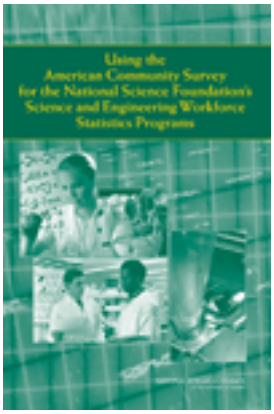

Using the American Community Survey for the National Science Foundation's Science and Engineering Workforce Statistics Programs

Panel to Assess the Benefits of the American Community Survey for the NSF Science Resources Statistics Division, Committee on National Statistics, National Research Council

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for the NSF Division of Science Resources Statistics

Committee on National Statistics

Division of Behavioral and Social Sciences and Education

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Acknowledgments

This report results from contributions and expertise provided by many individuals. First, I acknowledge and thank my fellow panel members, who offered their time and collective expertise in planning the October 2007 workshop, served as moderators and active participants during the workshop, and were full partners in writing this report.

Staff of the National Science Foundation (NSF) and the Census Bureau were incredibly helpful in assisting the panel's work and providing the information necessary for our making informed and realistic recommendations. The panel is grateful for their helpful presentations at the panel's two open meetings and their timely responses to the panel's numerous questions about their programs.

In particular, we thank Nirmala Kannankutty, who served as liaison between the panel staff and NSF and contributed very useful presentations on the work of the Division of Science Resources Statistics at NSF. Mary Frase and Stephen Cohen at NSF contributed to the discussions at the panel's meetings and provided helpful presentations on the NSF mandates and sample design options. The panel is also indebted to Ron Fecso, who prepared the original analysis of survey design options when he was on the staff of the NSF and continued to assist the panel with advice even after he had moved to the Government Accountability Office. Overall, the panel's work and the assistance we received from the NSF staff would not have been possible without the invaluable participation of Lynda Carlson, director of the Division.

Susan Schechter, Jennifer Tancreto, and Cheryl Landman from the Census Bureau expertly answered the panel's questions about the uses of the American Community Survey (ACS) and particular concerns surrounding NSF's and other users' needs for information on graduates' fields of degree. Ms. Tancreto's workshop presentation on the testing for the field-of-degree question and the timeline for testing offered the panel an essential framework for its work on the topic.

Several users of the Scientists and Engineers Statistical Data System program, including three panel members, offered insight on the varied options for research with these data at the workshop. The panel is grateful for the outside perspective on the important uses of the National Survey of College Graduates data provided by Donna Ginther of the University of Kansas and Sharon Levin of the University of Missouri at St. Louis.

In testimony before the panel, Graham Kalton, Westat, who had chaired the National Research Council (NRC) Panel on the Functionality and Usability of Data from the American Community Survey, offered a fresh perspective on the design options under discussion and helped guide the panel to consider a broader range of alternatives.

The panel acknowledges the excellent work of the staff of the Committee on National Statistics (CNSTAT) and the NRC for support in developing and organizing the workshop and this report. We are especially grateful for the excellent leadership of Tom Plewes, the panel's study director. Tom used his experience and wise counsel to facilitate communication among panel members and between the panel and the NSF staff and to keep the project on schedule. His attention to the needs of the panel was invaluable in the process of producing this report. Tom was ably assisted by Caryn Kuebler of the CNSTAT staff, and Michael Siri of the CNSTAT staff, who provided administrative support. The panel also benefited from the work of Eugenia Grohman of the Division of Behavioral and Social Sciences and Education for editing the report.

We are especially indebted to Constance F. Citro, CNSTAT director, for her general expertise and for sharing her extensive knowledge of the ACS. Her participation in the panel's meetings and deliberations benefited the report in numerous ways.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the Report Review Committee of the NRC. The purpose of this independent review is to provide candid and critical comments that assist the institution in making its report as sound as possible, and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

The panel thanks the following individuals for their review of this report: Barbara A. Bailar, consultant, Washington, DC; Richard Freeman, National Bureau of Economic Research, Cambridge, MA; Donna K. Ginther, Economics Department, University of Kansas; James M. Lepkowski, Institute for Social Research, University of Michigan; Sharon Lohr, Department of Mathematics and Statistics, Arizona State University; Sally C. Morton, Research Triangle Institute, Research Triangle, NC; and Paula E. Stephan, Department of Economics, Andrew Young School of Policy Studies, Georgia State University.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Richard Kulka, Abt Associates, Durham, NC. Appointed by the NRC, he was responsible for making certain that the independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests entirely with the authoring committee and the institution.

Hal Stern, *Chair*
Panel on Assessing the Benefits of the
American Community Survey for the
NSF Division of Science Resources Statistics

Contents

Executive Summary

As the sponsor of the National Survey of College Graduates (NSCG), the U.S. National Science Foundation (NSF) faces a series of challenges as well as opportunities associated with the elimination of the decennial census long form that has served as the basis for locating college graduates for the NSCG. In response, NSF has proposed to sample from the list of respondents to the new American Community Survey (ACS), using criteria similar to those used in past NSCG surveys.

The ACS now collects information that is roughly the same as that collected on the long form—the highest degree or level of school that the respondent has completed (Question 11, ACS-1), occupational and employment characteristics, and demographic characteristics. However, conversion to the ACS will not be an easy task. One drawback of the ACS is that this survey covers a smaller number of households in a given year than the long-form sample. The substitution of the ACS for the long form for sampling purposes is considered feasible because it is possible to identify a set of households that could serve as the sample frame for the NSCG by accumulating 2-3 years of ACS households. This issue, along with several others, needs to be resolved before the Census Bureau and NSF can shift from the long form to the ACS.

To assist in identifying and resolving those issues, the NSF's Division of Science Resources Statistics asked the Committee on National Statistics to form a committee to assess the benefits of the ACS to NSF. The committee was specifically charged to conduct a workshop with the objective of studying the issues involved in replacing the decennial census long

form with the ACS as a sampling frame for the NSCG and other human resources surveys and, specifically, to consider options for survey design in this new environment. The workshop had the additional objective of identifying issues for the collection of field-of-degree information on the ACS with regard to goals, content, statistical methodology, data quality, and data products. Finally, the committee was asked to consider the relevance and adequacy of ACS products for meeting current and emerging data needs for NSF. This report responds to that statement of work.

FINDINGS AND CONCLUSIONS

There are several important mandated uses embedded in the legislation that established NSF that direct the periodicity of the data and the kind of detail to be provided: updates are required every 2 years, and the main subpopulations of interest are females, minorities, and disabled people. In addition to these mandated uses, NSF in recent years has faced escalating demands for science and engineering (S&E) workforce data in response to such issues as globalization, competitiveness, the role of the S&E workforce in national economic growth, the dynamic nature of S&E workforce flows, and federal interventions to improve the health of U.S. science and engineering. Those uses require a robust collection of data on S&E workers. They also call for reexamination of the kind of data that have been collected in light of those uses.

This rethinking takes place in the context of an integrated database—the Scientists and Engineers Statistical Data System (SESTAT)—that includes data from three surveys that together offer a comprehensive picture of the S&E workforce. It is appropriate to reconsider elements of this system, particularly the design and content of the National Survey of Recent College Graduates (NSRCG), when data on the S&E workforce with field-of-degree information become available on a flow basis from the ACS. In these and other ways, the ACS is expected to have a major effect on the NSF's S&E workforce statistics program.

The committee finds that the upcoming changes for the NSF surveys are potentially very positive for NSF. These changes provide an opportunity to improve the NSCG sample and to enhance the timeliness, frequency, and quality of the S&E workforce data. Yet the transition to the ACS as a sample frame and as a source of data on the S&E workforce will create some challenges. There are significantly larger margins of error in ACS estimates than in estimates from the decennial census because of smaller sample sizes even when estimates are cumulated over 5 years. On balance, however, the committee concludes that the replacement of the decennial census long form with the ACS offers an opportunity for realizing NSF goals and objectives for the SESTAT Program.

The use of the ACS will afford an opportunity to review the SESTAT Program. This review should proceed as a priority, but any changes that stem from this review should be approached gingerly, with careful planning for transitioning to the new databases and a research program to underscore longer term revisions in the program. In that regard, the committee lays out and discusses three options for a research program that would provide support for decisions on the future of the SESTAT Program: (1) focusing only on data for mandated reports, (2) continuing the current range of surveys and reports, and (3) a preferred program that develops a collection program that expands the ability to analyze the S&E workforce and provides a more comprehensive, longitudinal dataset on the nation's S&E workforce. The committee could find no compelling rationale for eliminating any of the current components of the SESTAT Program. However, the availability of the ACS with a field-of-degree question affords an opportunity for fine-tuning and redirecting the surveys.

The timing of this study was such that the committee did not have the benefit of the results of a content test of the field-of-degree question for the ACS. On the basis of its examination of the potential benefits of the question, the committee concludes that an open-ended question would be more useful than a categorical one, but it is mindful that this version may not meet the evaluation criteria that have been established for the content test and may generate unacceptable costs for coding and editing.

CONCLUSIONS

The committee has carefully considered the four options for using the ACS as a sampling frame that were identified and presented to the committee by NSF staff. The committee included in its consideration a fifth option that was offered in the workshop.

- **Current Approach:** ACS data would be used once a decade to draw a new panel for the NSCG that would have the advantage of requiring the least amount of organizational change, meaning an easier transition. This option fails to take advantage of the yearly accumulation of ACS cases, which allows the Census Bureau to oversample rare groups (e.g., minorities) that were available on the long-form census samples, so the statistical error of the estimates for these groups of interest would increase. This option would continue the current peaks and valleys in the funding pattern in which a significant infusion of new funds is required once each decade to fund the replenishment of the sample. **The committee concludes that replicating the current design is not an efficient way to use the ACS.**

- **Selective Updates:** The once-each-decade sample draw would be modified by using the ACS in later years of a decade to update the sample for certain domains whose coverage becomes problematic as the decade progresses (e.g., recent immigrants) or for populations of emerging interest. Although this option would maintain the currency of the sample by preventing coverage losses and allowing gathering data on emerging issues, it requires a periodic major redesign, calls for the expensive draw of a very large sample periodically from the ACS and may create data series discontinuities. **The committee concludes that the disadvantages of the selective update design outweigh the potential advantages. However, selective subsamples could be considered to supplement another design to enable the study of subpopulations of emerging interest.**
- **Continuous Sample Updating:** A fresh sample from the ACS would be selected each time the NSCG is conducted, or, at least, more frequently than once a decade. This option would maintain the currency of the NSCG sample, permit oversampling of emerging or special interest populations during the decade, prevent discontinuities in the estimates, support trend analysis, and smooth out the NSF budget cycle. However, it would impose a burden on the ACS by requiring continuous access to the entire ACS sample for all years to derive the desired sample sizes for rare populations. It would also reduce (or eliminate) the longitudinal feature of the ACS. **The committee concludes that a freshly selected sample from the ACS each time the NSCG is conducted is not an efficient design, particularly for small populations. If rare populations were to be effectively studied, extensive and continuous use of the ACS sample would be required, which might preclude use of the ACS for other survey purposes.**
- **Rotating Sample Approach:** Select panels that represent the population would be rotated through the NSCG sample frame. This approach incorporates all of the coverage advantages of the selective updating option and has the additional advantage that the process of screening to identify scientists and engineers would be spread more evenly over time. There are obvious cost efficiencies in that replacing only a portion of the sample would smooth out data collection costs across time and avoid ballooning costs once a decade. However, this approach requires assured continuous access to the ACS sample for NSCG frame building, and the rotating panels may suffer from sample attrition over time. **The committee concludes that the rotating sample approach is the most promising of all the NSCG design options and that a biennial**

survey cycle with four or five rotating panels is the most efficient and cost-effective use of the ACS as a sampling frame.

