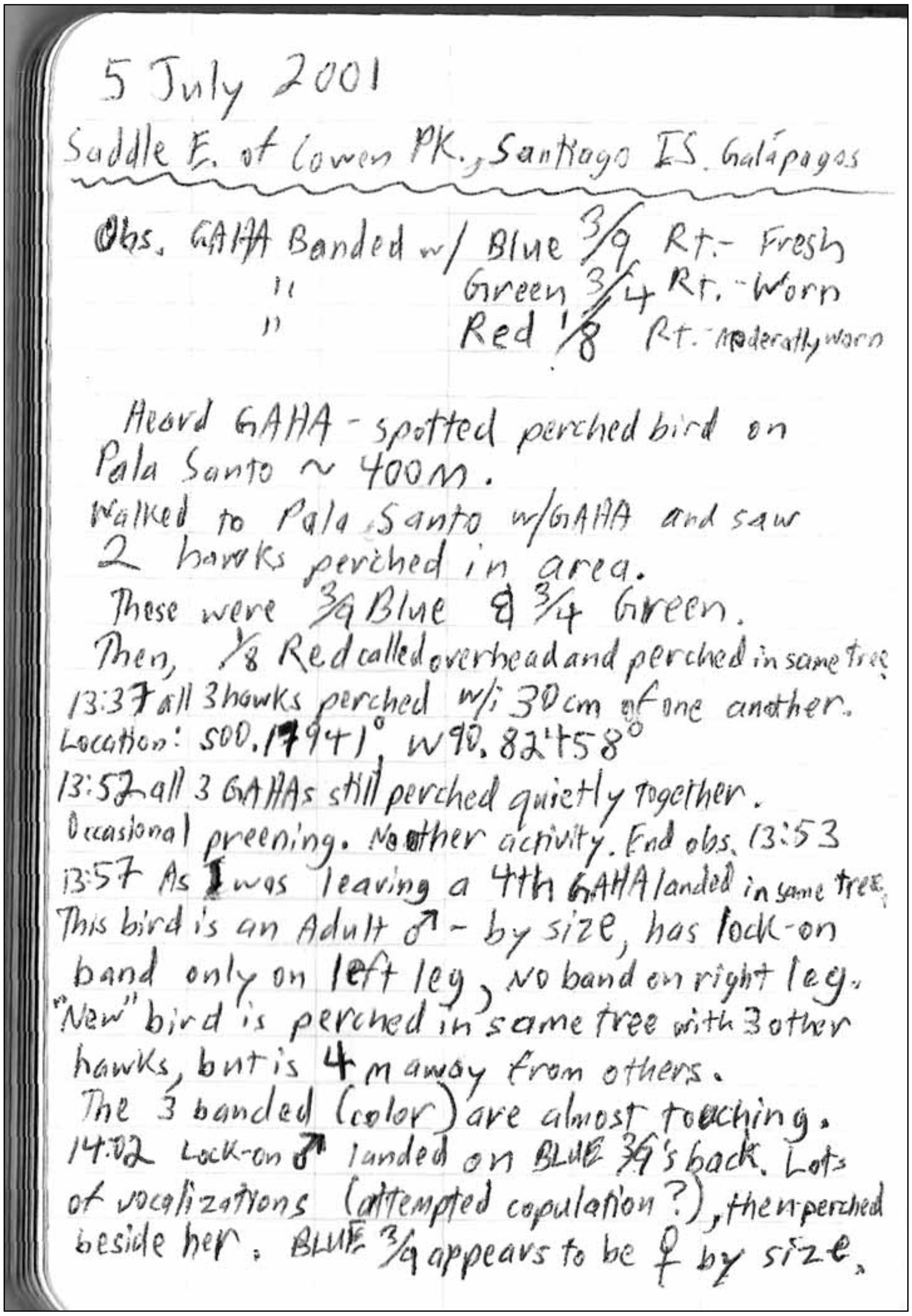
Organization

The existence of magic windows for data collection means that organizing time in the field is of paramount importance. Researchers should devise general season-long and more specific week-to-week plans of required tasks or activities. In my own research projects, we have commonly used over-sized calendars, chalkboards, or dry boards to plan the specific research tasks that need to be accomplished within the next 7 to 10 days. Such planning takes into account priorities such as checking all occupied nests at 3-day intervals, regular replacement of tapes and batteries at time-lapse video cameras located at nests, maintaining standard intervals of monitoring radio-instrumented hawks, and other required tasks demanded by the research study design. Whether the project is large (>10 investigators and technicians) or small (a single graduate student), I recommend that key project investigators should take time to review study needs and priorities at least weekly, and develop a task plan for the coming 7 to 10 days. The plan should emphasize priority and time-critical tasks, allocate time for lower-priority tasks as available, and involve input of all members of the study team. Also, the plan should allow for contingencies (e.g., nest or transmitter failures, inclement weather that cancels field work) and be adjusted when those events arise. Importantly, this plan of tasks should be written down.

DATA

I believe that one lost art in this day and age is the practice of writing accurate and complete field notes. I have been in the field checking on nests or research sites of interest with several graduate students, who never once jotted down what we saw in a field notebook. Do they remember the data (e.g., that we saw two chicks about three weeks old in a nest and the adult flew in with a frog) and record this vital information later? Can that researcher remember what they saw and record that information accurately later in the evening? Or, do memories fade and become confused as additional information is observed and the researcher tries to retain more facts before "downloading" the information into their field notebook. Every raptor researcher should maintain a complete and accurate field notebook with all facts recorded as soon as possible after observation. Exceptions would be data recorded on pre-prepared data sheets (see below).

