

# Index



- 0.05 convention, 36
- Absolute comparison, 234
- Absolute difference, 234
- Abundance curve, 117
- Accidental association, 232
- Accidental bias, 33
- Accidental sampling, 31
- Accidents, effect on data accuracy, 29
- Accumulation rate, 83, 84
- Acoustic monitoring. *See also* Calling activity
- audio strip transect technique, 77, 92–93
  - at breeding sites, 119, 120, 121, 122–123
  - at fixed sites, 150–152
- Across-site comparison, 118
- Activity patterns, statistical representation of, 90
- Air temperature, 44, 50
- Alpha error, 35–36, 38
- Alternative hypothesis, 35
- Aluminum flashing, as drift fence material, 126–127
- Amphibian Techniques Book*, 273
- Anemometer, 46
- cup, 48, 52
  - height for, 52–53
- Anesthetics/anesthetization, 276
- for radio transmitter implantation, 157
  - for toe clipping, 279
- Animal care committee, 162
- ANOVA, 125, 186
- Anura. *See* Frogs
- Aquatic habitat
- descriptions of, 59
  - larvac sampling in, 130–141
  - lentic, 59
  - lotic, 59
  - pH measurement in, 45
  - quadrat sampling in, 98
  - thermometer placement in, 44
- Arboreal species, sampling of, 6
- quadrat sampling, 98, 99
- Archives, of herpetological data, 272
- Areal species richness, 246
- Artificial habitats, 143–150, 186
- artificial cover as, 144, 146–150
  - artificial pools as, 144–146
- Assemblage, 325
- diversity comparison of, 248
  - subset sampling of, 125
  - visual encounter survey of, 90
- Association
- accidental, 232
  - measures of, 208, 209–232
    - classes of coefficients, 209–224
    - correlation and, 228
    - data classification and, 224–227
    - homogeneity of, 230
    - independence and, 227–228
    - invariance of, 230
    - linearity and, 230
    - maxima/minima, 230–231
    - monotonic relationships of, 231

- Association (*continued*)  
 measures of (*continued*)  
 notation and evaluation for, 224  
 properties of, 229–231, 255–270  
 range of, 229–230  
 terminology of, 227–229  
 traditional measures, 228–229,  
 262–265  
 proper, 231
- Association model, 237
- Assumptions, of sampling program,  
 19–20
- Audio strip transect, 77, 92–97
- Aural surveys. *See also* Calling activity  
 of breeding sites, 119, 120, 121,  
 122–123
- Automated data acquisition  
 equipment, 47–57  
 data loggers, 45–46, 47–49  
 use with calling activity recording  
 devices, 54–55, 56  
 use with radio tracking devices,  
 56–57  
 environmental sensors, 49–54
- Automated radio tracking, 55–57,  
 155–158
- Automated recording, of frog calling  
 activity, 54–55, 285–287  
 at fixed sites, 150–152
- Automated weather station, 48–49,  
 161
- Available population, 22
- Bailey's modification estimator, of  
 population size, 187, 188–189
- Bait, 186
- Barometer  
 continuous-recording, 46  
 hand-held, 45
- Barometric pressure, 44–45, 46
- BASIC program, for population size  
 estimation, 200
- Bayesian approach  
 to geographic information systems  
 data, 169  
 to population size estimation, 200
- Behavioral definition, 24
- Beta error, 36, 39
- Bias, 19, 26, 238  
 accidental, 33  
 inconsequential, 34  
 index of, 237–238  
 in quadrat sampling, 99, 101
- Binary data  
 definition of, 208  
 measures of association of. *See*  
 Association, measures of
- Binomial distribution, 235–236, 241
- Binomial model, negative, 248–249
- Biochemical analysis, tissue sample  
 collection for, 299–301
- Biological diversity, definition of, 1
- Biphasic complex life cycle, 6
- Blocking, 33
- Bobbins, use in tracking, 153–155
- Body temperature  
 factors affecting, 53  
 patterns of, 56–57
- Bottom-net sampling, 137–138
- Box sampling, 135, 136
- Branding, as marking technique,  
 282–283
- Breeding chorus, 80, 81, 92. *See also*  
 Calling activity  
 distribution of, 122  
 population density of, 97
- Breeding period  
 explosive, 13  
 prolonged, 13, 94
- Breeding site  
 drift fence enclosure of, 77, 125–130  
 larval sampling at, 15  
 location of, 94  
 surveys of, 118–125  
 along streams and rivers, 122–123  
 aural, 119, 120, 121, 122–123  
 nocturnal, 123  
 regional, 120  
 single-area, 120, 122  
 visual-encounter, 87, 88  
 water level measurements at, 45
- Broad sampling, 99, 100–101
- Broken stick model, 248
- Bromeliads  
 patch sampling of, 107–108  
 as salamander habitat, 12
- Bucket, use as pitfall trap, 112–115,  
 127–128
- Burrow density, 90
- Buzas and Gibson index, 254
- Caecilians, 7  
 habitat utilization by, 5–6, 8  
 larvae of, 7, 15  
 taxonomy, 7
- Calling activity, 14  
 acoustic monitoring of  
 at breeding sites, 119, 120, 121,  
 122–123  
 at fixed sites, 150–152  
 audio strip transect sampling of, 77,  
 92–97  
 of birds, 93–94, 95  
 of diurnal species, 96  
 environmental factors in, 44–45, 51  
 of nocturnal species, 96  
 during nonbreeding season, 125  
 recording of, 48, 51, 67, 97  
 equipment for, 54–57, 285–286  
 recording technique, 286–287  
 voucher specimens, 70, 287  
 state surveys of, 177  
 ventriloquial, 95
- Call intensity, 150, 151
- Call rate, 150, 151
- Call repetition interval, 152
- Campbell Scientific CR10 data  
 logger, 48–49, 51, 54–55
- Canoe-based survey, 122–123
- CAPTURE computer program  
 for population size estimation, 188,  
 201, 202, 203  
 for species density estimation, 116
- Capture-resight method, 199–200
- Catchability  
 equality over sampling period, 175,  
 201–202, 204  
 of larvae, 140, 141
- Catch-per-unit-effort estimator, 201,  
 203, 205
- Caudata. *See* Salamanders
- Center for Environmental Data  
 Management, 272
- Change-in-ratio estimator, 203–206  
 two-stage, 204–205
- Chapman's modification estimator, of  
 population size, 186, 187, 189
- Chi-square, 209, 227, 228, 229, 236,  
 239–240  
 continuity correction of, 241, 242, 253  
 problems in application of, 231,  
 237–239
- Chloretone, as killing solution,  
 291–292
- Climatic data. *See* Weather data
- Closed population  
 removal sampling of, 201  
 size estimation of, 184, 187, 203, 204
- Cluster analysis, 208
- Cluster sampling, 32, 247
- Coding  
 of data, 45, 57  
 for computerized databases, 129–130  
 of presence-absence data, 208  
 for toe clipping, 279–282
- Coefficients, of associations. *See*  
 Associations, measures of
- Collecting  
 permits for, 72–73  
 species extinction and, 68
- Collector, name of, 70