In addition, the committee considered a hybrid design that would implement a rotating design for rare populations only, while a cross-sectional strategy would be used for the more populated groups of interest. Under this option, it would be possible to accumulate a sufficiently large number of sample cases for relatively rare populations to produce precise estimates and to capture the strength of the large number of sample cases to produce current estimates similar to those produced for other groups. However, there would be drawbacks: a limited ability to follow respondents over time and potential problems of panel conditioning over time. **The committee concludes that a hybrid approach using a rotating design for rare populations would have the drawback of not keeping time-in-sample constant across subpopulations and thus might lead to differential levels of nonsampling bias across subpopulations.**

RECOMMENDATIONS

There are exciting possibilities and promising venues of research and analysis of the science and engineering workforce that will be possible when the ACS with a field-of-degree item is made available. In this new environment, timeliness and efficiency gains will translate into a myriad of new opportunities that solve longstanding knowledge gaps. The committee urges NSF to seize the new opportunities and offers two overarching recommendations along those lines as well as several recommendations that address specific issues associated with adding the field-of-degree question to the ACS, using the ACS as the NSCG sampling frame, and looking to the future when the ACS with a field-of-degree question is fully available for both sampling and analytical purposes.

Overarching Recommendations

Recommendation 7.5: The National Science Foundation should use the opportunity afforded by the introduction of the American Community Survey as a sampling frame to reconsider the design of the Scientists and Engineers Statistical Data System (SESTAT) Program and the content of its component surveys.

Recommendation 7.6: The National Science Foundation should conduct a careful assessment of internal and user priorities for studying the science and engineering workforce to capitalize on

the expanded analytical opportunities afforded by the addition of a field-of-degree question to the American Community Survey.

Adding a Field-of-Degree Question to the ACS

Recommendation 5.1: The field-of-degree question on the American Community Survey questionnaire should be the open-ended version if the Census Bureau and the National Science Foundation agree that it meets the evaluation criteria established for the content test and if an efficient coding procedure can be developed.

Recommendation 5.2: The National Science Foundation should ask the Census Bureau to conduct an additional evaluation of the field-of-degree question to assess the validity of the responses provided by respondents. As part of this evaluation, a sample of individuals should be reinterviewed to determine if they do have degrees in the fields reported.

Using the ACS for the NSCG Sample Frame

Recommendation 6.1: The National Science Foundation should stipulate that the target population of people with bachelor's degrees be defined as of the beginning of the American Community Survey year.

Recommendation 6.2: If the National Science Foundation wishes to consider continuation of the National Survey of College Graduates with the sample drawn from the American Community Survey, the agency should use a rotating panel design.

Recommendation 6.3: The National Science Foundation should work with the Census Bureau to develop plans for using the American Community Survey as a sampling frame for a transitional period as well as for the continuing design.

Recommendation 6.4: The Census Bureau should use unswapped American Community Survey data (with sample weights) for drawing a National Survey of College Graduates sampling frame.

Recommendation 6.5: The National Science Foundation and the Census Bureau should initiate a program of research on imputation and nonresponse treatment for missing field-of-degree and education-level responses.

Recommendation 6.6: The National Science Foundation and the Census Bureau should sponsor a research program to explore means of permitting a sample draw from the American Community Survey for a rotation panel for the National Survey of College Graduates while preserving American Community Survey sample units for other surveys.

The ACS and SESTAT in the Future

Recommendation 7.1: The National Science Foundation should use current data from the American Community Survey to evaluate the degree to which the American Community Survey with the field-of-degree question would allow for the production of mandated indicator reports in the future.

Recommendation 7.2: If the American Community Survey is selected to produce indicator reports, the National Science Foundation and the Census Bureau should develop a supplemental program of special, targeted surveys to obtain information on topics and groups of interest.

Recommendation 7.3: The National Science Foundation and the Census Bureau should consider establishing a continuing experimental panel program to support testing and development of techniques and methods for the National Survey of College Graduates.

Recommendation 7.4: The National Science Foundation should sponsor the development of a matched sample of American Community Survey and National Survey of College Graduates respondents for research purposes with access provided to researchers through the Census Bureau's Research Data Centers.

1

Introduction

The U.S. National Science Foundation (NSF) has long collected information on the number and characteristics of individuals with education or employment in science and engineering and related fields in the United States. One of the three vehicles employed by NSF for collecting this information is the National Survey of College Graduates (NSCG). This survey is a key component in a group of three surveys of scientists and engineers conducted by the Division of Science Resources Statistics of NSF: the other two are the National Survey of Recent College Graduates (NSRCG) and the Survey of Doctorate Recipients (SDR).

The NSCG covers people with at least a bachelor's degree by a given reference date. The NSRCG complements these data with information on people with recent college degrees at the bachelor's or master's level and the SDR covers Ph.D. scientists and engineers in some detail. These workforce surveys make up the Scientists and Engineers Statistical Data System (SESTAT). (For a list of acronyms and abbreviations used in this report, see Box 1-1.)

These surveys provide critical information on the education and career outcomes of the nation's college-educated workforce, including salaries, occupations, and whether the individuals are working in their highest degree field of study. An important motivation for this effort is to fulfill a congressional mandate to monitor the status of women and minorities in the science and engineering workforce. Consequently, many statistics are calculated by race or ethnicity, gender, and disability status.

BOX 1-1
Acronyms and Abbreviations

ACS	American Community Survey
AHS	American Housing Survey
B&B	Baccalaureate and Beyond Survey
CAPI	computer-assisted personal interviewing
CATI	computer-assisted telephone interviewing
CNSTAT	Committee on National Statistics
CPS	Current Population Survey
HREP	Human Resources Experts Panel
MAF	Master Address File
NESARC	National Epidemiologic Survey on Alcohol and Related Conditions
NLS	National Longitudinal Survey
NSCG	National Survey of College Graduates
NSF	U.S. National Science Foundation
NSRCG	National Survey of Recent College Graduates
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy, Executive Office of the President
PSID	Panel Study of Income Dynamics
S&E	science and engineering
SDR	Survey of Doctorate Recipients
SED	Survey of Earned Doctorates
SESTAT	Scientists and Engineers Statistical Data System
SIPP	Survey of Income and Program Participation
SRS	Division of Science Resources Statistics, U.S. National Science Foundation
WMPD	*Women, Minorities, and Persons with Disabilities Report*

The three surveys are coordinated to provide complete coverage of the science and engineering workforce every 2-3 years.

For more than 25 years, NSF obtained a sample frame for identifying the target population for the NSCG from the list of respondents to the decennial census long form who indicated that they had earned a bachelor's or higher degree. The probability that an individual was sampled from this list was dependent on both demographic and employment characteristics. The source for the sample frame will no longer be available because the census long form is being replaced as of the 2010 census with the continuous collection of detailed demographic and other information in the new American Community Survey (ACS).

PANEL CHARGE AND APPROACH

At the request of NSF's Division of Science Resources Statistics, the Committee on National Statistics of the National Research Council formed a panel to conduct a workshop and study the issues involved in replacing the decennial census long-form sample with a sample from the ACS to serve as the frame for the NSCG and, perhaps, other science and engineering human resources surveys. The workshop had the specific objective of identifying issues for the collection of field of degree information on the ACS with regard to goals, content, statistical methodology, data quality, and data products. In the context of the workshop, the Panel on Assessing the Benefits of the American Community Survey for the NSF Division of Science Resources Statistics was asked to review NSF's assessment of the potential of the addition of this information as a screening element for subsequent inquiries such as the NSCG, which now uses level of degree information from the decennial census long form. The panel was charged, as well, with considering the relevance and adequacy of ACS products for meeting current and emerging data needs for NSF, as well as potential analytical uses of information on graduates' fields of degree that is proposed to be collected on the ACS. These tasks were assigned in order to assist NSF in enhancing the analytical content of the NSCG and meeting the needs of data users.

The panel held two meetings and the workshop. At its first meeting, the panel had the benefit of a comprehensive staff paper from NSF (2007) and extensive briefings by representatives of NSF and the Census Bureau. The panel then conducted the workshop, which included presentations from NSF and Census Bureau staff, other subject-matter experts, and interested data users. The workshop participants considered NSF's assessment of the potential of the addition of the field-of-degree information as a screening element for subsequent inquiries. The participants also considered the relevance and adequacy of ACS planned products for meeting current and emerging science and engineering workforce data needs. The agenda and a workshop summary are in Appendix A.

GUIDE TO THE REPORT

SESTAT is the key context for understanding the NSCG, so Chapter 2 details the SESTAT data system, its components, and the uses of the SESTAT data. Some of the uses are mandated in law, directives, and tradition, and others are designated for the support of analysis of the science and engineering workforce. Chapter 3 discusses the NSCG, the survey that will be most affected by a change from the census long form to the ACS for the sampling frame, and it provides a broad comparison of the long form and the ACS in that vein.

In Chapter 4 the panel discusses the ACS in more detail, focusing on its potential for changing the SESTAT Program. A very important aspect of the ACS for NSF involves the potential addition of a question on field of degree, which is discussed in this chapter. Chapter 5 examines the issue of adding a field-of-degree question to the ACS, while Chapter 6 discusses in detail the pros and cons of using the ACS with the field-of-degree question as a sampling frame for the NSCG (and other NSF surveys). The final chapter responds to the panel's charge to consider potential future improvements in the ability to understand the nation's science and engineering workforce when the ACS is available for sampling and analysis purposes.

2

The Scientists and Engineers Statistical Data System

For the most part, this report focuses on the National Survey of College Graduates (NSCG). The NSCG is the survey that will be immediately and significantly affected by the switch to the American Community Survey (ACS) as a sample frame and will benefit from the addition of a field-of-degree question on the ACS. However, the NSCG is nested in a group of three surveys that comprise a carefully constructed system of information on the science and engineering workforce, the Scientists and Engineers Statistical Data System (SESTAT). Consequently, the issues associated with the conversion to the ACS as a sample frame must be considered in the larger context of SESTAT.

In this chapter we describe the SESTAT data system. We then turn to a discussion of mandatory requirements and user needs for the SESTAT data, and discuss data elements and series that are of special interest and that should be taken into account when designing a SESTAT data system for the future.

SCOPE OF SESTAT

The SESTAT surveys include the NSCG, the National Survey of Recent College Graduates (NSRCG), and the Survey of Doctorate Recipients (SDR). These three large surveys, with more than 100,000 total respondents drawn from separate sampling frames, cover more than 21 million people. The three surveys have been thoughtfully integrated in that they use nearly identical data collection instruments and data processing

procedures; they are fielded at the same time and they use the same reference period.[1] They have been designed to provide coverage of the same target population: noninstitutionalized individuals residing in the United States, under 75 years of age, with a bachelor's or higher degree, and educated or working in science and engineering (S&E) and related fields and occupations. Scientists and engineers are those who hold a bachelor's or higher degree in an S&E or S&E-related field or who have a bachelor's or higher degree in a non-S&E field but have an S&E or S&E-related occupation. Special emphasis in the surveys is given to relatively rare populations, such as doctorates, recent graduates, minorities, and people with disabilities.

All cases that qualify as scientists and engineers according to the SESTAT target population definition are integrated into a comprehensive database, the SESTAT integrated file, of all college-educated scientists and engineers in the United States. Because a person may be eligible for inclusion in more than one of the surveys, the National Science Foundation (NSF) uses a sophisticated method to ensure that each person is counted only once.[2] The integrated file is used to produce national estimates of the number and characteristics of scientists and engineers in the United States.