Field researchers should obtain a suitable field notebook before the first scheduled field day. In my lab, we use low-cost, "Rite in the Rain" all-weather No. 350 field books (J.L. Darling Corp., Tacoma, WA U.S.A), which have bright yellow covers and waterproof paper. I generally employ a system of taking notes similar to that which was originally developed by Joseph Grinnell and is known as the "Grinnellian system" (Herman 1986). In brief, each page should have the current date on the top line; location information should be given on the second line (use multiple lines if necessary), followed by field observations (Fig. 1). Importantly, field notes should be entered immediately after observations are made as needed during the course of a field day. Observations should be recorded on sequential pages in chronological order, each page with the date indicated on the top line (undated field-note pages can often lead to confusion as to which date applies to which page). Include every detail and record the maximum amount of quantitative information possible (e.g., numbers, estimated distances, directions, duration of events or behavioral patterns in seconds or minutes as appropriate). I encourage frequent use of sketches of locations,



5 July 2001
Saddle E. of Cowen PK., Santiago IS. Galápagos

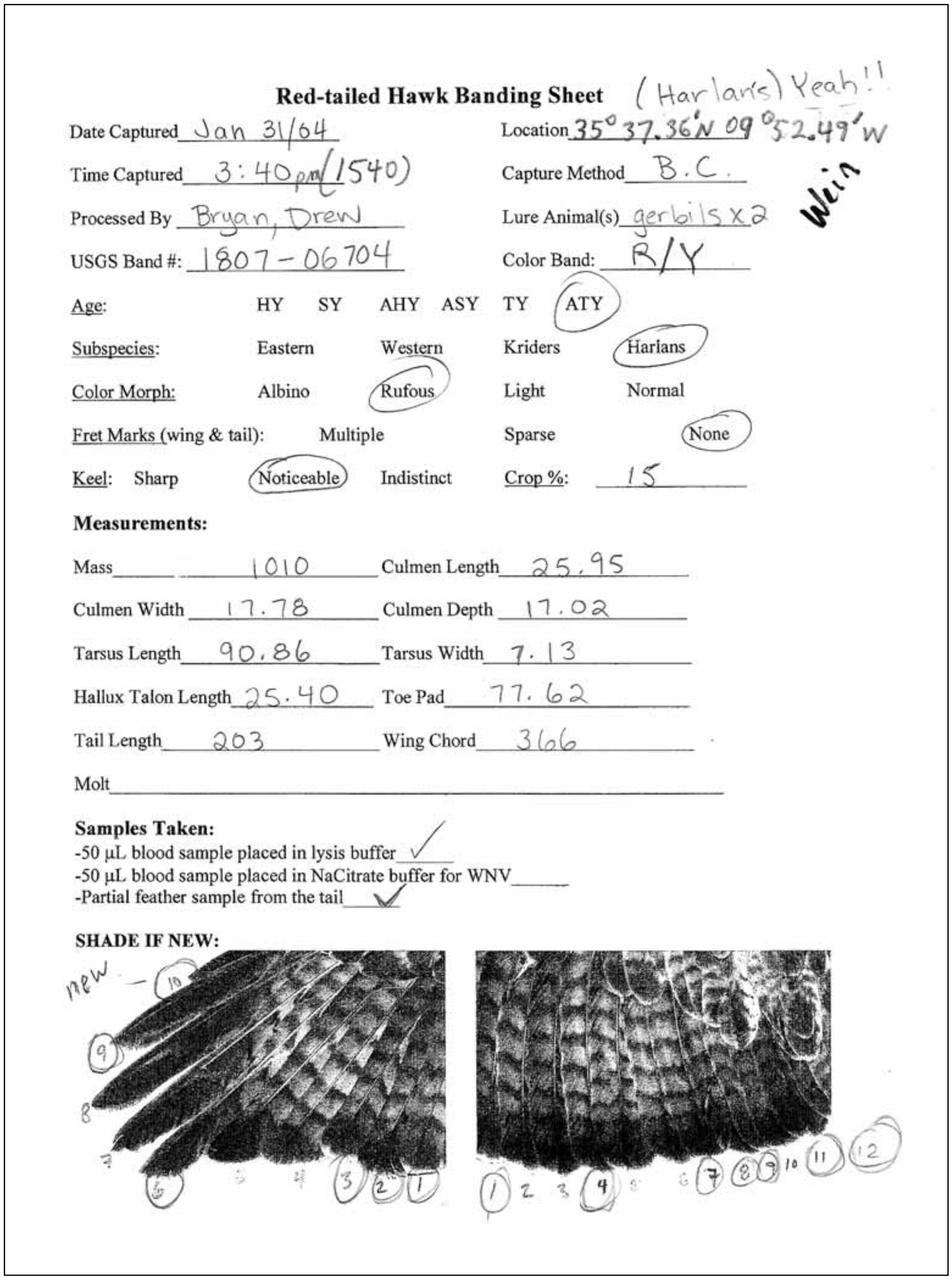
Obs. GAHA Banded w/ Blue 3/9 Rt.- Fresh
" Green 3/4 Rt. -Worn
" Red 1/8 Rt. -Moderatly worn

Heard GAHA - spotted perched bird on
Pala Santo ~ 400m.
Walked to Pala Santo w/GAHA and saw
2 hawks perched in area.
These were 3/9 Blue & 3/4 Green.
Then, 1/8 Red called overhead and perched in same tree
13:37 all 3 hawks perched w/i 30 cm of one another.
Location: S00.17941°, W90.82458°
13:52 all 3 GAHAs still perched quietly together.
Occasional preening. No other activity. End obs. 13:53
13:57 As I was leaving a 4th GAHA landed in same tree.
This bird is an Adult ♂ - by size, has lock-on
band only on left leg, No band on right leg.
"New" bird is perched in same tree with 3 other
hawks, but is 4 m away from others.
The 3 banded (color) are almost touching.
14:02 Lock-on ♂ landed on BLUE 3/9's back. Lots
of vocalizations (attempted copulation?), then perched
beside her. BLUE 3/9 appears to be ♀ by size.