- Color pattern, as natural marker, 277–278
- Combination transect method, 107
- Comparison, 234–235
- Complete species inventory, 78–84
- Computer
- data entry accuracy, 29
  - field use of, 66, 185
- Computerized data files
- of artificial pool sampling data, 146
  - data coding for, 129–130
- Computer programs. *See also*
- CAPTURE computer program
  - for automated weather station operation, 48–49
  - for population size estimation, 188, 201, 202, 203
  - for species diversity estimation, 116
  - for trapping grid data analysis, 116
- Concept, 22
- Conditional distribution, 233
- Constitutive definition, 23
- Construct, 22
- Control group, 33
- Control variables, 33
- Convenience sampling, 31
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 72, 73
- Correlation, statistical, 228
- Cover, artificial, 144, 146–150
- CRC Handbook of Census Methods for Terrestrial Vertebrates* (Davis), 2
- Crossing-the-gradient approach, 104–105
- Crossover, in radioactive tag studies, 160
- Cross-study comparison, 20, 273
- Data, availability of, 20, 271–272
- Data accuracy, 28–29
- Data acquisition systems
- automated, 47–57
  - data loggers, 45–46, 47–49
  - environmental sensors, 49–54
  - for radio tracking, 55–57
  - for recording frog calls, 54–55
- digital, 46
- portable, 46
- Data analysis, 207–270. *See also*
- Statistical design
  - data classification for, 224–227
  - asymmetry, 225–226
  - category definitions, 226–227
  - ordering, 225
  - underlying continua, 225
  - interrelationships of standard tests in, 235–241
  - measurement scales for, 29–30
  - observer effect in, 95
  - of species abundance data, 232–235
  - of species density data, 243–244
  - of species diversity data, 244–251
  - of species richness data, 207–232
  - classifying of data, 224–227
  - conceptual relationships of, 227–229
  - measures of association, 209–232
  - notation and evaluation, 224
  - presence-absence data, 207–209
- Databases
- of artificial pool sampling data, 146
  - data coding for, 129–130
- Data logger, 45–46, 47–49
- environmental sensors used with, 49–54
  - frog calling recording devices used with, 54–55, 56
  - radio tracking devices used with, 56–57
- Data sheet
- for aural surveys, 121
  - copying of, 57
  - data coding for, 57
  - for field use, 90, 91
  - for larval amphibians, 63
  - for mark-recapture studies, 185–186
  - for microhabitat data, 62, 63
  - for pitfall trapping, 115, 116
  - for quadrat sampling, 102, 106
  - for surveys, 121, 178, 180, 181, 182
  - for systematic sampling surveys, 82
  - temporary, 66
  - for transect sampling, 106
  - for visual encounter surveys, 91
- Data standards, 57–66
- for geographic characterization, 58
  - for habitats, 58–71
  - aquatic, 59
  - microhabitats, 60–66
  - terrestrial, 58–59
  - for sampling, 81–84
  - for voucher specimens, 69–70
- Date-specific marking, 165, 277
- Dead specimens, handling of, 115
- Declining Amphibian Populations program, 181
- Declining Amphibian Populations Workshop, 273
- Definition, scientific, 22–23
- Dependence model, 237
- Depth zone, 132–133
- Development, of amphibians, 6
- Dipnet sampling, 131, 145
- of caecilians, 7
  - of larvae, 133, 134–135, 137
- Direct development, 6
- Distance marker, 90
- Diversity indices, 20, 117, 249–251
- DNA analysis, 300, 301
- Dominance, 248
- Dominance diversity curve, 247
- Dominance diversity indices, 249
- Drainage system, of study site, 58
- Drift fences
- at breeding sites, 77, 125–130
  - construction of, 114
  - trap construction and operation, 112–115
  - use with pitfall traps, 90–91, 109–117, 127
- Drowning
- of trapped animals, 117
  - of voucher specimens, 292
- Effect size, 36–38
- Eggs
- development of, 6
  - processing as specimens, 291, 294–295
- Electric shocking, 140
- Elevation, of study site, 58
- Elevational gradients, transect sampling of, 103–107
- Emergence time, 56–57
- Emigration, of mark-recapture study populations, 186
- Enclosure sampling, 131, 132, 135–138, 201
- Endangered species
- legal protection of, 72, 73
  - visual encounter surveys of, 89
  - vouchers, 66
- Endangered Species Act, 72
- Environmental gradients, transect sampling of, 103–107
- Environmental health indicator, 2
- Environmental sensor, 49–54
- Equitability index, 249. *See also* Species equitability
- Error, statistical
- in data accuracy, 29
  - definition of, 26
  - type 1, 35–36, 39, 233
  - type 2, 36, 39
- Escape response, 137
- Evenness. *See* Species evenness
- Export permit, 73