The SESTAT surveys are unique in the federal system in that they compile detailed occupational, educational, and demographic data in one database. The complete educational histories that are collected for each person allow for a detailed examination of the relationship between education and career outcomes.

The SESTAT surveys are conducted every 2-3 years and are designed, primarily, to provide cross-sectional time-series data. However, an important new analytical dimension to the surveys was added when SESTAT individual data were assembled into longitudinal files that were prepared for the period from 1993 to 1999. The history of the SESTAT Program and the interrelationship between the component surveys is shown in Figure 2-1.

[1]For further information on SESTAT, see http://sestat.nsf.gov; for NSCG, see http://www.nsf.gov/statistics/srvygrads; for NSRCG, see http://www.nsf.gov/statistics/srvyrecentgrads; and for SDR, see http://www.nsf.gov/statistics/srvydoctoratework [accessed April 2008].

[2]The statistical integration process uses a unique linkage rule. Each survey is weighted according to the frame developed for that survey and a series of overlap variables are calculated that allow for the identification of cases that are eligible for more than one survey. To remove these multiple selection opportunities, each case in the SESTAT target population is uniquely linked to one and only one component survey, and that individual is included in the SESTAT integrated file only when he or she is selected for that linked survey.

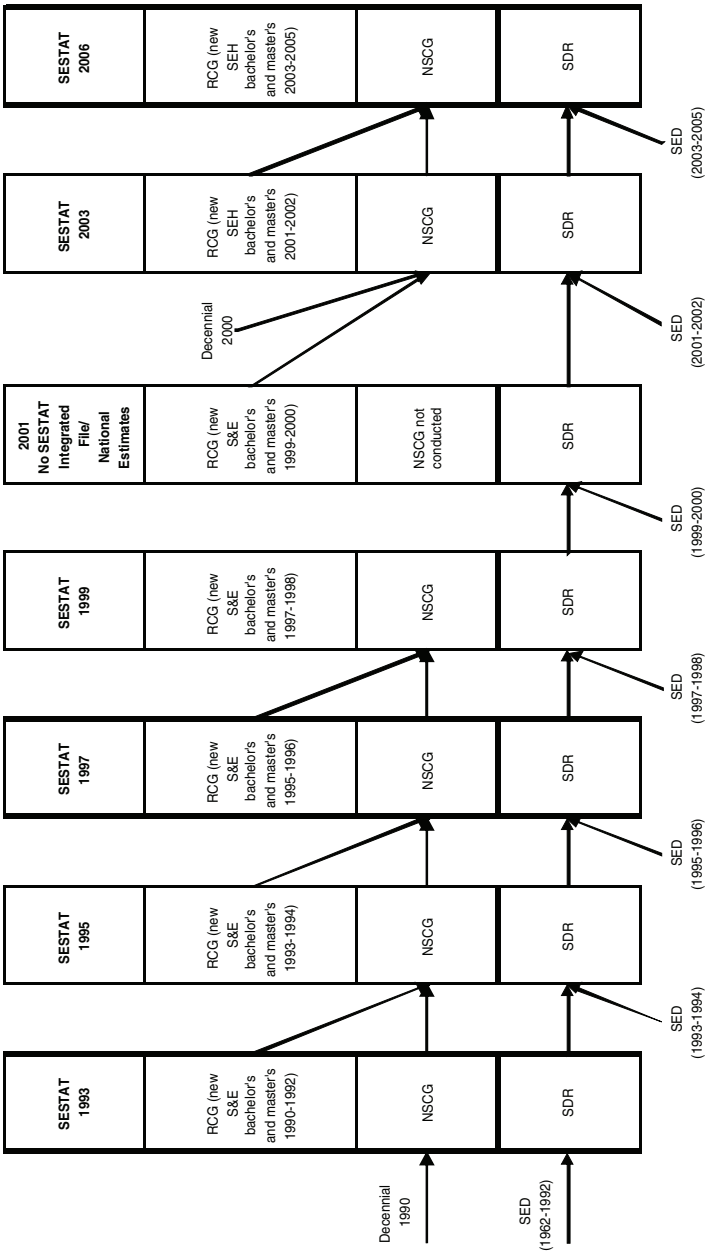

FIGURE 2-1 SESTAT surveys.
NOTE: SESTAT = Scientists and Engineers Statistical Data System, RCG = National Survey of Recent College Graduates, S&E = science and engineering, NSCG = National Survey of College Graduates, SDR = Survey of Doctorate Recipients, SED = Survey of Earned Doctorates.
SOURCE: National Science Foundation (2007, p. 6)

SESTAT is complex in that it represents both stocks and flows of scientists and engineers:

- The NSCG, which provides the majority of cases in the SESTAT integrated database, represents the "stock" of scientists and engineers at the beginning of the decade. A new panel has been selected at the beginning of each decade for the NSCG. Respondents to the NSCG who are identified as eligible respondents are included in the NSCG follow-up surveys for the rest of the decade.
- The NSRCG captures the "flow" of new U.S. graduates with bachelor's and master's degrees in science, engineering, and health. It is a two-stage, cross-sectional survey: first, a sample of institutions; and second, a sample of graduates from those institutions. In addition to providing flow information on new graduations, the NSRCG provides a subsample that is followed in the NSCG (as part of the stock).
- The SDR provides data on the stock of experienced workers with U.S. doctorates, as well as the flow of new U.S. doctorates in science, engineering, and health fields. The target population for the SDR is all people with doctoral degrees in those fields awarded at U.S. institutions. The overall sample size of the SDR is held steady, while for each new round a sample of new doctorates is added to the sample from its frame, the Survey of Earned Doctorates (SED).

A summary of information about the three components of the SESTAT program is shown in an NSF-produced table, shown here as Table 2-1. All three surveys are collected with a combination of mail and computer-assisted telephone interviewing (CATI) and in some years, the NSCG uses computer-assisted personal interviewing (CAPI) follow-up as well. The program has been developing a web-based collection option for the NSRCG and the SDR in the last two rounds.

The response rates shown in Table 2-1 deserve some explanation. The NSCG response rates for 1993 and 2003 are the rates for the initial (full coverage) sample as selected from the census long-form records and do not include "carryover" sample units from the prior decade. There are two response rates shown for the later years of NSCG—"conditional" response rates pertaining to the sample of respondents from previous cycles (including supplemental cases from the NSRCG) and "unconditional" response rates pertaining to the original decennial sample. The response rates shown for the NSRCG and the SDR are "unconditional" response rates pertaining to the cross-sectional samples that were selected for the particular years.

TABLE 2-1 SESTAT Survey Characteristics, 1993-2006

National Survey of College Graduates (NSCG)							
	1993	1995	1997	1999		2003	2006
Survey mode	m/c/p	m/c/p	m/c/p	m/c		m/c/p	m/c
Sample size[a]	214,643	61,897	46,075	35,714		170,800	59,349
Unweighted response rate							
Conditional	78%	95%	94%	91%		63%	88%
Unconditional	78%	74%	70%	63%		63%	55%
National Survey of Recent College Graduates (NSRCG)							
	1993	1995	1997	1999	2001	2003	2006
Survey mode	c/m	c/m	c/m	c/m	c/m	m/c/w	m/c
Sample size	25,785	21,000	14,057	13,918	13,513	18,000[b]	27,000[c]
Unweighted response rate	86%	86%	82%	79%	80%	66%	68%
Survey of Doctorate Recipients (SDR)							
	1993	1995	1997	1999	2001	2003	2006
Survey mode	m/c	m/c	m/c	m/c	m/c	m/c/w	m/c/w
Sample size	49,228	49,829	54,103	40,000	40,000	40,000	45,000c
Unweighted response rate	87%	77%	85%	82%	82%	79%	79%

NOTE: m = mail; c = computer-assisted telephone interviewing (CATI); p = computer-assisted personal interviewing (CAPI); w = web-based.

[a]Includes only sample originally from the decennial census; does not include sample updates from the NSRCG.

[b]Sample size increase because health fields were added to the NSRCG.

[c]Sample size increase due to the sampling of three graduating cohorts instead of two.

SOURCE: National Science Foundation, Response to Committee Questions, October 11, 2007.

MANDATED REQUIREMENTS

The legislation that established NSF contained a provision that Congress has mandated the agency "to provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources and to provide a source of information for policy formulation by other agencies of the Federal Government" (NSF Act of 1950, as amended; 42 U.S.C. 1862). A critical component of this mission is information on the science and engineering workforce in the United States.

NSF is also mandated to produce two biennial reports, *Science and Engineering Indicators* and *Women, Minorities, and Persons with Disabilities*

(WMPD). The mandate for *Indicators* is broad, requiring NSF to report on the status of science and engineering in the United States. The mandate is not specific about what topics should be covered, but the scientific workforce is clearly an important component of the S&E enterprise. The mandate for the *WMPD* is more specific. The Science and Engineering Equal Opportunities Act of 1980 (Public Law 96-516) mandated NSF to ensure that obtaining information on women, minority group members, and people with disabilities in the S&E workforce was an important consideration in data collection and analysis. The two reports require new workforce data every report cycle, which is every 2 years.

From nearly the beginning of NSF, there have been efforts to provide comprehensive information about the highly skilled technical workforce, starting initially as a registry of people who should be included and then expanding to surveys. The NSCG is particularly important because it has the most comprehensive coverage of the surveys that contribute to SESTAT. It is the only one that captures an increasingly important and growing segment of the S&E workforce: immigrants who received none of their higher education in the United States.

USER NEEDS

Workforce data are used in a variety of ways beyond fulfilling the legislative mandates. In recent years, the demand for S&E workforce data has increased as attention has been focused on issues of globalization, competitiveness, the role of the S&E workforce in national economic growth, the dynamic nature of workforce flows, and federal interventions to improve the health of U.S. science and engineering. The need for an adequate base of knowledge to be able to assess the effects of interventions and to better understand the complex system that educates and sustains a science and engineering workforce was recognized by a National Science Board (2003) study that recommended that the federal government lead a national effort to build a base of information on the current status of the S&E workforce.

This concern was echoed in a blue ribbon conference sponsored by the Office of Science and Technology Policy (OSTP) and the Sloan Foundation in late 2003. The conference report (Kelly et al., 2004) identified a number of "grand challenges" in the S&E workforce area that NSF would face, including the need to improve the estimate of the stock of scientists and engineers past the start of the decade (when the decennial census data are fresh and include a current estimate of immigrant scientists and engineers), fix problems with data on rare populations (such as persons with disabilities and foreign students), and integrate the workforce data with information from other NSF surveys on research and development.

Two recent federal government initiatives, fostered in large part by the report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007) are predicated on the need for better data on the S&E workforce. One is the NSF's Science of Science and Innovation Policy. This is a new funding channel which will underwrite fundamental research that creates new explanatory models and analytic tools designed to inform the nation's public and private sectors about the processes through which investments in science and engineering research are transformed into social and economic outcomes.[3]

The second initiative is the American Competitiveness Initiative, which funds federal investment in research and development (Office of Science and Technology Policy, 2006). It identifies NSF, the Department of Energy's Office of Science, the National Institute for Standards and Technology, and the Department of Defense as key agencies, and it emphasizes workforce education and training by seeking to increase access to college and to recruit and retain students in science, technology, engineering, and mathematics majors at the undergraduate and graduate levels. These and other initiatives will depend critically on a well-grounded information system to assist decision making and to measure progress toward national goals.

In reevaluating SESTAT for the 2000 decade, in January 2008, NSF undertook a comprehensive effort to gain input from a wide variety of users. The effort included focus groups, invited papers, and a variety of panel and information meetings to obtain input from federal agencies, academic researchers, policy makers, and other stakeholders who use the SESTAT surveys. NSF also contacted a variety of people who were not users to ask why they were not using SESTAT data for their research or other purposes (personal communication, NSF staff).