Figure 1. One page of field notes recorded by J. Bednarz during an investigation of Galápagos Hawks (*Buteo galapagoensis*) on Santiago Island on 5 July 2001. The assigned task that resulted in these notes was to obtain band reads (Acraft Co., Edmonton, Alberta, Canada) from the Peregrino Galápagos Hawk group that traditionally inhabits a territory on Cowen Peak.

cliff sites, maps, unique characteristics of birds, etc. Your field notebook also is a good place to record the names and contact information for people you encounter in the field (e.g., a landowner of the property that contains a raptor nest that you are monitoring), appointments you make while in the field, list of work tasks to be done, research supplies needed, and other vital information you need to accomplish the research. On the back pages of your field book, you might staple or attach critical research information that you need while conducting field research, such as a list of nest locations, band combinations of known study birds, frequencies of radio-tagged hawks, or available color band combinations for newly captured birds.

At the end of the field season, I carefully read through all my field notes again, number all pages starting at page one, and make an index of general topics (Tables 1 and 2). A thorough reading of the field notes at the end of a study season gives you a good sense of the successes and setbacks encountered, allows you to



Red-tailed Hawk Banding Sheet (Harlan's) Yeah!!

Date Captured Jan 31/04 Location 35° 37.36'N 09°52.49'W

Time Captured 3:40pm (1540) Capture Method B.C.

Processed By Bryan, Drew Lure Animal(s) gerbils x2

USGS Band #: 1807-06704 Color Band: R/Y

Age: HY SY AHY ASY TY ATY

Subspecies: Eastern Western Kriders Harlans

Color Morph: Albino Rufous Light Normal

Fret Marks (wing & tail): Multiple Sparse None

Keel: Sharp Noticeable Indistinct Crop %: 15

Measurements:

Mass 1010 Culmen Length 25.95

Culmen Width 17.78 Culmen Depth 17.02

Tarsus Length 90.86 Tarsus Width 7.13

Hallux Talon Length 25.40 Toe Pad 77.62

Tail Length 203 Wing Chord 366

Molt

Samples Taken:

-50 μL blood sample placed in lysis buffer ✓

-50 μL blood sample placed in NaCitrate buffer for WNV

-Partial feather sample from the tail ✓

SHADE IF NEW:

Figure 2. A completed, pre-printed data sheet for capturing and marking Red-tailed Hawks (*Buteo jamaicensis*) in the winter period.

identify discrepancies that still may be rectified, brings to mind important information that you may have forgotten, and helps you consolidate the information needed for preparation of end-of-season reports or planning of the next field season. The preparation of an index of field notes is a huge time-saver. This is particularly so when additional data are needed to conduct a new analysis, when an emerging issue needs to be addressed, or when one needs to contact an individual (e.g., a landowner) encountered in the field.

In addition to complete field notes, use of pre-printed data sheets is an effective way to ensure that you collect all data desired. Pre-printed data sheets also provide an excellent means to organize data for later processing. Pre-printed sheets or cards may be used for recording data when processing trapped hawks (Fig. 2), visiting nests, taking telemetry fixes, and recording vegetation types or habitat sampling. I strongly recommend use of pre-printed data sheets whenever possible. If pre-printed data sheets are well prepared, all data related to a

Table 1. Abbreviated field notebook index for a research project at the Los Medaños area of New Mexico, U.S.A. in 1987.

