Preface

This text is designed to form the core of a one- or two-semester introductory course for planning students at the graduate or advanced undergraduate level. It proceeds from several beliefs about planning education. First, I believe that planning students have an acute need to be able to document and process the uncertainty involved in three common planning tasks: making estimates, making predictions, and making comparisons. There is usually a high degree of ambiguity in both the normative and empirical realms of planning; professional excellence requires that planners confront this ambiquity with competence. Part of that competence involves the ability to assess empirical uncertainty. This is especially true as the work of planners becomes more public and formal through their participation in regulatory and quasi-regulatory activities, in which the standards of evidence are more stringent than in traditional plan development. The importance of statistical competence is underscored by the recent proliferation of required courses in planning and other professional schools throughout the United States.

Second, I believe that it is possible and proper for an introductory course to develop in students having limited mathematical preparation an ability to execute modest-sized statistical analyses. When designing a course, we should keep in mind the condition of the students several years hence. A course that aims low, seeking to train "educated consumers," is likely to produce only reluctant consumers who in time lose their shallow competences. At today's tuition prices that is not an impressive legacy. A course that aims higher and routinely takes the students to the point of doing rather than talking about analyses will leave students better off no matter how much further statistical work they undertake. Beware the student who approaches the subject vowing that he can always hire some consultant to do the statistics for him—such students show more than one kind of naivité about the use of consultants and small appreciation for a marketable skill.

Despite the good reasons for acquiring statistical competence through a course that asks students to be active, courses about methods for planners are very often troubling for students, especially when required. My third belief is that some significant part of this problem arises because of the paucity of good teaching materials. This text was developed to help fill the need for a stimulating treatment of statistics that uses the idiom of the planner. It should be easy to empathize with the student dragooned into

attending a class that drones on about red and black balls inside urns, or trudges from formula to formula. Statistics can be a planner's craft, and so can be about problems of substantive interest to planning students. Several excellent books inspired this one but were not written with planning students in mind. My debt to their authors will be clear to anyone who looks at the supplementary readings. My aim is to interpret their ideas for planners.

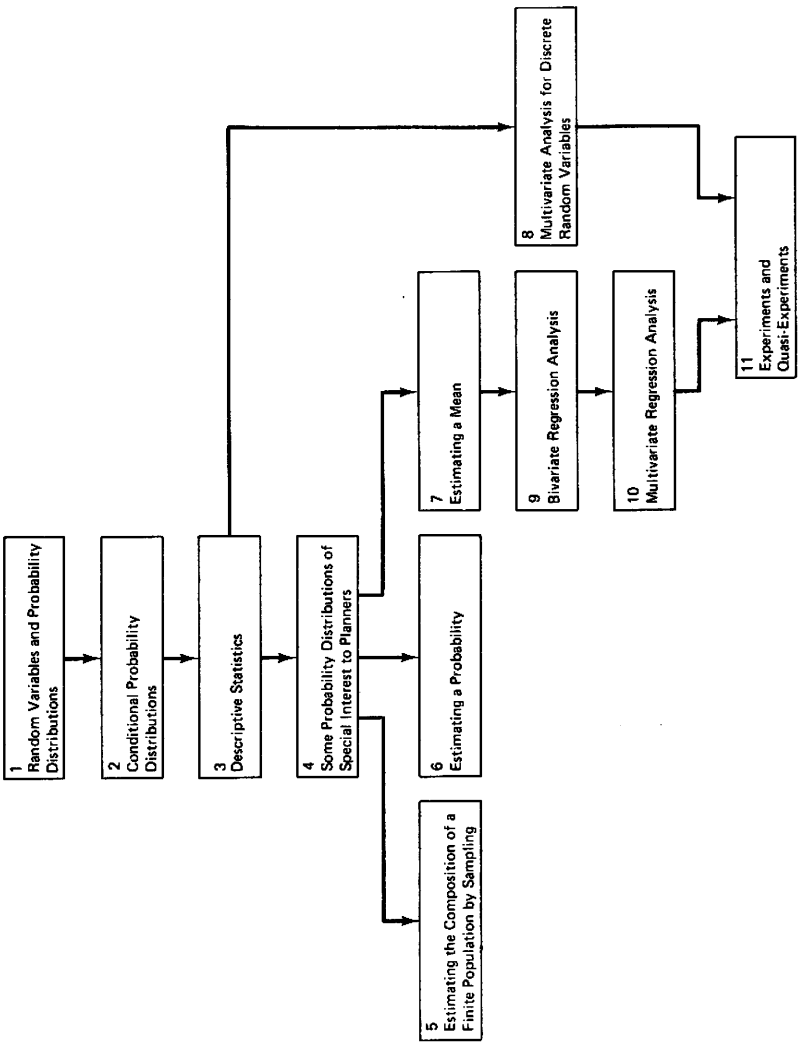
This text assumes a limited background in mathematics. Operationally, this translates into a working knowledge of algebra, graphing of functions, logarithms and exponentials, and the $\sum$ notation. No prior knowledge of probability or statistics is assumed beyond a nodding acquaintance with tables and histograms. Calculus does not appear. The text does presume certain equipment: a supply of graph paper (linear, semi-log, log-log, and probability) and a hand calculator (preferably programmable). During the years I taught the course at MIT, there were weekly computer exercises as well, and I recommend at least a few of these as supplements. By all means students should have access to standard census data, as in the *County and City Data Book*. Every student has theories and should be encouraged to test them empirically (for too many, this will represent their first confrontation of private theory and public data).