In response to the needs of users as expressed in these studies and initiatives, NSF has identified some common research questions that the SESTAT surveys are called on to address.[4]

- How many U.S. scientists and engineers were born abroad or have a degree from foreign countries?
- What are the labor force outcomes by degree field for college graduates?
- How do these vary by gender, race, and ethnicity?

[3]See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=501084 [accessed April 2008].

[4]Presentation by Nirmala Kannankutty, NSF. Panel workshop. October 5, 2007.

- What are the economic returns associated with additional degrees in S&E and related fields?
- What are the salary and occupational differences between those with and without S&E and related degrees?
- How have labor market conditions changed over the past decade for people with and without S&E degrees and working in S&E occupations and other occupations?
- How does job satisfaction vary by degree field and occupation?

The task of providing answers to these important analytical questions is a significant challenge for NSF. It is even more challenging when particular information needs are taken into account, as detailed in the next section.

GROUPS OF INTEREST AND KINDS OF DATA

Immigrants

Science is a global enterprise, and the impact of foreign-born scientists on U.S. competitiveness has been profound. The National Science Board (2006, p. 3-32) estimates that "foreign-born scientists are more than a quarter, and possibly more than a third, of the S&E doctorate degree labor force, and are even more important in many physical science, engineering, and computer fields." The percentage of foreign-born college graduates (including with either U.S. or foreign degrees) in S&E jobs has been growing: it increased from 11.2 percent of the workforce in 1980 to 19.3 percent in 2000 (National Science Board, 2006, p. 3-19).

The NSCG plays a critical role in addressing the current gaps in coverage of immigrants in SRS surveys. It provides information on non-U.S.-educated immigrants once each decade and is the only NSF survey that is able to do so because all the other surveys use U.S. higher education institutions as a sample frame. International immigration patterns play an important role in understanding the flows of the highly trained scientists and engineers. NSF attempted to obtain information on educated immigrants from the U.S. Department of Homeland Security but could not do so because individual records are considered confidential.

Graduates from Non-S&E Fields

The concept of "science and engineering" has evolved in NSF with respect to the SESTAT surveys. In the early history of the surveys, science and engineering was defined on the basis of the fields of science that were supported by NSF, with a focus on individuals with bachelor's or higher

degrees. In advance of the 1990s SESTAT redesign, one of the major recommendations from a National Research Council (1989) study was that NSF should cast a wider net with respect to the fields and occupations that were covered so that analysts could obtain a broader picture of the workforce.

NSF decided to implement this recommendation in its redesign of the NSCG, which also involved using the census long form as the sampling frame. However, because the census did not include information on respondents' field of degree, the NSCG had to include all college degree holders as its target population. The decision provided NSF with another valuable context in which to present the S&E workforce data—a comparison of college graduates with and without science and engineering degrees. After the 1993 and 2003 NSCG surveys, NSF conducted such comparisons. These comparisons have become a standard part of the *Science and Engineering Indicators* workforce chapter.

In implementing this change, the definition of the "non-S&E workforce" was reconsidered. Science and engineering fields and occupations have generally been defined by five broad categories: computer and mathematic sciences; biological sciences and scientists; physical sciences and scientists; social sciences and scientists; and engineering and engineers. Although everyone who reports holding at least one degree in one of these fields should be counted in the NSF science and engineering workforce data, not all are. In the post-censal NSCG, only the cases that were eligible to be followed in subsequent cycles of the NSCG were considered to meet the definition.

Another definitional issue involves important elements of non-S&E degrees and occupations. Specifically, there is a set of degrees and occupations that require attainment of scientific or mathematical skills or the use of these skills in a job, such as health occupations and technical support jobs in several fields. Although NSF recognized that there is a connection to science and engineering in the education or jobs of people with such training or jobs, the SESTAT surveys did not include all of them because of operational limits to coverage.[5]

Over the past decade or so, the population of those without an S&E degree working in S&E occupations has been expanding, in part as a result of growth in information technology fields. When NSF was evaluating coverage issues for the 2000 surveys, there was a conscious effort to expand coverage to include some of the non-S&E degrees and occupa-

[5]One exception is the SDR, which has always included people with health doctorates in the target population. However, in the 1990s SESTAT files, these were considered S&E cases, while people with bachelor's or master's degrees in health fields were considered non-S&E cases.

tions that had a close relationship to science and engineering. The two-tiered taxonomy was converted to a three-tiered taxonomy: S&E fields, S&E-related fields, and non-S&E fields.

Within the new taxonomy, the S&E definition and coverage did not change. The previous non-S&E group was split into two components—S&E related and non-S&E related. For the NSCG, there was no change in follow-up plans with regard to the non-S&E cases. The S&E-related group was created to allow for better coverage of the degrees and occupations in this group. The S&E-related group included the specified degrees and occupations: the degrees covered were those in health sciences, science and mathematics teacher education, and technology and technical fields; the occupations covered were health scientists, secondary teachers of science and mathematics, S&E managers, and technicians and technologists in science and engineering. For the NSCG, follow-up after the postcensal year was expanded to include people with S&E-related degrees or occupations. No changes were made to the SDR because of this change, since people with doctorates in health fields had always been included in the SDR. For the NSRCG, sampling was expanded to include people with bachelors' and master's degrees in health fields.

In practice, SESTAT coverage has expanded only for health degrees and occupations to make them as comprehensive as the data for S&E fields. To rectify the problem of partial coverage for other S&E-related fields and occupations, NSF has included a broader set of cases from the NSCG for follow-up.

Despite the importance of uses of the non-S&E workforce data, the need for these data is considered less critical for NSF than for the S&E and S&E-related data. For purely NSF uses, it may not be necessary to continue past practices of sampling large numbers of non-S&E cases. In part, this sampling scheme was an artifact of the type of information available on the census long form that was used for sampling. With the addition of a field-of-degree question to the ACS, the NSCG sample could focus more on S&E and S&E-related cases, with less emphasis on non-S&E cases, so there would likely be fewer cases sampled from the last group (except for people with health doctorates, as explained above). To the extent that non-S&E data are still necessary or wanted, it might be possible to include a representative (if smaller) samples of non-S&E cases, or it might be possible to ask questions on the NSCG that mirror questions on the Current Population Survey (CPS) or ACS questions so that information about NSCG S&E cases can be interpreted relative to all college graduates.

Associate Degree Holders

A significant number of the S&E workforce does not have bachelor's degrees, particularly among S&E technicians and technologists. There

were two motivations for seeking data related to sub-baccalaureate education that users identified: understanding the role of community colleges for those earning higher degrees in science and engineering and understanding the population of technologists and technicians who support science and engineering work in the United States. For the first need, NSF has included questions on the SESTAT surveys and the SED to gather information about community college attendance for those earning a bachelor's degree or higher. For the second need (which has a lower priority for the agency), NSF has investigated other data sources to see if it was possible to meet the interests in data on associate's degree holders, given the substantial increases in survey operations (and costs) necessary to expand the Division of Science Resources Statistics (SRS), NSF surveys to cover this population. If use of the ACS creates cost efficiencies, it may be possible to reconsider the inclusion of those with associate's degrees in the SESTAT target population.

NSF has determined that some information could be obtained from the CPS. Earlier this year, NSF published a working paper comparing SESTAT and CPS, which covered the types of analysis that could be done with CPS to report on the below-the-baccalaureate population (Tsapogas et al., 2007). The National Center for Education Statistics (NCES) also has a series of surveys that could be used for analysis of the associate's degree population. The ACS could provide a rich source of data on this population, though, unfortunately, not by field of degree since that question will only be asked of those with a bachelor's degree or higher.

To assure a continuous flow of advice from users, NSF has created a Human Resources Experts Panel (HREP) comprised of users of its human resources data. This panel will provide SRS advice about relevant data and policy issues related to graduate education and the S&E workforce. The HREP is scheduled to meet at least twice a year; the first meeting was held on October 11, 2007.

Longitudinal Data

All of the SESTAT surveys have been designed to produce cross-sectional estimates for their individual target populations and for use in the SESTAT integrated database. However, some respondents in all three of the SESTAT surveys are treated as panel cases that are eligible for follow-up in subsequent years. This ability to longitudinally follow persons over time has been related to the use of the decennial census long form as the sample frame. By tying the sample frame to the decennial census, a new frame was available only once a decade so a very large sample had to be drawn to identify persons eligible for inclusion in the postcensal survey. There was no advantage to selecting a new sample later in the decade as there was no updated frame and the extensive screening

to identify eligible cases (and the substantial costs involved) would have to be repeated. In addition, the selection of the decennial census as the frame spawned a longitudinal design that, in turn, provided stability to the estimates over time.

The design enables analysts to track changes in status, such as career paths over time, but analysts need to have longitudinal weights to generate estimates in order to fully exploit the potential of the longitudinal character of the survey. Until recently, only cross-sectional weights were available so an individual case's weight was permitted to fluctuate over time. NSF remedied this in a decision to develop longitudinal weights for the 1990s SESTAT integrated files to enhance the analytic capability of the panel data.

Developing longitudinal weights was a complex effort, as there were some elements of the individual survey designs and decisions on which cases were eligible for follow-up that limited the number of cases for which weights could be developed, which affected the weighting methodology. After reviewing a variety of options, NSF developed a set of longitudinal weights for the 1993-1999 integrated SESTAT data that worked around these limitations.[6]

The longitudinal weights that were developed were originally intended primarily for internal use by NSF. In recent years, NSF has been devoting substantially more resources to support data use by external users. For example, a user guide has been developed that explains to users what the limitations are and how to use the longitudinal weights; NSF has also written a short analytic piece that shows examples of how the longitudinal files could be used. The longitudinal data files are expected to be available for release to licensees when this analytic piece has been fully reviewed and released. Because there are users who have expressed an interest in these files, NSF expects them to be used immediately upon release (personal communication, NSF staff). As a result of this increased attention and the devotion of resources to this capability, it is likely that the number of users of longitudinal data will continue to grow and the demand for the data will increase as well.

Recent College Graduates

As an associated issue, the panel considered the continued need for data on recent college graduates that now comes mainly from the NSRCG. NSF reported to the panel that it is difficult to identify a mandated NSF need for the NSRCG data in and of itself. Although NSF and some outside users do make some analytical use of the data, it is not clear how much

[6]Three sets of longitudinal weights were developed: 1993-1995, 1993-1997, and 1993-1999.

the data elements collected in the NSRCG benefit the analytical community. However, there is some indication that NSRCG data are useful for employers and government to understand and predict trends in graduate school enrollment, employment opportunities, and salaries for recent graduates in S&E fields.

Part of the reason that there are so few uses of the survey data has to do with limitations in the design of the NSRCG. It is essentially a repeated cross-sectional survey so the NSRCG has limited utility for longitudinal analysis. NSF is not able to follow the respondents over time because of the loss of cases from sampling down of NSRCG cases in subsequent survey rounds and the practice of dropping of cases when the individual earns another eligible degree after the degree for which they were sampled for the NSRCG.

To the extent that data on this population are needed, there appear to be other options. For example, the NCES has a longitudinal survey of recent graduates, Baccalaureate and Beyond (B&B), which follows a cohort of master's and bachelor's degree recipients for a few years. A new B&B cohort is started about once a decade. B&B surveys recent graduates in all fields, with a particular focus on studying those who enter and remain in teaching at the K-12 level. The amount of analysis that is possible with B&B data for detailed S&E fields is currently limited by small sample sizes.[7]

[7]The 2000 cohort for the B&B survey numbered only about 10,000 sample cases; for details, see http://nces.ed.gov/programs/quarterly/Vol_5/5_3/5_2.asp#5 [accessed February 2008].