- Extinction, scientific collecting and, 68
- Faunal list, 78–79. *See also* Species list
- Faunal resemblance, 209
- Field catalogue, 70
- Field catalogue sheet, 61, 62. *See also* Data sheet
- Field identification, 67–68
- Field notes, 70, 289–291
- Field observation, recording of, 28–29
- Field trips, 175  
of herpetological societies, 178, 180–182
- Fisher-Ford estimator, of population size, 184, 187, 188, 196
- Fisher's exact test, 239, 240–241, 242
- Fixation techniques, 293–294
- Fluorescent pigment, as marking material, 279, 283
- Forest canopy, breeding choruses in, 92
- Formaldehyde, as preservative, 292–293
- FORTRAN program, for population size estimation, 188
- Fossorial species  
caecilian, 7  
quadrat sampling of, 99  
radioactive tags for, 161  
trespass by, 126
- Fourfold contingency tables, 208
- Fourier series, 90
- Fraction, 234
- Freeze-branding, 283
- Freezing, of tissue samples, 299–300
- Frequency curve, 90
- Frog calls. *See* Calling activity
- Frog houses, 143–144
- Frogs, 12–13  
habitat utilization by, 5–6, 8–12, 13  
larvae. *See* Tadpoles  
life cycle, 14  
reproductive behavior, 12–13  
taxonomy, 12  
thread bobbin tracking of, 153–155  
vocalizations of, 12. *See also* Calling activity
- Funnel trap  
construction of, 114  
drift fences used with, 109, 111, 112, 128
- Geographic characterization, of study site, 58
- Geographic information system (GIS), 166–175  
computer-based, 166–171  
manual, 171–175  
remote sensing and, 167, 171–175
- Geographic scale, of sampling, 18–19
- Glass bead bracelet, as marking device, 278–279
- Gleason's index, 246
- Goals, of research studies, 18–19
- Governmental regulations. *See also* Permits  
for radioactive materials use, 159, 161, 162
- Grab sampling, 31
- Gradients, transect sampling of, 103–107
- Graphical display, of species diversity, 243–244
- Grid system, 89, 90
- Group activities, 175–182  
herpetological society field trips, 178, 180–182  
state and province surveys, 177–178
- Gymnophiona. *See* Caecilians
- Habitat. *See also* Aquatic habitat; Microhabitat; Subhabitat; Terrestrial habitat  
change's in, 78–79  
disturbance of, 89, 90  
intra-habitat comparison of, 248  
sample size of, 81
- Halo effect, 32–33
- Handling  
of dead specimens, 115  
of live specimens, 275–276  
anesthesia for, 276  
of mark-recapture specimens, 186  
of removal sampling specimens, 202  
of tadpoles, 141, 145  
during tagging, 162–163  
of trapped specimens, 115, 128
- Haphazard sampling, 31–32
- Headlamps, for nocturnal sampling, 97, 123
- Head-spots, as identification, 278
- Health, weight-length as indicator of, 150
- Heip's index, 254
- Herpetological societies  
data archives of, 272  
field trips by, 178, 180–182
- Heterogeneity, environmental, 19
- Heterogeneity indices, 249
- H'* function. *See* Shannon's index
- Hill's index, 253, 254
- Histogram, 90  
of artificial pool population, 146
- Historical threat, 26–27, 28
- Home range, 159  
roads as, 163–164
- Homogeneity, statistical, 230, 232–233
- Humidity, relative, 44
- Humidity sensors, 48, 50, 52
- Hygrothermograph, 44
- Hypothesis  
alternative, 35  
formulation of, 21, 24–25  
null, 35–36, 37, 38, 39, 98, 209
- Import permit, 73
- Independence, statistical, 34, 227–228, 237
- Indicator species, amphibians as, 272
- Information indices, of species diversity, 249–251, 254
- Instrumentation, 27
- Interaction-with-selection effect, 27–28
- Intermediate-intensity search, 89
- Internal validity, 26–28
- Interval scale, 30, 207
- Invariance, 230, 255
- Inventory. *See also* Presence-absence data  
complete species, 78–84  
definition of, 18
- Inventory data, publication of, 20, 271–272
- IUCN/SSC Declining Amphibian Populations Task Force, 272
- Jackknifing, statistical, 254
- Jaw-tagging, 278, 283
- Joint frequency distribution, 233
- Joint probability distribution, 233
- JOLLYAGE program, for population size estimation, 188
- JOLLY program, for population size estimation, 188
- Jolly-Seber Stochastic estimator, of population size, 187, 188, 200
- Key, 68
- Key species, 2
- Killing, of voucher specimens, 291–292
- Kill-trapping, 117
- Larvae. *See also* Tadpoles  
catchability of, 140, 141

