# COMPUTER-ASSISTED MANAGEMENT AND ANALYSIS OF BIOLOGICAL DATA FOR BEARS

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*Abstract:* Statistical Analysis System (SAS) was used to provide continuous inventory, manipulation, and analysis of a wide range of biological information for black bears (*Ursus americanus*). We developed a computer-formatted field capture sheet to reduce transcribing effort and encoding errors, and to expedite data access. The system was flexible, easy to use, and versatile, allowing one to (1) update the data base, (2) detect and allow error correction, (3) handle missing values, (4) sort and combine data into different formats, and (5) produce reports and color graphics. Programs to locate errors included sorting variables into a formatted output to facilitate visual detection. The data base can be interfaced with statistical programs (SAS, SPSS), analysis systems for mark-recapture data, and telemetry, habitat, and land-use planning systems. Using a standardized data system optimizes preproject planning, consistency, and experimental design considerations for long-term projects. The SAS format is widely used, readily available, and enhances interdisciplinary interactions. Computerized data systems facilitate integrated information management for a broad range of research and management objectives and maximum resource input to ensure comprehensive management decisions.

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The wildlife profession has been characterized by advanced technology and increasing sophistication in recent years. Computers are routinely used, satellite technology is becoming more available, and advanced statistical analysis is now common. With continuing and effective technology transfer, computer-assisted techniques can provide valuable assistance in quantitative analysis and rapid manipulation of information into concise formats that will facilitate management decisions.

Computer packages have been developed to conduct mark-recapture analysis on open (Arnason and Baniuk 1980 [POPAN-2]) and closed (Otis et al. 1978 [CAPTURE]) populations, and a statistical method has been described that estimates black bear harvest rates and population densities from appropriately collected sex and age data (Fraser et al. 1982). Programs have been described for handling radiotelemetry (Siniff and Tester 1965, Koeppl et al. 1975, Hill et al. 1981, Hill and Fendley 1982) and habitat and land-use planning data (Gilmen et al. 1973, Beeman 1977 [IMGRID]). Comprehensive, user-oriented statistical packages (SAS Users Guide/Basics and Statistics 1982 [SAS], Nie et al. 1975 [SPSS]) are also readily available, but an apparent gap exists in the data-handling step between collection of raw field data and computer analysis. To fully realize the potential of computer-assisted techniques, adequate data collection and management considerations should be integrated to ensure valid and timely interpretations.

Increasing management concern for bears, especially grizzly bears (*U. arctos*), in many national parks has prompted managers to maintain substantial observational information in a computer system called the Bear Information Management System (BIMS) (Joslin and Kapler 1979, Smith 1983). The system has been used to analyze management problems associated with bear-person incidents in several national parks (Keay and VanWagtendonk 1983, McArthur 1983). Parks have been reluctant to accept BIMS because of technical problems associated with a centralized, nation-wide computer system and reduced support from the development to operational stage.

The University of Tennessee (Dep. of For., Wildl., and Fish., and the Grad. Prog. in Ecol.) has been conducting a comprehensive black bear research project since 1969 in Great Smoky Mountains National Park (GSMNP or Park). The large data base accumulated soon made it evident that conventional information handling procedures were not suitable. Our objectives are to describe and evaluate a data management and analysis system that evolved to handle large amounts of biological data for black bears.

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## STUDY AREA

Great Smoky National Park, an International Biosphere Reserve, provided a valuable opportunity to study bears; the large (2,075 km$^2$), diverse, and rel-

atively undisturbed area with a high bear population (Pelton and Marcum 1975) allowed an assessment of data procedures, methodologies, and information needs for developing population and habitat models.

## METHODS

Our raw data set consisted of 614 individual captures of 362 bears and 62 variables per capture. The data set contained information on all black bears captured and handled from 1969 to 1980. SAS sessions were run using a modem/telephone line from the DECwriter, Televideo, and IBM PC terminals.

## RESULTS AND DISCUSSION

### Computerized Data Management and Analysis System

*Current System Operation.*—Black bear data were keypunched, run on the IBM mainframe computer, and transferred to the CMS disk. The CMS system (Sall 1981) functioned as a complete computer system. We used it to create and modify data files and programs, prepare text, and submit and retrieve batch jobs using the Remote Job Entry/Remote Job Output facility, thus reducing the time delay normally encountered between submission and output times. The SAS procedure output files (Fig. 1) could then be routed to our terminal, a printer, or to another disk.

The SAS procedure output (Fig. 1) was stored on the CMS disk in SAS-specified format. Normally, this format is not in manuscript form; therefore, this file was transferred to a floppy disk on the IBM PC. A word processor was then used to format and edit for the final letter-quality printing of the manuscript (Fig. 2).