3

The National Survey of College Graduates

The National Survey of College Graduates (NSCG) is the one National Science Foundation (NSF) survey most likely to be directly affected by the new American Community Survey (ACS); consequently, the panel paid special attention to it in its work. It is expected that the NSCG will be subject to substantial changes in the next several years, and change has been frequent for the NSCG since its inception in 1962; changes in sample design and content have been made with some frequency.

HISTORY AND DESIGN

The NSCG survey began in 1962 when NSF and other agencies sponsored a single, cross-sectional survey (the Postcensal Manpower Survey), with a sample derived from the long form of the 1960 decennial census to collect information on science and engineering personnel resources. A decade later, NSF sponsored the Professional, Technical and Scientific Manpower Survey, again drawing the sample from the decennial census, and the agency introduced smaller follow-up surveys using the same sample through 1978. This pattern was continued in the 1980s, when NSF again conducted a postcensal survey with follow-ups through 1989.

The survey that is now known as the NSCG emerged after a major redesign following the 1990 census. The post-1990 design continues an earlier data collection strategy of a large postcensal (baseline) survey, with smaller follow-up surveys during the remainder of the decade.[1] Since

[1]The redesign was largely based on recommendations in a report of the Committee on National Statistics (National Research Council, 1989).

then, the baseline decennial NSCG has served two purposes: to provide a once in a decade view of all college graduates in the United States and to act as a screening device (through detailed educational histories collected in the NSCG) for obtaining a sample of scientists and engineers for the integrated Scientists and Engineers Statistical Data System (SESTAT) file. The baseline was necessary because the decennial census long form contained information only on educational attainment, so it was not possible to identify people with science and engineering degrees.

Thus, the NSCG has a long history in which the Census Bureau has created a sampling frame based on responses to the decennial census long form at the beginning of each of the last four decades and has drawn a baseline NSCG sample from that sample frame. The baseline sample consists of long-form respondents with a bachelor's degree or higher at the time of the census. Because field-of-degree information was not available on the long form, occupations were used to begin the process of identifying respondents for the NSCG. To capture the entire stock of scientists and engineers, long-form respondents from both science and engineering (S&E) occupations and non-S&E occupations with a high likelihood of being held by someone with an S&E degree were given a chance of selection into the NSCG sample. This additional group was included because a high proportion of people with S&E or S&E-related degrees do not work in S&E or S&E-related occupations. They were either working in a non-S&E occupation or were not working. As a result of using this occupation-based sample design rather than a field-of-degree-based sample design, the NSCG is the only source of information for the SESTAT integrated database that cross-classifies people with non-S&E degrees by whether they work in S&E or S&E-related occupations. These cross-classifications are shown in Table 3-1.

The postcensal NSCG has used a reasonably complex, two-stage, random sample design. In the first stage, households are sampled from the census long-form sample using a stratified systematic sample, with differing sampling rates for administrative areas of different sizes (sampling rate of between 1 in 12 and 1 in 16). The second stage subsampled people from within those households who are in the target population.

The census long form yielded the several major sampling variables used to create the strata for the frame. In 2003, these variables were educational attainment (bachelor's degree or higher) by highest degree level achieved, occupation, demographic group (which combines citizenship, race and ethnicity, and disability status), and gender. Within each stratum, individuals were selected using probability-proportional-to-size (PPS) systematic sampling. Weighting was facilitated by the fact that the long-form sampling weight was used as the size measure for selection. This approach compensated as much as possible for the differing long-form

TABLE 3-1 Degree Field and Occupation, 2003 NSCG Respondents

Degree/Occupational Status	S&E Occupation	S&E-Related Occupation	Non-S&E Occupation	Not Working	Total
At least one S&E degree	22,669	6,676	13,959	7,877	51,181
No S&E degree but at least one S&E-related degree	1,135	5,637	2,130	1,623	10,525
No S&E or S&E-related degree	2,897	1,901	26,020	7,878	38,696
Total	26,701	14,214	42,109	17,378	100,402

SOURCE: National Science Foundation (2007, p. 7).

sampling rates and came close to establishing an overall self-weighting sample within each of the above second phase strata.

Additional precision in determining eligibility for the follow-up NSCG surveys throughout the decade is afforded by data collected in the postcensal NSCG baseline survey. The major item that has been added by the baseline survey is the field of degree. Thus, the sampling variables for the follow-up surveys have included the field of highest S&E degree as well as the original sampling strata.

LIMITATIONS OF THE CENSUS LONG FORM AS THE SAMPLING FRAME

The fact that the NSCG is derived from the decennial census has vexed some users of the survey over the years. Access to the raw data, important for both understanding the quality of the data and for analytical uses, is severely limited because records derived from confidential decennial census records are protected by Title 13 and can be used only under specific Census Bureau supervision.

Another major issue has been the lag in timing of the availability of the NSCG data because it is linked to the decennial census. Because of the time needed to process the decennial census and make the data available for NSCG sampling, the postcensal baseline NSCG has generally been fielded about 3 years after the decennial census. These issues are endemic to the operation of the decennial census and the result of long-standing practices.

A recent study for NSF highlighted several other sample selection and coverage problems related to the content of the decennial census long

form (Fecso et al., 2007a), including efficiency, missing groups, declining response rates, and loss of historical continuity.

Efficiency

The census long form has been an inefficient means for identifying those with S&E degrees mainly because of the lack of information that would allow identification of those with science, engineering, and health degrees. As shown in Table 3-2, this has been a historical problem. In 1993, a selection of about 215,000 individuals for the NSCG sample from the decennial long-form sample frame yielded only about 75,000 cases that met NSF's definition of a scientist or engineer and therefore were eligible for the SESTAT integrated database and the NSCG follow-up surveys.

The efficiency of the process was slightly improved after the 2000 census even though the target population was expanded to include S&E-related degrees and occupations. In 2003, the 171,000 people selected from the 2000 census long-form sample frame yielded 67,000 cases with S&E and S&E-related degrees or occupations. Despite this slight improvement, the process of identifying the target population in the absence of a field-of-degree question can only be described as inefficient.

There was one positive side effect of this sampling inefficiency. Using the postcensal survey as a screening mechanism made possible valuable comparisons of scientists and engineers with non-S&E degree holders. However, this comparison was only possible once in a decade (the year of the postcensal survey) because non-S&E individuals were not part of the follow-up sample frame.

TABLE 3-2 Yield of SESTAT-Eligible Cases from the 1993 and 2003 NSCG

Characteristic	1993 NSCG	2003 NSCG
Sample Size	214,643	170,800
Respondents	148,905	100,402
SESTAT-eligible	74,462	66,504
Ratio of sample size to usable cases	2.88:1	2.56:1
Ratio of respondents to usable cases	2.00:1	1.51:1

NOTE: The definition of SESTAT-eligible was expanded between 1993 and 2003 to include people with S&E-related degrees or occupations.
SOURCE: National Science Foundation (2007, p. 8).

Group Coverage

Using a decennial census to identify the stock of engineers and scientists to be interviewed over the decade and supplementing it with new graduates of U.S. institutions in S&E fields from the National Survey of Recent College Graduates (NSRCG) and the Survey of Earned Doctorates (SED) inevitably means that some population groups were missed. One population that is of great interest are the scientists and engineers whose degrees were all earned abroad. This population is captured in the sample only once a decade in the baseline survey. Foreign-educated scientists and engineers entering the United States after the decennial census and receiving no further degrees in the United States are not included in any SESTAT survey, so the undercoverage of this group grows throughout a decade.

Another group that is partly covered in the postcensal NSCG but not in later surveys is people with non-S&E degrees who enter S&E or S&E-related jobs after the postcensal NSCG. This is an important omission in the case of computer occupations, which include a significant number of workers not educated in a science, engineering, or related discipline who have moved into computer-related occupations.

These omissions are exacerbated because a substantial number of scientists and engineers are both non-S&E graduates in S&E and S&E-related occupations and foreign educated. In a report, NSF estimates that in 2003 there were over 720,000 people in S&E occupations and nearly 790,000 people in S&E-related occupations with non-S&E degrees (National Science Foundation, 2007).[2] Additionally, there were estimated to be close to 1.5 million people in the SESTAT population who had only foreign degrees. Taking into account the overlap between these two populations, approximately 2.6 million people in 2003 in the SESTAT population worked in an S&E occupation but had no S&E degree or had only a foreign degree. Such people represent approximately 12 percent of the 2003 SESTAT population of 21.6 million people.

Response Rates

Another problem in using the census long form as the sampling frame is increasing cumulative nonresponse through the decade. Nonresponse is a major concern with the current NSCG design since the sample is only refreshed once a decade. Although follow-on surveys later in the decade

[2]This number excludes those who graduated in non-S&E fields after April 1, 2000, who were working in S&E or S&E-related occupations in 2003 as well as those with only foreign degrees who were not in the United States at the time of the decennial census but were here working in an S&E or S&E-related occupation at the time of the 2003 NSCG.

generally have had very good response rates (well above 90 percent), the total attrition in the sample over the decade is substantial. The decade of the 1990s provides an example. As shown in Table 2-1, the unconditional unweighted response rates for the 1990 decennial sample went from an initial rate of 78 percent to 74, 70, then 63 percent over four survey cycles.

The problem of growing nonresponse appears to be increasing in the 2000s. In 2003, the NSCG had a response rate of 63 percent. By 2006, the unconditional response rate had fallen to 55 percent.

The declining unit response rates are particularly troublesome because they vary dramatically across demographic, citizenship, educational attainment level, and age groups. Non-Hispanic white individuals are more likely to respond than individuals in other racial and ethnic groups. U.S. citizens respond at a higher rate than non-U.S. citizens. Higher educational attainment levels directly relate to higher rates of response.

Longitudinal Continuity

One final difficulty posed by reliance on the decennial census is that the usual practice of discarding the old sample every 10 years brought about the complete loss of longitudinal continuity and a lack of information about how nonresponse adjustments during the decade might cause a shift in the time series. NSF addressed these issues by embedding an experiment in the design of the 2003 NSCG. In addition to drawing a new sample from the 2000 decennial long-form sample, NSF also included the remaining 1999 NSCG respondent population (which included cases originally sampled in the 1993 NSCG, as well as the 1995-1999 NSRCG surveys) to receive the 2003 survey.

This experiment found some large differences in estimates of the scope of coverage between various nonresponse adjustment cells made from newly drawn 2000 postcensal samples in comparison with retained longitudinal samples from the 1999 NSCG in 2003 (Finamore, Hall, and Fecso, 2006). It is believed that some of the difference could be caused by increasing nonresponse across key groups that is not ignorable. Further research is required to determine all the factors that may have contributed to the differences.

COMPARING THE LONG FORM AND THE ACS

In view of the above well-known limitations of the census long form as a sample frame, NSF commissioned reviews of potential sampling frames and designs by previous National Research Council panels. Each time, the reports found that the design based on the census long-form

sample for the NSCG was the best available strategy (National Research Council, 1989, 2003).

Most recently, in preparation for the NSCG surveys in the 2000s, NSF explored alternative sampling frames for SESTAT. It looked for a frame that could provide a more complete representation of the universe of scientists and engineers than the long-form sample approach (Fecso et al., 2007b). No suitable alternative to the long-form frame for the NSCG was identified, primarily because no other source had sufficient sample size to include a large enough number of scientist and engineers, a relatively rare population, to meet the needs of the NSCG and SESTAT.