Some important topics not included in the text which I emphasized in my course at MIT are making data (survey research, participant observation techniques, and creation of indices) and making decisions (decision analysis and linear programming). Nor are spatial probability and time-series techniques (like exponential smoothing and cohort-survival methods) included. To limit the size and sharpen the focus of the text, it proved necessary to restrict the range of topics to the statistical aspects of making estimates, making predictions, and making comparisons.

Several features of the text should make it more effective for planners. Perhaps the major feature is the strong, but not exclusive, focus on Bayesian methods of estimation. Bayesian methods are especially appropriate for planners for two reasons. First, the likelihood function is a more natural basis for inference than the null hypothesis: planning students instinctively know that sample results are more or less consistent with many possible values of a parameter, whereas the traditional null hypothesis rightly appears to be somewhat stilted and artificial. Second, planners

are highly invested in their sense of professional judgment, and the prior distribution offers them a graceful and constructive outlet for that professional judgment. My sense is that Bayesian methods are inherently more teachable than conventional approaches. Instructors who are used to confidence intervals will find the Bayesian construct of highest density regions numerically similar (if conceptually somewhat different). When Bayesian approaches are not available or too complicated, traditional significance testing material is presented instead.

Several other features should be noted. First, illustrations within each chapter are drawn from areas of substantive interest to planners. This facilitates the transition from purely statistical concerns to the kind of substantive discussion that ultimately makes for the most meaningful statistical analysis. Second, each chapter contains a few problems chosen the same way. Typically, a problem will contain a small data set and ask for an analysis; often the questions will lead the student somewhat beyond the text; frequently there is no unique solution to the problem. There are few straightforward computational problems—these should be prescribed as needed and should definitely be based on data sets of personal interest to the student. Third, each chapter contains references and supplemental readings. Often the readings are listed because they contain fascinating data, controversial findings, or useful paths into the deeper reaches of a topic. Many of the readings have proved themselves as good bases for classroom discussions; some are meant for only the most advanced students. Fourth, at several points the text stresses the illuminating use of synthetic data and Monte Carlo simulation as vehicles for nurturing a feel for randomness. Fifth, stress is laid on the importance of the assumptions underlying inferential statistics, on simple graphical methods to test the assumptions informally, and on how to react to apparent violations of the assumptions (this is especially important for those who will work in judicial or quasi-judicial environments). Sixth, some of the most useful recent writings on the problems of executing and interpreting regression analyses have been interpreted for the student in a first course. Included are such topics as outliers, multicollinearity, errors in measurement of variables, and making causal interpretations. Seventh, the issue of the internal validity of experimental designs is illuminated through use of a simple mathematical model of the nonequivalent control group design and its constituent parts.



Flow of chapters (arrows indicate prerequisites)

The flow of the material is illustrated in a diagram which shows the prerequisites linking chapters. Chapter 1 begins with a brief introduction to probability and random variables from the perspective of making primitive predictions. Chapter 2 introduces conditional probability from the perspective of refining predictions and develops Bayes' rule for later use in estimation. Chapter 3 treats descriptive statistics as portable summaries of probability distributions, stressing the relationship between choice of descriptive statistic and level of measurement. Chapter 4 describes five probability distributions of special interest to planners.

Chapters 5 through 7 present Bayesian methods for estimation. Chapter 5 addresses the problem of estimating from a sample the number of each of two kinds of cases in a population of finite size. Chapter 6 takes up the estimation of a probability. Chapter 7 concerns estimating the mean value of a variable in a large population from a small sample.

Chapters 8 through 10 focus on using attributes of a case to refine predictions. Chapter 8 deals with crosstabulations, presenting measures of strength of association and the chi-square test for the statistical significance of an association; the chapter also introduces the issues of multicollinearity and causal inference. Chapters 9 and 10 deal with bivariate and multivariate regression, respectively. Together the two chapters discuss data transformations, uncertainty in prediction, dummy variables, statistical inference, and problems in interpreting regression coefficients.

Chapter 11 focuses on comparative evaluation and experimental design, stressing the link between the structure of comparisons and their vulnerability to threats to internal and external validity. Chapter 11 also discusses randomization, matching, and the Mann-Whitney nonparametric test of the significance of differences between two sets of measurements.