Additionally, SAS/GRAPH was used to draw line plots; scatter, contour, and 3-dimensional plots; bar graphs; pie charts; stars; block charts; and coropleth and surface maps (SAS/GRAPH Users Guide 1981). All SAS retrieval, data management, statistical analysis, and other capabilities may be used with SAS/GRAPH. Data are put into SAS data sets before SAS/GRAPH procedures use them. With SAS/GRAPH and a color terminal and plotter such as Tektronics 4027 and 4662, displays show information in meaningful pictures; extensive title and footnote capabilities allow data explanation and display annotation. Carefully choosing default values in SAS/GRAPH permits immediate production of pictures with display options that fit current needs (e.g., 35 mm color slides and plots in manuscript form).

Examples of recent inquiries for information that were answered rapidly with this system include: (1) footpad measurements for evidence in a law enforcement case, (2) histories of bears captured in nuisance situations by the Natl. Park Serv., (3) incidents of collar-related injuries, (4) recovery times for bears

S T A T I S T I C A L  A N A L Y S I S  S Y S T E M  1
15:22 THURSDAY, JANUARY 27, 1983

| OBS | INDEX | TATTOO | CAP_DATE | CAP_TIME | CAP_METH | T_SNARE | D_OR_A |
|---|---|---|---|---|---|---|---|
| 1 | 104 | | 19JUL72 | 2125 | 3 | . | 2 |
| 2 | 305 | | 09JUN72 | 2250 | 2 | . | 2 |
| 3 | 503 | | 29JUN73 | . | 2 | . | 2 |
| 4 | 601 | | 23JUN72 | . | 2 | . | 2 |
| 5 | 1001 | 088 | 07JUL72 | 815 | 3 | . | 2 |
| 6 | 1204 | | 23JUL75 | 1139 | 1 | 2 | 2 |
| 7 | 1505 | | 20JUL72 | 930 | 2 | . | . |
| 8 | 2101 | | 17AUG70 | . | 2 | . | . |
| 9 | 2313 | 118 | 14AUG72 | 2134 | 3 | . | 2 |
| 10 | 2601 | | 25AUG72 | 2030 | 3 | . | 2 |
| 11 | 6002 | E7 | 29JUN77 | 1225 | 1 | 2 | 2 |
| 12 | 9302 | D13 | 19JUN77 | 1100 | 1 | 2 | 2 |
| 13 | 13501 | A8 | 22JUN76 | 1100 | 1 | 2 | 2 |
| 14 | 18001 | F21 | 30JUN77 | 1145 | 1 | 2 | 2 |
| 15 | 22003 | 609 | 04JUN79 | 1428 | 3 | . | 2 |
| 16 | 23201 | 465 | 11JUL78 | 948 | 1 | 2 | 2 |
| 17 | 31501 | 508 | 16SEP79 | 1015 | 6 | . | 2 |

**Fig. 1. SAS procedure output from the noninteractive program as stored on the CMS disk. (This information is not in manuscript form.)**

S T A T I S T I C A L  A N A L Y S I S  S Y S T E M

| INDEX | TATTOO | CAPTURE DATE | CAPTURE TIME | CAPTURE METHOD | TRICK SNARE | DEAD OR ALIVE |
|---|---|---|---|---|---|---|
| 104 | | 19JUL72 | 2125 | Free-ranging | . | Alive |
| 305 | | 09JUN72 | 2250 | Culvert | . | Alive |
| 503 | | 29JUN73 | . | Culvert | . | Alive |
| 601 | | 23JUN72 | . | Culvert | . | Alive |
| 1001 | 088 | 07JUL72 | 815 | Free-ranging | . | Alive |
| 1204 | | 23JUL75 | 1139 | Snare | No | Alive |
| 1505 | | 20JUL72 | 930 | Culvert | . | . |
| 2101 | | 17AUG70 | . | Culvert | . | . |
| 2313 | 118 | 14AUG72 | 2134 | Free-ranging | . | Alive |
| 2601 | | 25AUG72 | 2030 | Free-ranging | . | Alive |
| 6002 | E7 | 29JUN77 | 1225 | Snare | No | Alive |
| 9302 | D13 | 19JUN77 | 1100 | Snare | No | Alive |
| 13501 | A8 | 22JUN76 | 1100 | Snare | No | Alive |
| 18001 | F21 | 30JUN77 | 1145 | Snare | No | Alive |
| 22003 | 609 | 04JUN79 | 1428 | Free-ranging | . | Alive |
| 23201 | 465 | 11JUL78 | 948 | Snare | No | Alive |
| 31501 | 508 | 16SEP79 | 1015 | Barrel | . | Alive |

**Fig 2. SAS procedures output (Fig. 1) in final manuscript form after editing and formatting on the IBM PC.**

that were immobilized with M-99 but not given M50–50, (5) incidence of chest markings, (6) dosages of sernylan for evidence in a litigation suit, (7) breeding history and tree den reuse by progeny, and (8) cross-referencing tooth sections and age data.