The ACS was long ago identified as a future potential alternative to the census long form. Now that the ACS has been successfully implemented, the Census Bureau has agreed to permit use of the ACS as a sample frame for the NSCG in the future. This introduces a host of opportunities as well as some major challenges.

Some aspects of the sample design based on the decennial census would not need to change much in a transition to an ACS-based design. For example, it would be possible for NSF to draw the sample from a list of ACS respondents using criteria similar to those used in past NSCG surveys. That approach will be facilitated by the fact that the ACS now collects information that is essentially identical to that collected on the long form—the highest degree or level of school that the respondent has completed, occupational and employment characteristics, and demographic characteristics.

However, some things will need to change. The ACS surveys a smaller number of households in a given year than were surveyed by the long form. Consequently, it will be necessary to accumulate 2-3 years of ACS households in order to identify a set of households that could serve as a sufficient sample frame for the NSCG. This change introduces complications that are more fully explored in Chapter 6.

The potential for more substantial change during the shift to the ACS is embedded in the plan to add a question on the field of a bachelor's degree to the ACS on an ongoing basis, assuming successful completion of a full-scale field test of two alternative question versions. With this question, it will be possible not only to enhance the ability of the Census Bureau to identify respondents with the characteristics of interest for sampling for the NSCG, but also to provide a base of information, both in cross-section and in time series, on the population of college graduates by field of bachelor's degree. The data should have benefits to many federal agencies, particularly those with responsibility for assessing such issues as educational attainment, immigration, and public welfare, and for projecting occupational supply and demand. A further discussion of this new potential is presented in Chapter 7.

4

The ACS and the SESTAT Program

The American Community Survey (ACS) promises to have a profound effect on the Scientists and Engineers Statistical Data System (SESTAT) Program. Most directly, it will take the place of the census long form as the sampling frame for the National Survey of College Graduates (NSCG).[1] But the ACS will more significantly change SESTAT if, as seems likely, a field-of-degree question is included in the ACS on an ongoing basis. This chapter discusses the potential of the ACS for changing SESTAT and proposes several options for the future of SESTAT.

THE ACS AS THE SAMPLING FRAME

The questions on the ACS are generally identical to the questions that were on the decennial long form.[2] The most important difference in the two surveys is that the ACS can provide reasonably detailed information about households and individuals each year rather than once a decade.

The ACS is conducted every month. Estimates for the nation and large areas are produced annually from aggregating the monthly samples; for subnational estimates, the data are aggregated over longer time periods. The ACS takes a new sample of about 250,000 addresses each month,

[1]Information about the ACS can be found at: http://www.census.gov/acs [accessed February 2008].

[2]The ACS questionnaire can be found at: http://www.census.gov/acs/www/SBasics/SQuest/SQuest1.htm [accessed February 2008].

or a total of 3 million annual households.[3] Over a decade, the ACS will survey approximately 30 million addresses; for comparison, 17 million housing units were surveyed by the long form at one time in the decennial census.

A key function of the ACS is to produce estimates for various levels of geography (from small areas to the total nation) and other population groupings. The ACS provides estimates annually for areas (and population groups) of 65,000 or more people; these estimates are scheduled to be made available in the summer or early fall for the previous year's sample.[4] To attain similar reliability to that provided for some of the small groups in the 2000 decennial census, the ACS estimates for the smallest areas or population groups must be based on data aggregated over 5 years.

The problem of the reliability of data for the smallest areas (such as counties) presents an equivalent statistical problem to the problem of the reliability of estimates for small (rare) subpopulations (small domain estimates), such as scientists and engineers, in terms of sample size considerations. Both small-area and small-domain estimates are subject to insufficient sample sizes to produce sufficient reliability. The National Science Foundation (NSF) faces a reliability problem in using the ACS as the NSCG sample frame not because it wishes to produce small-area estimates, but because it needs the ACS sample size for rare populations.

A recent National Research Council (2007) report, *Using the American Community Survey: Benefits and Challenges*, points out that there are some important differences between the ACS and the decennial long-form census. One, such difference is that ACS data products are 1-year, 3-year, and 5-year *period* estimates that average 12, 36, and 60 months of data, respectively. In contrast, the 2000 long-form sample of more than 16 million responding households obtained data for one fixed time—Census Day, April 1. In comparison with the long-form sample, the report suggests that the ACS has three major benefits:

1. Timeliness: ACS data products are released 8-10 months, instead of 2 years, after data collection.
2. Frequency: ACS data products are updated every year instead of every 10 years, which will make it possible in many areas to track trends in population characteristics that are important for understanding the science and engineering (S&E) workforce.
3. Quality: Higher quality of the data in terms of completeness of response to the survey items. The higher response rates for the

[3]No address will be included in the ACS sample more than once in a 5-year period.

[4]Beginning in 2006, this information will be made available annually in late summer or early fall for the previous year's sample.

> ACS compared with the 2000 long-form sample is achieved by the use of more intensive methods of data collection by better trained interviewers. The ACS is conducted using an initial mail-out, mail-return, self-response questionnaire. The first follow-up to mail nonresponse is conducted by computer-assisted telephone interview (CATI); it is followed by a computer-assisted personal interview (CAPI) of a subsample of the remaining nonrespondents. The ACS interviewers are experienced and highly trained in contrast to the lightly trained temporary enumerators that were used for nonresponse follow-up in the 2000 census. The professional, fully trained Census Bureau interviewers have access to built-in computer edits and questionnaire routing software in the CATI and CAPI instruments, and so they obtain more complete data. Having more complete data means that there is less need for imputation of missing responses to questionnaire items.[5]

On the negative side, the National Research Council report points out that a weakness of the ACS is the significantly larger margins of error in its estimates, even when cumulated over 5 years. The primary reason for this outcome is the much smaller sample size of the ACS. Another reason is the greater variation in the ACS sample weights resulting from the smaller number of sample units available after subsampling for field interviewing of households not responding by mail or telephone. Also, the postcensal population and housing estimates used as survey controls in the ACS are less effective than the full census controls used with the long-form sample. These estimates are subject to unmeasured estimation error for which there is little information about magnitude; they are applied at a less detailed level than the census controls; and they are not directly related to the ACS in the way that the census controls are related to the long-form sample.

The sampling frame for the ACS is the Census Bureau's Master Address File (MAF), which will be updated throughout the decade to keep it current. The monthly samples are distributed throughout the country with no area or other cluster sampling, but there will be higher sampling fractions in small governmental units, such as small counties.

[5]The quality improvements inherent in converting to the ACS are substantial. For example, in comparison with the census long form, a precursor survey to the ACS (the Census 2000 Supplementary Survey) had lower imputation rates for 48 of 54 population items. For one item, weeks worked last year, the need for imputing missing values fell from 19.3 percent for the long form to only 9.6 percent for the ACS precursor survey (National Research Council, 2007, p. 57).

OPTIONS FOR ACHIEVING SESTAT PROGRAM GOALS

The replacement of the decennial census long form with the ACS offers an opportunity for NSF to meet its stated goals and objectives for the SESTAT Program. These goals and objectives were presented to the panel at its workshop in October 2007, and are summarized in Box 4-1.

Significant improvements in timeliness will likely be achieved by the conversion to the ACS. As noted above, by using the ACS, NSF could publish estimates for many key data items less than a year after the reference period. Although data on rare populations, with minimal variance, will be delayed for up to 5 years to accumulate a large enough sample, after the first 5-year delay the data will be available on a flow basis in each following year. Analytical power will be increased with the addition to the ACS of the field-of-degree question on an ongoing basis (see Chapter 5). The cost implications of the conversion are discussed below.

The ability of NSF to maintain consistent cross-sectional data and preserve the trend in a time series when converting from the long form to the ACS will depend on how NSF decides to implement the change from the long form to the ACS. In some of the options being considered (see below), cross-sectional time series can be strengthened. Trend preservation can also be assured by careful implementation and by developing "bridges" from the old data series to the new when it is decided that the new data series is an improvement over the old. For example, one such bridge could be for estimates of the disabled S&E workforce if it is decided to adopt the well-researched and tested ACS (standard) definition of disability rather than the definition of disability now in the NSCG.

The conversion from a decennial long-form-based sampling frame to an ACS-based sampling frame affords an opportunity to reconsider the goals and objectives of this major government data collection program on S&E. In Chapter 7, the committee suggests that NSF conduct such a

BOX 4-1
NSF Goals and Objectives for the SESTAT Program

- Improve timeliness
- Maintain coverage of rare populations with minimal variance
- Gain analytical power
- Maintain cross-sectional time series
- Preserve trend (minimize breaks in time series)
- Manage costs

review, with the caveat that changing the SESTAT Program should be approached gingerly. Proper consideration should be given to the needs of all interested stakeholders and should include plans for transitional and short-term program changes and long-run program modernization.

In the short run, for a transitional period, practical constraints would seem to dictate that the SESTAT Program would remain mostly unchanged. This conservative approach is justified because care should be taken when collecting data to understand time trends and to preserve, to the extent possible, historical continuity. Over time, as the ACS settles into an ongoing mode and responses to the new field-of-degree question become understood, new opportunities to replace some aspects of the current SESTAT Program with more streamlined data collection procedures may emerge.

To prepare for these opportunities, the NSF's Division of Science Resources Statistics (SRS) has appropriately begun to develop a research program that focuses on options for change. An agency report (National Science Foundation, 2007) outlines several options for SRS research efforts, all of which affect the types of data that SRS may wish to gather.

The panel has reviewed the NSF staff report, and the remainder of this chapter presents our view of three potential options to guide an SRS research program. The three options are configured here so that Option B is more expansive than Option A, and Option C is more expansive than Option B.

Under Option A, SRS would focus primarily on the congressionally mandated reports. Non-SESTAT sources, including the ACS and the Current Population Survey (CPS) could perhaps be used for the production of those mandated reports. The SESTAT components currently used for the purpose of producing data for the mandatory reports, primarily the NSCG and the National Survey of Recent College Graduates (NSRCG) could be reconfigured, conducted less frequently, or eliminated. The ACS and CPS would need to be augmented by the existing doctoral surveys (such as the Survey of Doctorate Recipients, SDR) and, perhaps, occasional NSF-commissioned special surveys that could be funded by using the financial savings that accrue from changing the nature of, or by eliminating the NSCG and the NSRCG. This option would require that the CPS add a field-of-degree question—a change discussed in Chapter 7.

This option obtains part of its justification from the fact that the ACS can provide a large sample of workers with bachelor's degrees in S&E fields in an extremely timely manner. The sample would naturally include individuals with degrees from non-U.S. institutions who are living in the United States. This option would free up significant resources for other, more specialized surveys or for research on the S&E workforce.

However, there would also be several significant opportunity costs in connection with Option A:

- People who have a bachelor's degree in a non-S&E field who subsequently obtain a master's degree in a S&E field would be mistakenly classified as non-S&E respondents because of the focus on a bachelor's degree.
- There will be no way to learn specifically about people with S&E bachelor's degrees who subsequently get a master's degree in a non-S&E field (often a business discipline). This sizable group is of great interest to NSF.
- If the field-of-degree question on the ACS were categorical rather than open ended, there could be a substantial loss in the usefulness of information about actual fields of degree. Currently, the NSCG distinguishes among more than 140 different fields; moving to only seven or eight broad categories would drastically limit the specificity of the data and would probably preclude doing meaningful statistical analysis with only ACS data.
- Information about the highest degree a respondent has would be solely from the ACS.
- The additional items that are now placed on the NSCG questionnaire would be lost to researchers, both those at and outside NSF.