- characteristics of, 15  
 developmental stages of, 6  
   at breeding sites, 118, 124  
 marking of, 184, 283  
 population density of, 118, 119  
 processing as specimens, 291, 294–295  
 quantitative sampling of, 130–141  
   data treatment and interpretation, 139–140  
   field methods for, 134–138  
   sampling of, 118  
   trapping of, 138  
   visual encounter surveys of, 85  
 as voucher specimens, 15, 69  
 Latitude, of study site, 58  
 Leaf litter  
   population density in, 81  
   thermometer placement in, 44  
   wetness sensors for, 44, 46  
 Lentic aquatic habitat, 59  
 Life cycle, of amphibians, 6, 14  
 Likelihood ratio test, 238, 239  
 Lincoln Index. *See* Petersen estimator  
 Lincoln-Petersen Index. *See* Petersen estimator  
 Linearity, in measures of association, 230  
 Line transect sampling, 93, 106  
   night-driving technique, 27, 34, 163–166  
 Locality, of study site, 58  
 Local residents  
   project involvement of, 42  
   as species location information source, 80  
 Log normal model, 248–249  
 Log ratio test, 238  
 Log series model, 248–249  
 Longitude, of study site, 58  
 Lotic aquatic habitat, 59  
  
 Manly-Parr estimator, of population size, 187–188  
 Map, geographic information system-generated, 168–169, 170–171  
 Marking techniques, 184, 185, 277–284  
   branding, 282–283  
   date-specific, 165, 277  
   fluorescent techniques, 279  
   for larvae, 184, 283  
   pattern mapping, 277–278  
   tagging, 278–279  
   toe clipping, 184, 279–282, 284  
   for tracked amphibians, 154, 157  
  
 Mark-recapture, 57, 76, 88, 202  
   of breeding populations, 119, 120, 122  
   enclosure sampling and, 137  
   field methods of, 185–186  
   jaw-tagging and, 283  
   of larvae, 140  
   population emigration and, 186  
   population estimators, 186–200  
     Bailey's modification estimator, 187, 188–189  
     Chapman's modification estimator, 186, 187, 189  
     Fisher-Ford estimator, 184, 187, 188, 196  
     Jolly-Seber Stochastic estimator, 187, 188, 200  
     Manly-Parr estimator, 187–188  
     Petersen estimator, 186, 187, 188–189  
     Triple Catch estimator, 186, 187, 188, 189–191  
   research design for, 185–186  
   unequal-catchability bias of, 175  
   with visual encounter surveys, 91  
 Matching coefficients, 209, 215–218, 259–261, 262–270  
 Measurement, of live amphibians, 276  
 Menhinick's index, 246  
 Metamorphosis, of larvae, 6  
 Meteorological station. *See* Weather station  
 Meter stick, collapsible, 45  
 Microhabitat  
   descriptive data, 41, 60–66  
   checklist for, 61–66  
   larvae sampling in, 135  
   patch sampling in, 107–109  
   productivity of, 81  
   thermometer placement in, 44  
   visual encounter surveys of, 88  
 Microhabitat selection, 56–57  
 Migration, breeding, 5, 120  
 Models  
   for data analysis, 236–237  
   for operative temperature measurement, 53–54  
 Moisture *See also* Precipitation; Rain amphibians' response to, 5  
 Monitoring  
   definition of, 18  
   voucher specimens for, 69  
 Monte Carlo simulation, 199  
 M-R-C. *See* Mark-recapture  
 Multiple effects interference, 28  
 Museum, as voucher specimen repository, 70–71  
  
 Mutilation, as marking method. *See* Toe clipping  
  
 Negative binomial model, 248  
 Nets  
   bottom, 137–138  
   for larval sampling, 133, 134–135, 140  
 Night driving technique, 27, 34, 163–166  
 Nocturnal radio tracking, 158, 160  
 Nocturnal sampling  
   of breeding sites, 123  
   headlamps for, 97, 123  
   night driving technique, 27, 34, 163–166  
   surveys, 86, 89  
 Nominal scale, 29, 207, 239  
 Nonmetric scale, 207–209  
 Null case, 20  
 Null hypothesis, 25, 35–36, 98, 209  
   of no difference, 39  
   sharp, 39  
   tests of, 37, 38  
 Number-constrained sampling, 79, 80, 81, 82–84  
 Numerical species richness, 246  
  