*Data Set Editing and Maintenance.*—Once on the computer, the data set was easily manipulated to edit or update with new bears, ages determined from tooth sections, and deaths of catalogued bears. Five search programs to locate errors included sorting measurements by sex and age; reproductive variables by sex; nuisance history by locations and trap types; and other numeric variables such as tag, tattoo, and index numbers; dates; and drug dosages into list-formatted output, which easily facilitated visual detection. The 5 searches located 20 errors; most were encoding mistakes such as being 1 column off or problems with vague handwriting (e.g., 2 vs. Z). Other errors and format problems were located through routine use. For example, the 1st printout of ages revealed bears that were 1890–1900 years old because birth year was in 4-digit format (1976) and the capture year was in 2-digit form (79).

Corrections, updates, and revisions were easily accomplished using the CRT or hard copy terminals with the CMS Xedit or Script on-screen editor. The editors have search, find, and redefine capabilities, and find and replace commands. Many other on-screen edit commands are available to correct any problems in the data system. This flexibility is essential feedback for improved system operation, incorporating rapidly advancing computer technology, and integrating into new systems.

*Computer-formatted Field Sheet.*—In 1981, we developed a field capture sheet with a computer format that corresponded to that of the 1968–80 data set because most data set errors resulted from transcribing field sheets to keypunch encoding forms. After 1 year of field testing the data sheet and using the existing data set, 2 new variables (age and total drug dose) were added, and the format was slightly altered to reduce character variables, add decimals, reduce the birth year to 2 digits, and clarify instructions (Figs. 3 and 4).

Important considerations in developing a computer-formatted field sheet included (1) using 2 colors in printing to clearly distinguish between the 2 cards, (2) placing card number and bear index number on each card, (3) printing necessary decimals in specified columns, (4) using a minimum of character variables and carefully distinguishing between numeric variables (e.g., O and Z vs. 0 and 2), (5) where appropriate, leaving the last numeric code for other and a blank for specification (e.g., 4 = neck; 5 = other, please specify ____), (6) providing extra space for comments and a recapture, for marking changes and making

UT Department of Forestry, Wildlife, and Fisheries
Black Bear Capture Data Sheet

| Index No.[1] | Tattoo No. | Right Ear Tag No. | Right Ear Tag Color[2] | Left Ear Tag No. | Left Ear Tag Color[2] | Capture Date Day | Capture Date Month[3] | Capture Date Year | Capture Location[4] | Release Location[4] | Release Date Day | Release Date Month[3] | Release Date Year | Time of Capture[5] | Time of Release[5] | Recorders Initials[6] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-5 | 6-9 | 10-12 | 13 | 14-16 | 17 | 18-19 | 20-21 | 22-23 | 24-25 | 26-27 | 28-29 | 30-31 | 32-33 | 34-37 | 38-41 | 42-47 |
| | | | | | | | | | | | | | | | | |

| Drug[7] | Initial Dose(mg)[8] | Inj. Point[9] | Latency Time(min) | Anti-dote[10] | Recovery Time(min) | Sub. Inj.[10] | Total Dose(mg)[11] | Sex[12] | Weight (lbs) | Wgt. tape (lbs) | Total Lgt(cm) | Card No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 48 | 49-54 | 55 | 56-57 | 58 | 59-61 | 62 | 63-68 | 69 | 70-72 | 73-75 | 76-78 | 79 |
| | | | | | | | | | | | | |

General Directions: Refer to footnotes on back of data sheet for specific directions and numeric codes. Leave the blocks blank if instructed by footnote (ex. footnote[1]), data were not collected (ex. latency time if subsequent injections were necessary to handle bear), or data does not apply (ex. teat lgt. for males). Round off numeric values ≥ .5 without decimal format stipulation in columns to larger whole number. All numbers should be right justified, Ex. 4 should be recorded as [ 4] or [0 4] and not [4 ]. Clarify any questions or information that does not clearly fit the numerical categories under General Comments. This space should also be used to show calculations of doseages, latency time, etc.