Option B is more closely aligned with the current approach. Under this option, NSF would continue to produce a longitudinal version of the NSCG survey for the S&E population along the lines of the current NSCG and SESTAT operations, using the ACS for the sampling frame. The panel envisions that this data collection effort would be stratified to oversample women, the disabled, and minority S&E respondents relative to nonblack, non-Hispanic males. NSF could supplement the data from NSCG and NSRCG with data from the ACS and CPS to enrich the mandated indicator reports.

This option comes with a cost that is relatively easy to estimate. The option would require the Census Bureau to recontact ACS respondents in order to complete subsequent interviews. The secular decline in response rates and the difficulty that the Census Bureau has had in obtaining cooperation in previous SESTAT surveys contributes to the expense of running such a survey and to the obvious attrition problems in the data.

The continued cost of conducting the NSCG survey is counterbalanced by a number of benefits:

- There would be better coverage of those who obtain non-S&E bachelor's degrees and work in S&E occupations. The panel

notes that in the past the NSCG sampled all holders of bachelor's degrees and above and so these respondents could be readily identified. With the ACS as the sampling frame, the issue of how many such people to survey will have to be considered before the survey. This group can be very expensive to sample because of their low frequency and the transitory nature of occupational assignments.

- There would be coverage of the S&E bachelor's degree holders who obtain advanced degrees in a non-S&E field. This may be a group of considerable interest to NSF if they have "left" the S&E workforce. (Many of these are combining their S&E skills with other kinds of expertise.)
- There would be more detailed coverage of foreign degree holders. Currently, the ACS design does not allow researchers to determine definitively whether the respondent obtained a degree in the United States or another country.
- The survey could include questions not on the ACS.
- If the Census Bureau merged information from the ACS and the NSCG, NSF and other researchers would have valuable information about the income of the S&E workforce.

The cost-benefit tradeoffs of Options A and B are a matter for NSF staff to determine. The panel notes, however, that it appears that much of the content of the congressionally mandated reports could be generated from ACS data alone when the ACS has a field-of-degree question, and research outside of NSF using the NSCG data seems to be quite limited.

Under Option C, in addition to the collection of the longitudinal data version of the NSCG for the S&E population, NSF would commission collection of data on the non-S&E population so that its staff and other researchers can compare outcomes of the S&E population to the non-S&E population. Under this option, S&E respondents would be oversampled relative to non-S&E respondents and women, disabled, and minority respondents would be oversampled relative to those who are nonblack, non-Hispanic, nondisabled males. It would also be possible to focus the oversample on subsets of the S&E population, based on field of degree (see Chapter 5), immigration status, or age.

This option is, in many ways, the most ambitious. Under this option, the current NSCG would be continued (though perhaps be smaller), and additional data would be collected to address issues relevant to the NSF goals and objectives. For example, it would be useful to systematically collect data on the non-S&E workforce for purposes of comparison with the S&E workforce. More generally, Option C places a burden on NSF to determine what the large unresolved issues are in the study of the S&E

workforce and to construct data resources that will allow these issues to be addressed.

The move to a sampling frame from the ACS makes the current SESTAT transition period an important decision time for NSF. It is an opportunity to review the SESTAT Program goals, as well as the needs and wishes of the outside research community, to determine the type and frequency of data collection. There are many options and this chapter has briefly discussed three of them. The central point is that because of the improved quality of information that the ACS with a field-of-degree question would provide, NSF now has a window of opportunity to decide whether the expense of separate surveys such as the NSCG and the NSRCG is justified.

In summary, it is clear that the NSF staff will have an opportunity to rethink the NSCG in light of the added information resources available through the ACS with the field-of-degree question. Given the speed at which the Census Bureau makes the ACS data available, the NSF staff will undoubtedly want to make use of the ACS data in the preparation of the congressionally mandated reports, no matter which option is chosen. Continued use of the NSCG or something like it would involve additional costs, but it would provide for the greatest continuity and provide much more detailed information about the experiences of the S&E workforce. The ACS frame also makes possible alternative approaches, such as a reconstituted NSCG that may have fewer respondents but a richer set of data.

5

Adding a Field-of-Degree Question to the ACS

In the past, the National Science Foundation (NSF) was constrained to using the decennial census long form to identify the sample for the National Survey of College Graduates (NSCG) for the upcoming decade as well as for analytical purposes. The salient question from the decennial census was the question on educational attainment, which when combined with other information, such as occupation, age, sex, and racial and minority status, allowed the selection of the sample members for the initial NSCG sample for the decade. People with bachelor's or higher degrees were brought into the NSCG sample frame. The collection of information on all persons with bachelor's degrees or higher has provided both the group of people who have science and engineering (S&E) degrees and those who do not have S&E degrees who could be asked questions about whether they worked in S&E occupations during the decade. It is important to obtain information about this group, but the need to query everyone with a bachelor's or higher degree to identify the S&E workforce has been inefficient and has resulted in higher than necessary costs.

Seizing on the opportunity afforded due to the mandatory conversion from the decennial census long form to the American Community Survey (ACS), the leadership of NSF has proposed adding a new question on the ACS that would ask respondents to identify their field of degree. This question would enable NSF to more efficiently use it to draw a representative sample of all persons with S&E training at the bachelor's or higher level, thus making them directly eligible for inclusion in the Scientists and Engineers Statistical Data System (SESTAT) target population.

The Census Bureau has been able to be somewhat more flexible in including new or revised questions on the ACS than they were on the census long form. However, due to the relative newness and the ACS's large size, decisions on adding or changing questions are not taken lightly. The Census Bureau has an extensive program of testing and refinement of potential questions and question wording in a content test program that has been a staple of the ACS since its inception. For example, the results of the content tests in 2007 will determine the content for the 2009 ACS. Before NSF can benefit from the potential sampling efficiency and lower costs of various future designs for the NSCG, the field-of-degree question must be subjected to development and testing.

The committee has observed the process of development and testing of a field-of-degree question and assumes, based on current evidence, that there will be a question added to the ACS which collects field-of-degree information. Based on that assumption, this chapter summarizes the central issues in the decision as to whether the field-of-degree question should come with specified categories or be open-ended and discusses the need to systematically test the actual responses to this question when it is implemented in order to understand the validity of the data. The addition of the field-of-degree question is a rare and major opportunity that should be approached with careful planning.

QUESTION DEVELOPMENT

The ACS now collects data on the highest degree or level of school completed using the question shown in Box 5-1. The inquiry appears as Question 11 on the ACS "persons" questionnaire. The response categories range from "no schooling completed" to professional and doctoral degrees.

The use of the highest degree or level of schooling question as a screening question was the first and easiest decision. To avoid unnecessary respondent burden and ensure data quality, the field-of-degree question would be asked only of the group of most interest, which would be most likely to provide usable information. Thus, the proposal is that only those who answer "bachelor's degree" or higher (master's, professional, or doctoral) would be asked about field of degree.

A more complex decision concerns the design of the field-of-degree question itself. A basic tradeoff in gathering information on field of degree is that the more detailed the information, the better that samples can be allocated to domains of interest, but the higher the cost in terms of time, the greater the potential loss of data quality. Mindful of these tradeoffs, NSF and the Census Bureau have developed and are testing two

BOX 5-1
The ACS Highest Degree Question

11. What is the highest degree or level of school this person has COMPLETED?
Mark (X) ONE box: If currently enrolled, mark the previous grade or highest degree received.

No schooling completed
Nursery school to 4th grade
5th grade or 6th grade
7th grade or 8th grade
9th grade
10th grade
11th grade
12th grade—**NO DIPLOMA**
HIGH SCHOOL GRADUATE—high school DIPLOMA or the equivalent *(for example: GED)*
Some college credit, but less than 1 year
1 or more years of college, no degree
Associate degree *(for example: AA, AS)*
Bachelor's degree *(for example: BA, AB, BS)*
Master's degree *(for example: MA, MS, MEng, MEd, MSW, MBA)*
Professional degree *(for example: MD, DDS, DVM, LLB, JD)*
Doctoral degree *(for example: PhD, EdD)*

SOURCE: National Science Foundation (2007).

variants to the question—one with a categorical or forced-choice design and another with an open-ended design.

This research, testing, and development program has been mounted quickly. It involves multiple venues and multiple methodologies and test populations. The final results, which were not available to the panel at the time this report was prepared, will have far-reaching impact on the availability and quality of data for sampling and analytical purposes.

COGNITIVE RESEARCH

The issues involved in the selection of the proper question format for the field-of-degree question have been carefully studied by three independent groups of researchers who recently conducted a series of coordinated

experiments that assisted in the development of the two versions (categorical and open-ended) of the questions tested in the 2007 test (Dillman et al., 2006a, 2006b; Cobb, Krosnick, and Bannon, 2006; Rothgeb and Beck, 2007). All the investigators ran into difficulties with questionnaire design and wording in one form or another but they persevered to develop plausible field of degree items.

The results of these cognitive research efforts led to the selection of question formats and wording that were chosen for the 2007 ACS content test. The questions included are shown in Box 5-2 and Box 5-3.

Asking the field-of-degree question using a list of categories requires a respondent to first accurately recall a major and then to map it into the broad list of categories offered in the question. This action involves an understanding of the categories and a link to the respondent's major field of study. A failure at any point in this cognitive process could result in a misclassification error.

The easiest way to avoid errors by respondents is to use the open-ended question. The open-ended question allows the respondent to name their major field of study and the responses are coded according to the agency's

BOX 5-2
Categorical Field-of-Degree Question

This question focuses on this person's BACHELOR'S DEGREE. In which of the following major fields did this person receive his/her BACHELOR'S DEGREE(S)?
Mark (X) "Yes" or "No" box for each category.

	Yes	No
a. Biological, Agricultural, Physical, Earth, or Other Natural Sciences	|__|	|__|
b. Health, Nursing, or Medical Fields	|__|	|__|
c. Engineering, Computer Sciences, or Mathematical Sciences	|__|	|__|
d. History, Arts, or Humanities	|__|	|__|
e. Psychology, Economics, or Other Social Sciences	|__|	|__|
f. Business or Management	|__|	|__|
g. Education or Education Administration	|__|	|__|
h. Some other major field - *Specify*	|__|	|__|

_____

_____

SOURCE: National Science Foundation (2007).

BOX 5-3
Open-Ended Field-of-Degree Question

This question focuses on this person's BACHELOR'S DEGREE. Please print below the specific major(s) of any BACHELOR'S DEGREES this person has received *(for example: chemical engineering, elementary teacher education, organizational psychology).*

_____

_____

SOURCE: National Science Foundation (2007).

criteria. The open-ended question also has the advantage of providing much more field-of-degree detail than the categorical question. Balanced against these advantages, the open-ended version requires expert coding.

Recommendation 5.1: The field-of-degree question on the American Community Survey questionnaire should be the open-ended version if the Census Bureau and the National Science Foundation agree that it meets the evaluation criteria established for the content test and if an efficient coding procedure can be developed.

CONTENT TEST

The Census Bureau has a formal process for testing proposed new content for the ACS. Through the Office of Management and Budget Interagency Committee on the ACS, the Census Bureau includes subject-matter experts and key data users from other federal agencies in identifying questions for inclusion in a content test. In general, a content test evaluates alternatives for questions that show some indication of a potential problem, such as high rates of missing data, estimates that differ systematically from other sources of the same information, or high sample nonresponse. In addition, a content test includes testing of new topics proposed by other federal agencies for inclusion in the ACS. The 2007 test of the field-of-degree question options was suggested and supported by NSF.

The 2007 field-of-degree content test was designed to test the questions across the three modes of ACS data collection: mail, computer-

assisted telephone interviewing (CATI), and computer-assisted personal interviewing (CAPI). The test questionnaire was mailed to 15,000 housing units for each of the two versions under consideration, and nonresponse follow-up was by telephone and, when necessary, in person. The field-of-degree coding system for the NSCG, which used autocoding, clerical coding, and expert coding, was adapted for the test.