 Observed effect size, 37  
 Observer, 27  
 Observer bias, in quadrat sampling, 99  
 Observer effect, 95  
 One-way variance analysis, 125  
 Ontario Herpetofaunal Summary, 177–178, 179  
 Operational definition, 23, 24  
 Operational sex ratio, 124  
 Operative temperature, 53–54, 57  
 Ordering, of numerical data, 29, 30  
 Ordinal scale, 30, 207  
 Orientation study, 126  
 Osteological specimens, preparation of, 295  
 Outlier, 29  
 Oversampling, 68  
  
 Packing, of specimens, 295–296  
 Passive integrated transponder (PIT), 57, 279, 283  
 Passive species inventory, 144, 145, 146  
 Patch sampling, 107–109  
 Pattern mapping, 277–278, 283  
 Pelvic patch, branding and, 283  
 Percentage, 234  
 Percentage comparison, 235

- Permits  
 for radioactive materials use, 162  
 for scientific collecting, 72–73  
 for seining, 140
- Petersen estimator, of population size, 186, 187, 188–189
- pH, measurement of, 45
- pH meter, 46, 53
- Phenology  
 of breeding, 92  
 of species presence and activity, 90
- Photoidentification, 277–278
- Pielou's *J* index, 253–254
- Pigment, fluorescent, as marking material, 279, 283
- Pigmentation, as natural marker, 277–278
- PIT. *See* Passive integrated transponder
- Pitfall trap, 186  
 use with drift fences, 90–91, 109–117, 127  
 at breeding sites, 125–130  
 trap construction and operation, 112–115
- Pithing, 292
- Plants, water-holding, 59. *See also* Bromeliads
- Point sampling, 99–100
- Polymorphic species, voucher specimen sampling of, 68, 69
- Ponds  
 larval sampling in, 132–133, 134  
 quadrat sampling in, 98  
 vernal, 5
- Population, definition of, 22
- Population decline, climatic conditions and, 42
- Population density. *See also* Species density  
 of calling males, 97  
 drift fence/pitfall trap estimation of, 111  
 larval, 118, 119, 135  
 of microhabitats, 81  
 pitfall trapping estimation of, 116, 117  
 transect sampling estimation of, 106–107
- Population size, estimation methods of, 183–205  
 breeding site-based, 124  
 capture-resight, 199–200  
 catch-per-unit-effort, 203, 204  
 change-in-ratio, 203–205  
 mark-recapture, 183–200  
 removal sampling, 200–203
- Precipitation, measurement of, 44, 46, 48, 52
- Predators  
 in artificial pools, 146  
 pitfall trapping of, 129
- Preparation  
 of specimens, 68, 289–297  
 of tissue samples, 300
- Preselection methods,  
 reactive/interactive effect of, 28
- Presence-absence data, 18, 207–209.  
*See also* Binary data  
 of artificial pool sampling, 144
- Preservation  
 of specimens, 115  
 of tissue samples, 166
- Preservatives, 292–293
- Primary data, publication of, 20, 271–272
- Probability sampling, 32
- Procedural definition, 23–24
- Project design, 21–28  
 hypothesis formulation for, 21, 24–25  
 research question and, 21–22
- Project planning, 41–73  
 of climatic and environmental data collection methods, 42–54  
 data standards of, 57–66  
 for geographic characteristics, 58  
 for habitats, 58–71  
 for sampling, 81–84  
 for voucher specimens, 69–70
- Proportion, 234  
 binomial distribution of, 235–236  
 correlated, 241  
 tests for trends in, 239
- Proposition, 25, 26
- Province survey, 177–178, 179
- Psychrometer, 52  
 sling, 44, 46
- Puddles, larval sampling in, 131–132
- PVC pipe  
 as enclosure material, 136  
 as trap, 128
- Pyranometer, 52
- Quadrat, random assignment of, 33  
 Quadrat design, 86–88  
 Quadrat sampling, 77, 97–102  
 as enclosure sampling, 135  
 of larvae, 19, 131  
 patch sampling as, 107  
 transect sampling versus, 105
- Quantitative sampling  
 during field trips, 175–176  
 of larvae, 130–141  
 data treatment and interpretation, 139–140  
 field methods for, 134–138  
 research design for, 21–39  
 project design, 21–28  
 statistical design, 28–39
- Quotient, 234
- Radio tracking, 55–57, 153, 155–158  
 with external transmitters, 156  
 with implantable transmitters, 155, 157
- Radioactive tag, tracking with, 152–153, 158–163
- Rain  
 effect on amphibian behavior, 5  
 effect on calling activity surveys, 95  
 night driving sampling during, 165
- Rainfall gauge, 44, 46  
 tipping-bucket, 48, 52
- Randomized-walk design, 86, 87
- Random number tables, 33–34, 313–314
- Random sampling, 19, 30, 31, 32–34  
 of ponds, 132  
 in probability sampling, 32  
 in quadrat sampling, 98  
 stratified, 32. *See also* Stratification  
 in transect sampling, 104, 106
- Rarefaction, 247–248, 253
- Rate, 234
- Ratio, 234
- Ratio scale, 30
- Recapture period, 186
- Recording, of frog calls. *See* Calling activity, recording of
- Recording devices. *See also* Tape recorder  
 digital, 46  
 for tracking, 55–57  
 for weather data recording, 45–46
- Regional survey, 120
- Regression, weight-length, 150
- Regression threat, statistical, 27
- Relative abundance  
 of artificial pool populations, 146  
 behavioral factors in, 175  
 estimation methods for  
 audio strip transects, 92–97  
 breeding site surveys, 118, 119, 124  
 drift fence/pitfall traps, 109, 111  
 night driving, 163, 166  
 patch sampling, 108  
 pitfall trapping, 117  
 quadrat sampling, 87–88, 101  
 visual encounter surveys, 90  
 of restricted-habitat species, 175
- Relative comparison, 234–235