Topic	Field Notebook Pages
Band	
Destroyed	148
Recovered	91, 127, 318
Barn Owl nests	73, 74, 84, 93, 99, 107, 114, 152, 153, 195, 211, 234, 280
Burrowing Owl nests	24, 96, 106, 128, 141, 142, 172, 178, 198, 200, 201, 205, 231, etc.
Dead raptor	8, 53, 55, 66, 127, 233, 236, 289, 318, 321
Emlen census	116, 122, 133, 150, 159, 170
Great Horned Owl nests	see Table 2
Harris's Hawks	
Banded bird obs.	4, 11,15, 22, 23, 24, 27, 33, 42, 53, 56, 59, 72,87, 92, 95, 104, etc.
Copulation	45, 49, 59, 86, 99
Nest blind watch	106, 108, 109, 110, 115, 116, 119, 120, 123, 126, 127, 129, etc.
Nest building	47
Observations	11, 16, 24, 25, 33, 43, 52, 56, 62, 74, 79, 89, 104, 147, 148, etc.
Harris's Hawk nests	see Table 2
Injured raptor	18, 161, 194, 305
Laparotomy	192, 195, 196
Nest	
Platform	48, 50, 51, 72, 78, 109, 112, 167, 171, 172, 173, 193, 213
Predation	123, 130
Other bird observations	56, 60, 85, 89, 90, 91, 137, 201, 267, 281, 283, 293, 294, 302, etc.
Rabbit census	12, 14, 28, 34, 46, 69, 97, 108, 124, 133, 168, 174, 185, 212, etc.
Radiotelemtry	
Hawk No. 322	3, 8, 9, 11, 13, 17
Hawk No. 755	3, 7, 18, 19, 27, 33, 35, 38, 46, 53, 58, 65, 75, 77, 78, 86, 90, etc. *(Pages related to telemetry listed for 15 additional hawks as above.)*
Raptor aggressive interaction	18, 19, 39, 97, 249, 250
Raptor captures	
American Kestrel	305
Barn Owls	93, 211, 247
Great Horned Owls	21, 23, 38, 88, 190, 255, 266, 268, 277, 304, 307
Harris's Hawks	1, 2, 23, 41, 52, 57, 60,82, 181, 188, 189, 255, 280, 306
Red-tailed Hawks	21, 25
Screech Owl	120
Swainson's Hawk	187
Raptor	
Census	6, 7, 10, 13, 16, 20, 22, 27, 29, 33, 34, 42, 45, 49, 53, 54, 57, etc.
Hunting	49, 274, 302, 315, 319, 325
Nest	169
Trapping	1, 4, 20, 22, 25, 31, 38, 39, 41, 43, 51, 55, 56, 59, 62, 63, 76, etc.
Raptor with prey	19, 27, 29, 30, 31, 35, 39, 40, 45, 46, 48, 59, 63, 65, 72, 86, etc.
Raven nest	92, 116, 127, 128, 129, 131, 135, 136, 137, 138, 139, 140, 141, etc.
Screech Owl nest	74, 93, 114, 118, 120, 125, 152
Swainson's Hawk	
Mist netting	184, 187, 197
Rehabilitated hawk	285
Swainson's Hawk nests	see table 2
Tethered prey blind watch	21, 23, 25, 26, 39, 40, 42, 300, 301, 302, 303
Transmitter	
Mounted	23, 41, 52, 60, 82, 181, 188, 189, 255, 281, 284, 306
Recovered	4, 58, 66, 67, 218, 224, 296
Vegetation transect	288, 294, 295, 296
People and contacts	
Dee Armstrong	170
Jack Barnitz	160
Larry Blum	37, 44
Marc Bluhm	68
John Brininstool	286
Joneen Cockman	285
Tim Fischer	19, 122, 170, 285, 311
Tay Gerstel	134, 184, 187, 197, 202, 203, 208, 209
Stuart Jones	115
Jess Juen	1, 9, 36, 40, 112,
Bob Kehrman	37, 48
Bill Iko	81
David Ligon	192, 193, 197
Danna Stretch	124, 126, 127, 128
Steve West	124, 125
Don York	113

Table 2. Abbreviated field note book index of 57 Harris's Hawk (*Parabuteo unicinctus*) nests monitored during the raptor research project at the Los Medaños Area of New Mexico in 1987. We constructed similar nest indexes of all notes related to 17 Great Horned Owl (*Bubo virginianus*) and 30 Swainson's Hawk (*Buteo swainsoni*) nests (not shown).

Topic	Field Notebook Pages
Harris's Hawk nest no.	
1	72, 92, 107, 158, 170
2	102, 134, 161, 183
4	98, 99, 109, 110, 115, 120, 162, 170, 179
5	67
6	61, 71, 102, 107, 109, 112, 116, 131, 151
7	78, 99, 122, 124
8	96, 105, 109, 131, 148
10	75, 98, 112, 119, 196
11	73, 103, 111
12	80, 100, 149, 151, 165
14	73, 103, 109, 110 133, 154
15	102, 105, 107, 134, 150
16	115, 120, 127, 132, 148, 151, 157, 159, 160, 166
17	81, 103, 126, 129, 130, 133, 153, 160, 179
20	80, 103, 120, 123, 129, 134
26	75, 98, 113, 161
28	84, 103, 126, 130, 133, 148, 164
29	70, 101, 102, 104, 109, 112, 117, 121, 126, 130, 134, 152, 156, 159
30	100, 117, 119, 161, 186
35	71, 100, 117, 150, 152, 156, 159, 163, 169, 171, 182, 183
37	79, 104, 122, 126, 129, 151
39	132, 151, 152, 182
40	70, 100, 164, 183, 192
41	70, 102, 104, 108, 139, 150
42	103, 108, 132, 165, 182
43	80, 107, 149, 150, 165 182
51	101, 111, 124, 149
54	88, 104, 129, 131, 151, 161
56	100, 109, 151, 153, 158, 160, 163, 169, 171, 178, 183, 184, 186
57	103, 132, 165

specific data-collection activity should be entered on one or multiple sheets. In wet environments, making copies of blank data forms on "rite-in-the rain" paper is strongly advised. An advantage of using pre-printed data sheets is that individual data sheets can be manually sorted (e.g., by species, by date, by nest) in various ways to facilitate efficient data entry. If data need to be sorted in different ways or stored in multiple locations, copies can be easily made to facilitate this type of data management.

Periodically, legible copies should be made of all completed data sheets and field notes (I recommend at approximately 2-week intervals) to avoid the catastrophe of data loss. Moreover, these data should be stored in a safe location away from the field location (e.g., at a university or agency office). Loss of a week or two of data is a serious setback; loss of a season of data is disastrous.

DATA ENTRY

It is always advisable to enter data into a computer file as soon as possible. On a number of research projects in which housing and computers are available, the data should be entered during the evenings of fieldwork, whenever possible. One advantage of this approach is that a duplicate data set based on the original notes or data sheets is now immediately available, which minimizes the potential of those data being lost. In many cases, this optimal approach is not available because data are collected in a remote field location, investigators are living out of tents, computers are not available, or field workers are simply fully occupied by the demands of field work each evening.