| Shoulder Hgt(cm) | Head Wdt(cm) | Between Ears(cm) | Skull Lgt. (cm) | Ear Lgt(cm) | Forearm Cir.(cm) | Neck Cir.(cm) | Chest Cir.(cm) | Hind foot Lgt.(cm) | Hind Foot Wdt.(cm) | Front Foot Lgt.(cm) | Front Foot Wdt.(cm) | Capture Method[13] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-3 | 4-5 | 6-7 | 8-9 | 10-11 | 12-13 | 14-15 | 16-18 | 19-20 | 21-22 | 23-24 | 25-26 | 27 |
| | | | | | | | | | | | | |

| Captured By[14] | Trick Snare[10] | Trap Injury[15] | Birthdate (year)[1] | Age[1] | Pan-handler[10] | Chest Blaze[10] | Cubs[16] | Lac-tating[10] | Teat lgt.(cm) | Est-rus[10] | Transmitter Frequency | Iso-tope[10] | Blood[10] | Hair[10] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | 29 | 30-31 | 32-33 | 34-36 | 37 | 38 | 39 | 40 | 41-43 | 44 | 45-51 | 52 | 53 | 54 |
| | | | | . | | | | | . | | . | | | |

| Tooth[10] | Rectal Swab[10] | Nasal Swab[10] | Vaginal Swab[10] | Scat[10] | Other Injury[17] | Prominent Scars[10] | Over-all Condition[18] | Ecto-parasites[19] | Dead or Alive[20] | Transmitter[10] | Index No.[1] | Card No. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66-70 | 71 |
| | | | | | | | | | | | | 2 |

Recapture Information: Recapture? (circle) Yes No
Tattoo No.: New ___ Location _____ Previous _____ Location _____
Ear Tags: New (#,color) _____ Previous (#,color) _____
Comments: (please clarify any changes, tag losses, tattoo legibility, etc.) _____
Estimated weight(s): _____
General Comments:

**Fig. 3. Computer-formatted field sheet and general instructions to record capture data for black bears (front side).**

[1]Leave blank (will be assigned later). [2]R=Red, Y=Yellow, Ø=Orange, B=Blue, G=Green, W=White, M=Silver metal. [3]Record number for month, ex. 1=Jan., 6=June, 12=Dec.

[4]
1=Bote Mt.
2=Defeat Rdg.
3=Rabbit Ck. Rd.
4=Parson's Br. Rd.
5=Bunker Hill Rd.
6=Colen Ground Rdg.
7=Ekaneetle Gap Loop
8=Sugarland Mt.-Husky Gap
9=Rough Ck-Upper Sugarland Mt.
10=Bent Arm
11=Green Camp Gap
12=Tremont Rd.-Long Br.
13=Jakes Ck.-Miry Rdg.-Derrick Loop
14=Lumber Rdg.
15=Hornet Tree Top
16=Tellico WMA
17=Dead End Rd.-Falls Br.
18=Double Camp
19=Cowcamp Rdg.
20=Sawmill Rd.-Bivens Br.
21=Citico
22=Gatlinburg
23=Cades Cove
24=Cataloochee
25=Hwy 441, TN
26=Collins Ck.
27=20-Mile
28=Chimney Tops
29=Tremont Turnaround
30=Smokemont
31=Walnut Bottoms
32=Oconaluftee
33=Cosby
34=Hazel Ck.
35=Cataloochee Divide
36=Mining Property, NC
37=Mt. Sterling Gap
38=Indian Camp Ck.
39=Collins Gap
40=Balsam Mtn. CG.
41=Upper Tremont Rd.
42=Little Bald
43=Sugarlands Vis. Ctr.
44=Clingman's Dome Rd.
45=Greenbriar
46=Elkmont
47=Indian Camp Rd.
48=Old Tremont
49=Spence Field
50=Forge Ck.
51=Cooper Ck.
52=Cooper Rd.
53=Tremont Env. Ed. Ctr.
54=Davenport Gap
55=Ramsey's Cascade
56=Siler's Bald
57=Hwy 129
58=Little Cataloochee
59=Schoolhouse Gap
60=Cocke Co., TN
61=Hwy 441, NC
62=Avery Co., NC
63=Greene Co., TN
64=McMinn Co., TN
65=Coastal, NC
66=Henderson Co., NC
67=Polk Co., TN
68=Indian Boundary
69=Horse Ck. Rec. Area
70=Green Cove
71=Big Creek, GSMNP
72=Hannah Mt. Tr.
73=Unicoi Co., TN
74=Other, Please specify_____
75=Mt. LeConte
76=Harmon Den Mtn.
77=Hurricane Rdg.
78=12-Mile Strip

[5]Time of capture is defined as time of initial injection and release time is defined as when the bear leaves site under its own power or is left to recover, use military time ex., 1:30 p.m.=1330, 6:00 p.m.=1800, etc.