- Relative entropy, of species abundance, 250
- Relative humidity, 44. *See also* Humidity sensors
- Remote sensing, 167, 171–175
- Removal sampling, 34, 131, 139, 200–205
- Repeat rate, 249, 250, 251, 254
- Replication, in sampling, 19, 35, 248
- Research design  
 project design, 21–28  
 statistical design, 28–39  
 0.05 convention, 36  
 data accuracy, 28–29  
 effect size, 36–38  
 measurement scales, 29–30  
 randomness, 30  
 random number tables, 33–34  
 representativeness of samples, 30–31  
 sample size, 35  
 sampling methods, 31–33  
 statistical independence, 34  
 statistical versus substantive significance, 38–39  
 testing errors, 35–39  
 test power, 36, 38, 39
- Research question, 21–22
- Research techniques. *See also* Sampling; *names of specific techniques*  
 modification of, 272–273  
 standardization of, 17–18, 273
- Restricted-habitat species, relative abundance of, 175
- Retreat time, 56–57
- Rivers, breeding site sampling along, 122–123
- Road cruising, 90. *See also* Night driving technique
- Road kills, 163–164, 166
- Roads, amphibian sampling on. *See* Night driving technique
- $R \times C$  tables, 236, 237, 239, 240, 242–243
- Salamanders, 7, 12  
 habitat utilization by, 5–6, 8  
 larvae, 7, 15  
 life cycle, 14  
 taxonomy, 7  
 visual encounter surveys of, 88
- Sample  
 definition of, 22  
 representativeness of, 30–31
- Sample size  
 determination of, 35  
 effect size correlation of, 36–38  
 per habitat, 81  
 random sampling errors and, 32  
 statistical importance of, 209, 224, 233  
 for tissue samples, 301  
 for voucher specimen collection, 68–69
- Sampling, 31–33  
 accidental, 31  
 with artificial cover, 144, 146–150  
 with artificial pools, 144–146  
 bottom-net, 137–138  
 box, 135, 136  
 broad, 99, 100–101  
 cluster, 32, 247  
 considerations in, 18–20  
 convenience, 31  
 dipnet, 7, 131, 133, 134–135, 137  
 efficiency, 32  
 enclosure, 131, 132, 135–138, 201  
 geographic scale of, 18–19  
 grab, 31  
 haphazard, 31–32  
 line transect, 93, 106  
 night-driving technique of, 27, 34, 163–166  
 methodology of, 60  
 number-constrained, 79, 80, 81, 82–84  
 periodicity of, 88  
 point, 99–100  
 probability, 32  
 quadrat, 77, 97–102  
 as enclosure sampling, 135  
 of larvae, 19, 131  
 patch sampling as, 107  
 transect sampling versus, 105  
 quantitative  
 during field trips, 175–176  
 of larvae, 130–141  
 research design for, 21–39  
 random, 19, 30, 31, 32–34  
 for pond sampling, 132  
 for probability sampling, 32  
 for quadrat sampling, 98  
 stratified, 32. *See also* Stratification  
 for transect sampling, 104, 196  
 removal, 34, 131, 139, 200–205  
 seine, 131, 134, 140  
 short-term, 79–84  
 stove pipe, 135  
 strip transect, 93–94, 106–107  
 study goals and, 18–19  
 systematic, 32
- Systematic Sampling Surveys, 79, 80, 81, 82–83, 84  
 time-constrained, 26, 79–80, 84, 85  
 transect, 87, 88, 89, 90  
 audio strip, 77, 92–97  
 of breeding sites, 121, 122, 123  
 placement of transects in, 34, 121, 122, 123  
 strip, 93–94, 106–107  
 visual encounter surveys, 76, 79, 84–92, 119, 120, 122
- Sampling bias. *See* Bias
- Sampling points, distribution of, 19
- Sampling unit, 35  
 random assignment of, 33–34
- Scale, numerical, 29–30
- Scale inequality, 95
- Scientific collecting  
 permits for, 72–73  
 species extinction and, 68
- Scintillation counter, 158, 161
- Search, time-constrained, 79
- Seasonal study, 42–43, 42–43
- Seine sampling, 131, 134, 140  
 permits for, 72
- Selection, interactive effects of, 27–28
- Sex ratio, operational, 124
- Shannon's index, 229, 249, 250–251, 254
- Shannon-Weaver index, 254
- Shannon-Weiner index, 254
- Shipping  
 of specimens, 296  
 of tissue samples, 300
- Short-term sampling, 79–84
- Shrews, pitfall trapping of, 127
- Significance level, 35–36
- Significance tests, 209, 231, 232  
 statistical versus substantive, 38–39
- Silver nitrate, as branding material, 283
- Single-area survey, 120, 122
- Sketching, of study specimens, 283
- Slope indices, 247
- Snout-vent length, 148, 276
- Society for the Study of Amphibians and Reptiles, 272
- Soil moisture, measurement of, 44, 46
- Soil temperature, measurement of, 44, 50
- Solar radiation sensor, 52
- Spatial data. *See* Geographic information system (GIS)
- Species abundance  
 estimation techniques for individual counts and proportions, 232–233  
 interrelationships of standard tests for, 235–243