Most data may be entered in a computer spreadsheet (e.g., Microsoft EXCEL), which allows for versatile management and transfer into most other programs including most statistical packages. The general format for data entry should be variables labeled on the top of columns and each observation or sample should be entered across the row (Table 3). I encourage the use of the maximum possible "identifier" variables that precede the data columns. Identifier variables basically identify what the observation is (e.g., subject individual, site name, date, year, and all attributes of that observation [gender, age, experimental vs. control, etc.]). In the example data set (Table 3) the variables — Year, No. of Males, Territory Name, Min. Observ., Start Date, and End Date — could be classified as identifier variables. The identifier variables are useful in subsequent manipulation of data and in implementing analyses. Year is one identifier variable that relatively new researchers tend to overlook, but is really a must as Year is typically a key analytical or confounding variable in most field research. In the example provided (Table 3), one of the key questions of interest was "does frequency of prey delivery differ by the number of males (i.e., No. of Males) in the group?" In an ANOVA type analysis this would be a main-effect variable. However, the data also could be examined for the effect of year, observation time, and the influence of territory site by employing a time-series, mixed-model analysis.

Table 3. Example of a summary data set on the prey delivered at Galápagos Hawk (*Buteo galapagoensis*) nests in 1999 and 2000 on Santiago Island, Galápagos, Ecuador.

Year	No. of Males	Territory Name	Min Observ.	Start Date	End Date	Centi-pede	Lizard	Rat	Dove	Mice	Snake	Sea-bird	Finch	Goat	Small Unid.	Total Prey
1999	2	Cave	3620	5-May	10-May	7	2	2	0	1	0	0	0	0	0	12
2000	2	Cave	3125	16-May	21-May	0	0	0	0	0	0	0	0	0	0	0
1999	1	Coast	3620	12-May	17-May	15	0	1	0	0	2	0	0	0	0	18
1999	2	Cowan 2	3630	21-May	26-May	8	6	0	0	0	11	0	0	0	0	25
2000	2	Cowan 2	3014	25-May	30-May	1	0	0	3	0	0	0	0	0	0	4
2000	1	Espino	3030	8-Jun	13-Jun	3	1	0	3	0	0	0	1	0	0	8
1999	3	Guayabillo	3645	29-May	2-Jun	12	0	1	0	1	0	0	0	0	0	14
2000	1	Gully	3261	21-Jun	26-Jun	4	4	0	0	0	0	0	0	0	2	10
2000	2	Lagoon	3851	1-Jul	6-Jul	8	2	0	0	0	0	0	0	0	0	10
2000	2	Lava	3090	12-Jul	17-Jul	0	1	0	0	0	0	0	0	0	0	1
1999	3	Malgueno	3770	4-Jun	9-Jun	2	0	0	0	0	0	0	0	0	0	2
2000	3	Mordor	3400	23-Jul	28-Jul	2	0	0	0	0	0	0	0	2	0	4
1999	2	Peak	3809	23-Jun	28-Jun	3	0	1	0	0	0	0	0	2	0	6
1999	3	Peregrino	3705	30-Jun	4-Jul	3	0	0	0	0	0	1	0	0	0	4
2000	3	Peregrino	3025	30-Jul	3-Aug	0	0	0	1	0	0	0	0	0	0	1
2000	2	Red Mtn	2162	5-Aug	10-Aug	3	0	0	0	0	0	0	0	0	0	3
2000	2	Shangri La	3155	11-Aug	16-Aug	4	1	0	0	0	0	0	0	0	0	5
1999	2	Valley	3635	11-Jul	16-Jul	1	1	1	0	0	0	1	0	0	0	4
2000	2	Valley	3071	17-Aug	22-Aug	0	0	0	0	0	0	0	0	0	0	0

Spatial data are readily displayed and analyzed with the relatively recent availability of Geographic Information System (GIS) software. The most frequently used software related to biological analyses is ArcView or ArcGIS (ESRI, Redlands, CA U.S.A). The low cost of Global Positioning System (GPS) receivers (<$150 U.S.) readily allows researchers to collect relatively accurate data on spatial coordinates. All field researchers should have and use a GPS receiver to collect location information. These data generally can be input into an EXCEL spreadsheet in a manner similar to that described above. Two columns with UTM or degree location coordinates should be included for each observation in these spreadsheet files. Files can then be converted to "dbf" files and uploaded into ArcView or similar software packages for spatial displays on maps or aerial images.

DATA ANALYSIS

Most students and practicing biologists have been trained in significance or null-hypothesis-testing statistical techniques. These analytical techniques have been aggressively criticized in journals recently (e.g., Johnson 1999, Anderson et al. 2000) because these approaches have emphasized the testing of trivial "straw-man" or "silly-null" hypotheses and the analyses often are uninformative. A variety of alternative approaches have been offered including emphasis on reporting estimates of effects (e.g., providing means and confidence intervals), use of Bayesian inference approaches (Johnson 1999), and the information-theoretic (I-T) approach (Anderson et al. 2000). The Bayesian approach has not been well accepted as a tool to evaluate data patterns in the ecological disciplines, in part because the mathematics involved are relatively complex and the lack of available "canned" programs to calculate Bayesian probabilities. I do not cover this approach further here, but refer interested readers to Ellison (1996) for an introduction with an ecological orientation. The I-T approach (Anderson et al. 2000, Burnham and Anderson 2002) recently has gained some popularity and, in my view, has both advantages and disadvantages over traditional null-hypothesis testing. In brief, the I-T approach involves examining alternative models that affect a selected response variable (traditionally considered a dependent variable) based on several potential explanatory variables (independent variables). Then, formal likelihood measures (e.g., often Akaike Information Criteria [AIC]) may be used to evaluate the fit of the data to various alternative models. Currently, some referees and editors advocate almost exclusive use of the I-T approach. However, assessments by Guthery et al. (2001, 2005) review I-T approaches and point out several limitations with these analyses, as well as the fact that such approaches can be misused (also see Anderson and Burnham 2002) in much the same manner as null-hypothesis testing.