[6]Use only 2 initials of names of recorders, up to 3 persons.

[7]1=M99, 2=Sernylan, 3=Succinylcholine chloride (Sucostrin), 4=Ketamine, 5=Ketamine-Rompum, 6=Ketamine-Rompum-Carbocaine, 7=Other, please specify_____

[8]M99, 1cc=1mg; Sernylan, 1cc=100mg; Ketamine, 1cc=100mg; Ketamine-Rompum, 1cc=200mg of Ketamine and 100mg of Rompum [add the 2 doseages and enter the total in blanks, ex. 2cc=600mg (400mg Ketamine + 200mg Rompum)]; Ketamine-Rompum-Carbocaine, 1cc=200mg of Ketamine and 100mg of Rompum and 20mg of Carbocaine [add the 3 doseages and enter the total in blanks, ex. 2cc=640mg (400mg Ketamine + 200mg Rompum + 40mg Carbocaine)]; Other, please specify_____

[9]1=Hip; 2=Flank; 3=Front shoulder; 4=Neck; 5=other, please specify_____

[10]1=Yes, 2=No

[11]Enter sum of initial dose and amount of all subsequent injections

[12]1=Male, 2=Female [13]1=Snare; 2=Trailer-mounted culvert; 3=Free-ranging; 4=other, please specify_____; 5=killed, please specify (rd. kill, legal hunter kill, depredation kill, control action, illegal kill, unknown-found dead)_____; 6=barrel trap; 7=den capture.

[14]1=rt. front paw, 2=left front paw, 3=rt. rear paw, 4=left rear paw.

[15]0=None, 1=broken teeth, 2=swelling, 3=cable cut on paw, 4=cut and swelling, 5=broken bones, 6=dislocation, 7=broken toes, 8=killed by another bear.

[16]Leave blank if undetermined; 0=None, 1=one, 2=two, 3=three, etc.; specify if yearlings under general comments.

[17]0=none, 1=battle injuries or scars, 2=collar injury, 3=other, please specify_____

[18]1=excellent, 2=good, 3=fair, 4=poor [19]0=none, 1=ticks, 2=lice, 3=other, please specify_____ [20]1=dead, 2=not dead

**Fig. 4. Specific instructions and numeric codes for computer-formatted field sheet to record black bear capture data (backside).**

clarifications, and (7) using counties for general and broader than expected coverage of the study region and then coding locations to more specific study areas or sites (Figs. 3 and 4).

The computer-formatted field sheet reduced transcribing and encoding effort and errors, and expedited access to the data. The format also provided only discrete data categories that aided interpretation and statistical analysis. Blanks on initial data forms resulted in so many descriptions that often no useful data resulted. Using a standardized data sheet optimizes preproject planning, consistency, and experimental design considerations for long-term projects. The disadvantages of the computer field sheet were that field personnel were reluctant to change, and the sheets were more trouble to develop, type, and print than conventional data sheets. Once field personnel became familiar with the new field sheets, most preferred them because all variables and instructions were clearly defined. Personnel complaints were further alleviated by providing extra space for comments.

*Plans for Future Developments.*—The present data base will be interfaced with POPAN-2 (Arnason and Baniuk 1980) and CAPTURE (Otis et al. 1978) programs for further population density and dynamics analysis. Sex, age, harvest, and capture data can also be evaluated in relation to population dynamics. Population density and dynamics data allow us to validate and calibrate our standardized bait-station surveys to monitor the relative density and distribution of bears over large areas. Integrated data systems will allow formulation of valid, reliable population models, monitoring surveys, and predictive capabilities.

The next step is to interface population data with movement, habitat, and land use data. The shortcomings of IMGRID (Beeman 1977) as a black bear habitat and movement analysis system have been identified (Quigley 1982:108–111, Villarrubia 1982:100–103). Presently, the geographical land based and telemetry data from IMGRID are being converted into SAS format for more efficient manipulation and analysis. The SAS format will also easily interface with geographic information systems such as Earth Data Resource Analysis System (ERDAS, Inc., Atlanta, Ga.). A new SAS-formatted telemetry analysis system (Hill et al. 1981, Hill and Fendley 1982) provides the final link toward comprehensive analysis of telemetry, habitat, and land-use information.

The major objective of the GSMNP bear studies has been to establish baseline ecological information for regional comparison. Bears are a good environmental indicator species, and our ultimate goal is to develop 1 interactive population and habitat monitoring system to ensure comprehensive resource management in the Southern Appalachian region.

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