- Species abundance (*continued*)  
 estimation techniques for (*continued*)  
 terminology of, 234–235  
 larval, 133  
 total species/individual counts  
 relationship of, 246–248
- Species-area curve, 245–246
- Species count, 245, 246  
 species abundance relationship of,  
 246–248
- Species density  
 broad sampling of, 100–101  
 data analysis techniques for, 243–244  
 definition of, 243
- Species diversity  
 data analysis techniques for, 244–251  
 definition of, 244  
 indices of, 20, 117, 249–251
- Species dominance, 248
- Species dominance diversity curve,  
 247
- Species dominance diversity indices,  
 249
- Species equitability, 248  
 indices of, 249
- Species evenness, 248–249, 253–254  
 as species diversity component, 244
- Species extinction, scientific  
 collecting and, 68
- Species identification, 57  
 in the field, 67–68
- Species inventory  
 complete, 78–84  
 passive, 144, 145, 146
- Species list, 77–78, 245, 246–247  
 breeding site-based, 124  
 complete, 78–84  
 inadequacy of, 1–2
- Species number, 245
- Species richness, 79, 83, 87–88  
 areal, 246  
 data analysis techniques for, 207–232  
 classifying of data, 224–227  
 conceptual relationships of, 227–229  
 measures of association, 209–232  
 notation and evaluation, 224  
 presence-absence data analysis,  
 207–209  
 larval, 133  
 sampling methods for  
 breeding site-based, 118, 119, 124  
 night driving, 163, 166  
 patch sampling, 108  
 pitfall trapping, 116  
 quadrat sampling, 101  
 as species diversity component, 244,  
 245–249, 251
- Specimens  
 description of, 60  
 discarded, 115–116  
 number of, 35  
 packing and shipping of, 115, 295–296  
 preparation of, 68, 289–297  
 documentation procedures, 289–291  
 of eggs and larvae, 294–295  
 field equipment and supplies for,  
 296–297  
 fixation techniques, 293–294  
 killing of specimens, 291–292  
 for osteological study, 295  
 preservatives for, 292–293
- Spotted amphibians, pattern mapping  
 of, 278
- SSS. *See* Systematic Sampling  
 Surveys
- Staining, as larval marking technique,  
 283
- Standardization, of techniques,  
 17–18, 273
- Standard techniques, 75–141. *See*  
*also* Sampling  
 breeding site surveys, 118–125  
 complete species inventories, 78–84  
 drift fences encircling breeding sites,  
 77, 125–130  
 drift fences with pitfall traps, 77,  
 90–91, 109–117, 127  
 larval quantitative sampling, 130–141  
 patch sampling, 107–109  
 quadrat sampling, 77, 97–102  
 selection of, 75–76, 77  
 transect sampling, 77, 103–107  
 visual encounter surveys, 76, 79,  
 84–92, 119, 120, 122
- State surveys, 177, 180
- Statistical design  
 0.05 convention, 36  
 data accuracy, 28–29  
 effect size, 36–38  
 measurement scales, 29–30  
 randomness, 30  
 random number tables, 33–34  
 representativeness of samples, 30–31  
 sample size, 35  
 sampling methods, 31–33  
 statistical independence, 34  
 statistical versus substantive  
 significance, 38–39  
 testing errors and, 35–39  
 test power, 36, 38, 39
- Statistical tests, power of, 36, 38, 39
- Statistics, descriptive, 244
- Storage, of voucher specimens, 70–71
- Stove pipe sampling, 135
- Straight-line drift fences. *See* Drift  
 fences
- Stratification, 32, 33, 35, 132–133  
 data analysis for, 139–140
- Streams  
 breeding site sampling along, 122–123  
 larval sampling in, 133
- Strip transect sampling, 93–94,  
 106–107
- Structural definition, 24
- Study site  
 geographic characterization of, 58  
 locality of, 58  
 number of visits to, 75, 76  
 random selection of, 167
- Subhabitat, calling-male population  
 of, 97
- Subset-of-the-gradient, 105
- Substrate  
 as enclosure sampling limiting factor,  
 137, 138  
 moisture content of, 44
- Systematic sampling, 32
- Systematic Sampling Surveys (SSS),  
 79, 80, 81, 82–83, 84
- Tadpoles, 15  
 artificial pool sampling of, 144–146  
 developmental staging system for, 146  
 handling of, 141, 145  
 mark-recapture of, 133  
 preservation of, 294, 295  
 quantitative sampling of, 144, 145,  
 146  
 trapping of, 138
- Tags  
 as marking device, 278–279, 283  
 for radioactive tracking, 152–153,  
 158–163  
 for voucher specimens, 291
- Tape recorder  
 for calling activity recording, 285–286  
 in audio strip transect studies, 97  
 data logger-controlled, 48, 51, 55,  
 56  
 of voucher specimens, 70  
 for field data recording, 57–58
- Target population, 22
- Tattooing, as marking technique,  
 282–283
- Temperature  
 air, 44, 50  
 automated measurement of, 50  
 body, 53, 56–57  
 effects of, 43  
 measurement instruments for, 43–44  
 operative, 53–54, 57