Individual researchers need to consider alternative approaches as possible analytical tools (e.g., null-hypothesis testing, effects estimation, I-T modeling). I agree with Guthery et al. (2001, 2005) that I-T approaches tend to be more exploratory in nature and that this technique in most cases is probably not the best analytical approach in which to test patterns in data for a well-developed field or lab experiment in which potential causal and response variables are well-defined. In the latter case, I advocate the use of traditional null-testing statistics, especially ANOVA, a technique that is both robust and in which the results can be understood readily. However, Anderson et al. (2000) seem to imply that the I-T approach can be used as a rigorous "test" of alternative models. At least in most uses that I have seen, I question this assessment because explanatory variables are often selected arbitrarily or as a matter of convenience, they typically include relatively easy-to-measure available variables, and relationships with the response variable may go in either direction (positive or negative) producing an acceptable model (this is not an *a priori* test of a clearly stated research hypothesis). Therefore, most uses of I-T approaches seem to be best suited to exploring relationships rather than testing a specific research hypothesis. Moreover, if two or more alternative models fit the data well (similar AIC values), there is no acceptable way to discriminate which model is best, except by subjective argument. That said, the I-T approach does have value in identifying possible meaningful relationships between response variables (e.g., survivorship) and a suite of possible explanatory variables (e.g., age, year, and selected cover/vegetation or behavioral variables). Although often misused (Anderson and Burnham 2002), the I-T approach also could be used to evaluate the relative merit of competing explanatory research hypotheses if vacuous models are eliminated *a priori* from the analysis (Guthery et al. 2005).

Data as entered in spreadsheets (described above) may be easily imported or "cut-and-pasted" into statistical software packages such as SAS, Minitab, or Systat. If a study is well designed, most data may be analyzed using parametric or non-parametric analyses (see Potvin and Roff 1993, Johnson 1995, Smith 1995). The I-T analysis can often be accomplished based on output values from SAS and other canned statistical programs (see Anderson et al. 2000, Burnham and Anderson 2002).

It is not my purpose here to review the standard null-testing statistical procedures. A brief review of the common statistical analytical techniques used in wildlife studies is provided by Bart and Notz (2005) and more extensive treatments can be found in statistical textbooks, such as Sokal and Rohlf (1995).

SUCCESSFUL PRESENTATION AND PUBLICATION OF RESULTS

Once data are collected and analyses are mostly complete, the final and most important step in raptor science is the presentation of the results. There are three primary means for presenting data: (1) preparing a manuscript for publication, (2) giving an oral presentation at a scientific meeting, and (3) giving a poster presentation at a scientific meeting. Of these, the most challenging to accomplish is the publication of the results in manuscript form, which undergoes rigorous peer evaluation. There are additional detailed resources addressing various aspects of how to present your research in final form and how to write a scientific paper (e.g., Day 1998 and see below). My purpose here is to hit some key points that may be especially useful in the successful publication of manuscripts about raptors, and regarding specific points not well covered in other resources.

Although I focus primarily on manuscript presentation, many of the basic guidelines for presentation of research results, such as keep it simple and eloquent, and make it clear, apply equally to oral and poster presentations.

Develop an Outline

The first step that I firmly recommend is to prepare an outline for your manuscript. This could be done in classic outline format (i.e., designating topics with numbers and letters indicating levels of importance) or simply writing down major headings (e.g., Introduction, Methods) and developing a list of items in logical order that you wish to address under each of these major headings. The outline allows you to "brainstorm" about how to approach the write-up of your research and see a logical sequence in the proposed topics to address. The outline should provide a framework to help you organize your thoughts and materials, as well as to highlight deficiencies or areas where you will need to do more literature research or analysis before you begin writing. The outline serves as an adaptable guideline that will enable you to better see adjustments that will make your manuscript more logical, complete, and effective. Therefore, expect to cut-and-paste and move topics around, and to add and eliminate topics until you are satisfied with the proposed framework of the manuscript. As you develop the outline, make sure to follow the same sequence of topics (e.g., provide information on observations of birds first, reproductive success next, and relationships with vegetative structure last) in each major section of the paper (i.e., Introduction, Methods, etc.).

General Guidelines for Manuscript Preparation

At this stage of preparing a scientific manuscript, I recommend selecting an appropriate "target" journal. The selection of a target journal is a topic that requires careful deliberation, regarding the stature of the journal, time to decision of acceptance or rejection and to potential publication, probable quality of the referees and review process, interest of the readers of the journal, dissemination potential related to the topic of your manuscript, and other factors. For relatively new scientists, I encourage you to discuss the selection of a journal with senior investigators involved in the project or with academic advisors active in raptor science. Once a target journal is selected, I strongly recommend that authors review the manuscript preparation guidelines for that journal and adhere carefully to those guidelines as they prepare their manuscript. Most scientific journals or their sponsoring societies maintain a web site where manuscript preparation guidelines can be found. I also recommend obtaining copies of recently published articles or issues of that journal and carefully reviewing them for format and style. Typically, journals also publish their manuscript guidelines periodically in the journal issues. *The Journal of Raptor Research*, for example, publishes information for contributors annually in the December issue (e.g., *J. Raptor Res.* 39:480–483).