- soil, 44, 50  
water, 50
- Tensiometer, 46
- Terrestrial habitat, descriptions of, 58–59
- Thermal environment, 53–54
- Thermistor, 48, 50
- Thermocouple, 47–48, 50  
hand-held, 43
- Thermograph, continuous-recording, 44
- Thermohygrometer, hand-held, 44, 46
- Thermometer  
maximum-minimum, 43, 46  
placement of, 43–44
- Thread bobbin technique, of tracking, 153–155
- Ties-in-ranking, 101
- Time-constrained sampling, 26, 79–80, 84  
with visual encounter surveys, 85
- Time-constrained search, 79, 85
- Time-series graph, of artificial pool populations, 146
- Tissue samples  
collection for biochemical analysis, 299–301  
functions of, 67  
preservation of, 166  
from road kills, 166
- Toads, calling activity measurement of, 51, 55
- Toe clipping, 184, 279–282, 284
- Total-days-survival-by-marks, calculation of, 191–195
- Tracking, 55–57, 152–163  
radio tracking, 155–158  
radioactive tag technique, 153, 158–163  
recording devices for, 55–57  
thread bobbin technique, 153–155
- Transect sampling, 87, 88, 89, 90  
audio strip, 77, 92–97  
of breeding sites, 121, 122, 123  
placement of transects in, 34, 121, 122, 123  
strip, 93–94, 106–107
- Transects-in-homogenous-areas technique, 105–106
- Transponder, passive integrated (PIT), 57, 279, 283
- Transverse sampling, 103–107
- Trapped animals, release of, 117
- Traps  
amphibians' avoidance of, 126  
for enclosure sampling, 135–137  
funnel, 109, 111, 112, 114, 128, 138  
kill-traps, 117  
for larvae, 131, 138  
permits for, 72  
pitfall, 90–91, 109–117, 127, 186  
construction and operation of, 112–115  
with drift fences, 90–91, 109–117, 127  
as shelter, 126
- Tree holes, larvae sampling in, 131–132
- Trespass, in drift-fence sampling, 126, 127, 128, 130
- Triple Catch estimator, of population size, 186, 187, 188, 189–191
- Two-stage change-in-ratio estimator, 204–205
- Two-way variance analysis, 125  
2 × 2 tables, 208, 224, 236  
independence of, 227–228  
tests for, 239–242  
values of, 252
- Type 1 error, 35–36, 39, 233
- Type 2 error, 36, 39
- Ultraviolet radiation, measurement of, 52
- United States Fish and Wildlife Service, 72, 73
- Validity, 25–28  
threats to, 26–28, 29
- Variance analysis, 125
- Vendors, list of, 303–311
- Vernal pond, 5
- VES. *See* Visual Encounter Surveys
- Visual Encounter Surveys, 76, 79, 84–92  
of breeding sites, 119, 120, 122
- Visual location, of amphibians, 80–81
- Vocalizations, 12. *See also* Calling activity
- Voucher specimens, 57  
alternative to, 66–67  
from artificial pools, 145  
call recording of, 70, 287  
collection permits for, 72–73  
data associated with, 69–70  
larval, 15  
from pitfall trapping, 115–116, 117  
of polymorphic species, 68, 69  
preparation of, 289–297  
repository for, 70–71  
road kills as, 166  
sample size for, 68–69  
for tissue samples, 300  
of visual encounter surveys, 89
- Waistband  
for radiotransmitter attachment, 156  
for tracking tag attachment, 153, 154
- Water conductivity, automatic measurement of, 53
- Water-holding plants, 59. *See also* Bromeliads
- Water temperature, measurement level for, 50
- Weather, as amphibian activity factor, 81
- Weather data, 41, 42–46  
basic, 43–44  
for seasonal studies, 42–43
- Weather station  
automated, 48–49, 161  
thermometer placement at, 44
- Weighing, of amphibians, 148, 276
- Weight-length regression, 150
- Wind, effect on calling activity surveys, 95
- Wind direction, 45
- Wind meter, hand-held, 46
- Wind speed, measurement of, 45, 46, 52–53
- Wisconsin, frog and toad survey programs, 120, 121, 124–125, 177
- $\chi^2$  test. *See* Chi-square
- Zero entry, 101
- Zero point, 29