Numerous books and other resources have been published to provide a how-to guidance on preparing a scientific manuscript for publication (e.g., Day 1998, Gustavii 2003). For a simple and straightforward writing style guide, I recommend the 4th Edition of Strunk and White (1999). This brief book provides excellent advice regarding effective writing (scientific or otherwise). This style manual advises use of simple, eloquent and active voice in writing, which is also most effective in scientific prose. Text written in passive voice is usually wordy, unclear, and somewhat awkward. Always strive for both brevity and completeness, which often equals clarity.

Introduction. In some respects this is the most important section of the manuscript, and in many ways the most difficult to write. I have seen many otherwise excellent manuscripts rejected simply because the author set the stage poorly with their Introduction. Pay careful attention to the development of this section, and do not hesitate to re-write this section again, and again, if necessary. Specifically, you need to develop the context for the research. Why is this study important to advancing our understanding of raptor biology or to ensuring their conservation? The Introduction should answer this question clearly and provide the appropriate background citations to support your case that this research is a meaningful contribution. Cite only the "best," most current, and most-relevant references. Avoid being too scholarly and exhausting: do not provide excessive citations in the Introduction and elsewhere in the manuscript. The Introduction should be relatively easy to compose if your research idea and study design were developed with scientific rigor prior to the initiation of data collection.

Methods. The Study Area and Methods is usually the easiest section to compose. Although somewhat falling out of favor these days, in part because of the relatively high costs of producing figures and the difficulty that authors have in developing a suitable map, I feel that study-area figures are extremely informative. An appropriate "picture" is always worth a thousand words, probably more when it comes to setting the stage for describing a research study. Thus, use of an informative study-area figure can provide maximum content (it can and should be used to illustrate key spatial relationships such as distributional patterns of cover types, locations of nests, or other key features relative to the study) and is probably among the most "cost-effective" approaches to provide supportive documentation for a field study.

The Methods section is a straightforward description of the techniques used by the author(s) of the manuscript. The key point here is to provide enough detail that readers would be able to duplicate your study or experiment. The Methods section can be shortened by citing other papers that clearly describe the techniques used in the current study. By relying on citations, you would only need to describe clearly any modifications employed beyond what was described in the original reference of that technique.

Results. This is a critical section of any manuscript, but, generally, is easy to write. Following the original outline of topics to cover in the Results (see Develop an Outline), I recommend first preparing working tables and figures for possible inclusion in the results. The working figures and tables provide an outline for the text of the Results. Text should not repeat data presented in tables, but should briefly describe primary patterns in the data that are evident in tables and figures. All tables and figures should be cited in the text. If a figure or table is not cited, then it is not needed and should be omitted. If data are few in a working table, these may be more concisely presented in the text. Key means, medians, estimates of variation, and statistical results should be provided parenthetically in the text of the Results. During the course of writing the Results, each working figure and table should be evaluated and revisions should be made to improve clarity for the final version of the manuscript.

Tables should rarely provide raw data, but rather summaries of statistical data (e.g., means, confidence intervals, sample sizes). Tables need to be clear, straightforward, simple, and easy to interpret. Avoid excessive clutter and footnotes in tables. Also, eliminate redundancy and minimize the use of acronyms or cryptic variable codes in tables and text. Sometime in the 1970s, somebody "decided" that the use of cryptic acronyms to label individual vegetation structural or other variables was a concise approach for presenting such results. Unfortunately, this confusing and ineffective presentation approach carries on today. As such, papers often include the analysis of scores of vegetation variables, and the jumble of confusing acronyms (e.g., PDFCC = Percent Deciduous Forest Canopy Cover) is almost impossible to follow unless the reader makes a cheat-sheet of the codes to refer to as the paper is read. All but a few dedicated readers are willing to make this effort to sort through the confusion of cryptic acronyms. I strongly recommend that authors avoid the use of cryptic codes for data variables and use an abbreviated, but descriptive variable name. Consider again PDFCC, for example. If the author analyzed 40 vegetation variables with similarly awkward codes; the text and tables would be extremely difficult to comprehend. For this variable, a clearer label might be "Tree Canopy Cover." Minimize the use of acronyms and cryptic codes throughout manuscripts.

I strongly recommend figures over tables, as I feel visual representations can leave very effective and lasting impressions of the results in the readers' minds. Tufte (1983) offers some guidance on the visual display of quantitative data. Some examples of particularly effective figures include the following in the *J. Raptor Res.* (39:356, Fig. 1; 39:369, Fig. 2; 39:397, Fig. 1; 39:448. Fig. 1; 39:464, Fig. 1; 39:470, Fig. 3; 40:14, Fig. 9; 40:18, Fig.14; 40:68, Fig. 2). Always give consideration as to whether the data in any of your working tables can be presented more effectively in the form of a figure.

Discussion. The Discussion should address the same sequence of general topics that was set forth in the Introduction and other sections of the manuscript. Probably the first items to address in your Discussion are the research questions and hypotheses introduced in the Introduction of the paper. Assess how your data support or refute the hypotheses that you set out to test. Discuss and acknowledge any inconsistencies in the results. Then review any potential biases in your methodology and comment on the seriousness of these biases. Do these weaknesses potentially affect any of your interpretations? Compare your results with those of current and relevant literature objectively. And again, generally avoid being too scholarly. There is no need to compare your results to every paper remotely addressing the same question(s). Simply stick to the most relevant papers.

If you have unexpected or surprising results, it is fair to suggest reasonable and logical explanations. Support these hypotheses with whatever *post hoc* data you have available and consistent patterns reported in the literature. Do not, however, go off the deep end. If you have no supporting evidence or reasonable logic to support your speculation, do not go there. Excessive speculation will get your manuscript rejected almost every time. The Discussion section does provide you with the opportunity to develop new hypotheses, but your data should be consistent with these new ideas. Be prudent with speculation; restrict it to the development of one or two alternative hypotheses at the most. Finally, it is often worthwhile to highlight interesting patterns that may have emerged from the data as a spin-off from collecting data on your primary research questions.

Authorship

One issue of importance to scientists in all disciplines is the question of how to assign authorship to reflect the contributions of individuals to science. Although the topic largely has been ignored in the past (e.g., Tarnow 1999), ethical guidelines on who qualifies to be an author and the order of authors are now available from a number of sources (e.g., Day 1998, Macrina 2005). Ideally, general principles and philosophies of assigning authorship should be discussed by potential collaborators (e.g., a graduate student and graduate advisor) before the research begins. However, actual assignment of authorship can only be done fairly after the research, including the preparation of the manuscript, is near completion.

It is a clearly accepted ethical norm that only individuals that have substantially contributed to the development and execution of the research should be included as authors. Substantial contributions are typically described as those that have an effect on the direction, scope, or depth of the research (Macrina 2005), or involve significant contribution to the concept, design, and interpretation of the study (Tarnow 1999). Honorary authorship, especially by individuals who merely facilitated funding, inclusion of project or program directors that were not directly involved in the research, or listing technicians that simply collected data violate acceptable ethical standards.

Moreover, all authors should accept responsibility for the content and the integrity of the science reported in a published paper. Thus, to the extent reasonable, all listed authors must understand and defend the basic aspects of the work, and take responsibility for errors, flawed interpretations, and the consequences resulting from publication (including any bad science). For example, consider a group of authors that published data, based on a pseudoreplicated and confounded study design further masked by a vague presentation of results, that suggested a rare species of raptor benefited by logging operations. Then resource managers, on the basis of this publication, undertook a good-faith effort to initiate aggressive timber harvest operations "to benefit" this rare raptor, which subsequently resulted in near total demise of the species. Although this hypothetical scenario would expose multiple shortcomings in the publication processing of this specific paper (e.g., superficial reviews by referees, poor decisions and oversight by editors, lack of critical assessment of the research by resource managers), the major responsibility for the near loss of this species would reside with the authors who published the paper. Certainly, honorary authors or individuals with poor understanding of the research should not be included in the authorship line because they cannot defend or critically evaluate the science, potentially leading to the publication of unreliable results and conservation disasters similar to the scenario that I described above.

Dickson et al. (1978), Schmidt (1987), and others offer guidelines for assigning authorship in papers published in basic and applied ecology. Their guidelines have been elaborated by J. F. Piatt (unpubl. manuscript), and I briefly summarize his suggestions here. There is general agreement that scientific investigations can be broken down into five basic areas:

1. **conception** — including original study idea, development of proposals, and acquisition of funding;
2. **design** — development of study design, intricacies of data-collection protocols, and related logistic matters;
3. **execution and data collection** — the actual work of data collection and the administrative and logistic efforts needed to support the field or laboratory activities;
4. **data analysis** — including all aspects of data manipulation such as data entry, verification, and analysis;
5. **writing** — including synthesis and interpretation, which most often represents the most intense intellectual development of any paper (generally the first draft of any manuscript is written by the lead author). As a guideline, for an individual to be considered as a potential co-author they should make significant contributions in at least two of the five key areas of

research described above. One area that all co-authors should be involved with is manuscript preparation. At a minimum, all co-authors should carefully review and provide critical input on the validity and interpretation on an early draft of the manuscript. Later, before submission, all co-authors should be comfortable with and accept responsibility for the science and results presented in the manuscript. This "approval step" may be accomplished informally and given verbally, or more formally with all co-authors providing written consent via a letter or e-mail message.

Order of authors should be based on the importance of significant and practical contributions to the overall research. Piatt (unpubl. manuscript) offers a suggested approach to assess the relative contribution of each individual by having all co-authors estimate their contribution to each of the five key areas of producing a research manuscript. All potential co-authors should review their estimated contributions and revise these estimates until they reach a consensus. This "quantitative" assessment could indicate differences between co-authors and individuals that should be listed in the acknowledgments if there is a distinct break between scores of major and minor contributors. The contributions of closely ranked individuals ideally should be discussed and further resolved by agreement of all co-authors. In some fields, including the medical sciences and molecular biology it is customary for the leader of the research group or laboratory — assuming they are actively involved in that specific research — to be last author on papers, a position considered to be second in importance and prestige following that of the first author. Generally, in the wildlife field this is not the convention and the order of authorship reflects the overall contribution of each co-author, with the first author providing the greatest contribution and so on. However, this philosophy is changing with the convergence of disciplines, and many laboratory raptor biologists ascribe added significance to the last individual listed on an author byline.

CONCLUSION

In some respects, the task of presentation, particularly the publication of results, is the most challenging aspect of conducting raptor research. This often is the most humbling aspect, especially when one receives frank criticism from one's peers, as well as the most gratifying aspect of raptor science. Keep in mind that your study is not complete until it has been published. In a way, the research project really never even took place unless the results are published in a scientific journal. If the data never see the light of publication, you in essence wasted much of your time conducting the research, wasted the funder's money, and most likely unnecessarily disturbed the birds (by using them as research subjects, which may have involved observations, trapping, banding, "disturbing" nesting activities, etc.). On the other hand, perhaps one of the most gratifying aspects of science is the recognition of the importance of your work as reflected by publication in a peer-reviewed scientific journal and the knowledge that you have made a lasting contribution to the knowledge base and probably to the conservation of raptors.

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