For quality assurance purposes, a content follow-up reinterview of a sample of the interviews was conducted to assess the reliability of the responses. In the reinterview survey, interviewers contacted respondents by telephone, attempted to speak to the original respondent, and repeated the field-of-degree questions.

The Census Bureau has specified evaluation measures and decision criteria for assessing the results of the content test of the field-of-degree questions. They include comparability to other data sources, the rates of missing data, reliability, the agreement or correspondence between the versions, and departures from the current NSCG sample frame (personal communication, Jennifer Tancreto, U.S. Census Bureau).

In comparing the versions across these criteria, the Census Bureau is using a decision tree that assigns most weight to the comparison with the NSCG, then the item missing data rates and reliability considered together, then the correspondence between the versions, and, finally, an assessment of the impact on the NSCG sampling frame.[1]

NSF identified several key issues that need to be resolved regardless of the question version that is chosen (National Science Foundation, 2007, Table 4, p. 23). Some issues will affect the version that is chosen; others will affect the use of the data for sampling or analysis. There are six issues:

1. *Space on the ACS* The categorical version requires approximately one-third of a column. The open-ended version requires less than one-fourth of a column.
2. *Coding After Collection* The categorical version requires only limited postdata collection coding, although nonsampling error could be added by incorrect coding of the "other-specify" item. The open-ended version requires extensive, ongoing coding, which may delay data processing and final delivery time. and nonsampling error could be added by incorrect coding of the open-ended response(s).
3. *Number of Fields Available* The categorical version limits the number of fields to seven, with one residual category. The open-ended

[1]The preliminary results of the content test were not available in time to be incorporated in this report.

version makes it possible to develop a more extensive list of fields (for analysis and NSCG sampling) than with the categorical version, but the possibility will depend on the level of detail provided by respondents. This is because the initial basis for the development of the coding will be the code list and coding procedure used for the 2003 SESTAT survey. The field-of-degree code list for the SESTAT surveys has 144 field-of-degree codes. This list, however, has far more detail for S&E and S&E-related degree fields than for non-S&E fields. For the full evaluation of the ACS data, a greater level detail for non-S&E fields would be desirable. (NSF will be working with the Census Bureau and other agencies to develop such a list. Ultimately, this list may become useful not only for NSCG sampling, but also for analysis of the field-of-degree data from the ACS if the open-ended version of the question is fielded.)

4. *Reporting of Multiple Bachelor's Degrees* The categorical version of the question explicitly allows for the reporting of multiple bachelor's degrees. The open-ended version question stem indicates that more than one degree may be reported, but it is not clear that respondents will do so.
5. *Type 1 Errors* Reducing type 1 errors (i.e., checking or writing having an S&E or S&E-related bachelor's degree when a non-S&E field-of-degree is appropriate) can have a major effect for NSCG sampling because this type of error would lead to unnecessarily sampling a case that does not have a required degree. However, this can easily be resolved during the NSCG data collection, when the case can be identified as ineligible. Type 1 errors will cause a larger problem for analysis of ACS data because there is no other information on the ACS to validate the field of degree.
6. *Type 2 Errors* Reducing type 2 errors (i.e., not reporting an S&E or S&E-related field-of-degree while actually having one) is a special challenge because this type of error will lead to population undercoverage for the NSCG. Additionally, as with type 1 errors, it will cause problems for direct analysis of the ACS field-of-degree data. Working with the Census Bureau, NSF needs to attempt to estimate the prevalence of these errors in a structured research program.

The form of the question on field of degree and the accuracy of the information provided will affect the gains in efficiency. For example, it is unclear how accurate reports on the field-of-degree item will be for those reporting for others in the household (proxy reports) compared with those reporting for themselves. If the field-of-degree and occupa-

tion items can be used to accurately distinguish scientists and engineers from other college graduates, substantial gains in efficiency are possible. For NSCG sampling purposes, the most important concern is whether a degree is accurately reported as falling into an S&E, an S&E-related, or a non-S&E category.[2]

VALIDITY TESTING

Analysis of the reinterviews in the 2007 test of the two field-of-degree questions will provide some information about the reliability of the responses to the item, but it cannot provide much in the way of insight into the validity of the data. There is a heightened risk in proceeding from the content test to full data collection without the benefit of a validity study of the question version that has been selected. Under current plans, the accuracy of the field-of-degree reporting will not be known until the first NSCG is conducted using a complete or partial sample from the ACS. The information from the detailed education histories that are collected as part of the NSCG, which does not have proxy reporting, can be compared with the information reported on the field-of-degree and educational attainment questions in the ACS. If it is determined that proxy reporting may lead to a quality degradation of the scientist and engineer data from the ACS, the Census Bureau is urged to conduct research on this topic as part of the validation study program.

The panel believes it would be advantageous to assess the validity of the responses using the NSCG questionnaire and procedures prior to the initial fielding of the NSCG based on an ACS sampling frame. If this is not possible, then it may be advisable in drawing the first NSCG sample from the ACS to allocate part of the sample to test the efficiency of the field-of-degree item for sampling purposes. This could be done either by drawing a larger number of apparently non-S&E cases than might be done otherwise or by drawing a portion of the sample using procedures like those used with the long-form sampling frame, i.e., procedures that do not take the field-of-degree information into account.

Recommendation 5.2: The National Science Foundation should ask the Census Bureau to conduct an additional evaluation of the field-

[2]In the categorical version of the question that is now being tested, only one set of S&E-related fields (health) can be captured accurately. To identify a sample in other S&E-related fields, NSF would have to sample some of the non-S&E field-of-degree categories, as well as some non-S&E occupations. For example, to find individuals with degrees in science or mathematics teacher education (an S&E-related field), it will be necessary to sample some individuals with bachelor's degrees in "education or education administration" as well as some secondary teachers.

of-degree question to assess the validity of the responses provided by respondents. As part of this evaluation, a sample of individuals should be reinterviewed to determine if they do have degrees in the fields reported.

Information about the accuracy of the field-of-degree responses will be helpful in future planning for the NSCG sample. Some number of cases apparently not meeting the criteria of being a scientist or engineer (a non-S&E bachelor's degree and a non-S&E occupation) will likely need to be drawn in any NSCG sample from an ACS sampling frame both to provide a comparison group and to account for those in non-S&E occupations with a non-S&E bachelor's degree but an S&E or S&E-related degree at a higher level. Knowledge of error rates for the field-of-degree questions will help NSF and the Census Bureau determine how many such cases would be required.

There may be additional benefits to having the field-of-degree question beyond its immediate help in making the sample more efficient. The field-of-degree question, enhanced by the use of outside information, might, over time, help sharpen the definition of the target population for the survey. This possibility is discussed further in Chapter 7.

6

Using ACS for the NSCG Sample Frame

As discussed above, the idea of using the American Community Survey (ACS) as a sample frame for the National Survey of College Graduates (NSCG) was born of necessity. In this chapter we discuss the use of the ACS for drawing and maintaining the NSCG sample. We begin with the requirements and constraints that drive our consideration of alternative sample designs as they relate to the ACS as the sampling frame. We then discuss a number of design issues that are important in setting criteria for our recommendations. Next, we identify and discuss the various sample design features and approaches that have been discussed during the panel's deliberations. We offer our recommended design and close the important issue of the transition from the current design to the new one.

REQUIREMENTS AND CONSTRAINTS

Requirements

In adopting the ACS as the NSCG sampling frame, some aspects of the NSCG sample design, such as weighting of women, minorities, and other population groups, may not change much, but other aspects may be markedly affected by the ACS design. As noted above, the ACS is a continuous monthly sample in contrast to the long form, which used point-in-time sampling on Census Day (April 1). Consequently, the ACS reference period for questions on education and occupation rotates throughout the

year. Although the use of a question on field of bachelor's degree in the ACS sample design will be highly beneficial for targeting potential sample members, it will also pose complexities for integration of the new variable with other previously used variables in the design. The continuous nature of the ACS also raises questions about the frequency with which the NSCG should be conducted and the sample refreshed, either for the entire college graduate population or for subgroups, such as immigrants and other new populations or those with low response rates.

The use of the ACS as a sampling frame for the NSCG and other National Science Foundation (NSF) surveys raises several technical issues. The continuous nature of the ACS poses opportunities for frequent updating of the NSCG sample frame, while the limited size of 1 year's ACS sample (relative to the long-form sample) requires accumulation over several survey rounds to provide a frame of suitable size for oversampling rare populations, such as minority college graduates by field of science and engineering (S&E) degree. These issues must be addressed and considered in the development of an implementation plan to begin in fiscal year 2009.

The conversion to the ACS opens the possibility of reconsidering the target population for the survey. The fact that the questions on the ACS are much like the questions on the census long form mitigates against major changes, but the addition of the field-of-degree question (in either format) permits a rethinking of the target population. The current surveys in the Scientists and Engineers Statistical Data System (SESTAT) cover U.S. residents with bachelor's and higher degrees in science and engineering, including:

- recent (past 2 academic years) U.S.-earned-S&E-degree recipients, a population that is currently identified in the National Survey of Recent College Graduates (NSRCG) and the Survey of Earned Doctorates (SED);
- not-recent U.S.-earned-S&E-degree recipients (those tracked in the NSCG);
- U.S. residents without S&E degrees who work in S&E occupations (also tracked in the NSCG); and
- new immigrants to the United States with all S&E bachelor's and higher degrees earned outside the United States (currently obtained only through the initial postcensal NSCG).

In SESTAT, there is special attention on minority populations with separate estimation capability by race and ethnicity, gender, disability status, and U.S. or foreign citizenship.

Converting to an ACS-based sampling frame also provides the opportunity to rethink the NSCG sample size as it relates to the targeted precision for population subgroups of interest. The 2003 postcensal NSCG sampled more than 170,000 cases, plus about 40,000 respondents who were carried forward into the 2003 sample from the 1999 NSCG or the 2001 NSRCG. The 1999 NSCG cases were surveyed for methodological reasons and were not included in SESTAT. Because the census long form did not include a field-of-degree question, the remaining 2003 NSCG sample had to be sufficiently large to derive the required sample size of scientists and engineers needed to achieve the targeted precision for estimates of characteristics of interest.

For the NSCG, the targeted precision levels were expressed in terms of generalized variance parameters for the different degree fields and population subgroups. With the inclusion of a field-of-degree question in the ASC, the screening sample size requirements can be reduced although it would be expected to be more than the 68,000 cases used for the 2006 NSCG, which followed those 2003 cases derived from the census long-form portion of the NSCG together with a subsample of recent graduates from the 2001 and 2003 NSRCG surveys.

Constraints

(1) Sample Size

In a presentation to the panel at its October 2007 workshop, Stephen H. Cohen of NSF identified some possible drawbacks to using the ACS as a sample frame associated with the need to accumulate a sufficiently large sample to meet specific objectives. The ACS sample over one annual cycle does not capture enough of rare populations for NSCG needs. Although most cells have adequate population counts after two cycles of the ACS, some rare populations would require up to five ACS cycles to produce a sample equivalent to the 2003 postcensal sample.

The ACS surveys 250,000 addresses a month. Thus, most uses of the ACS for the NSCG sampling frame will require aggregating 1 or 2 years of the ACS. The largest sample that could be needed from the ACS would occur if the entire NSCG sample is replenished in a single draw (see section on options, below). In 1993 and 2003, the requisite sample sizes were 215,000 and 171,000, respectively. However, much smaller sample sizes are required at any one time for design options that move away from a large once-a-decade sample (see below).

The ACS annual sample selection includes approximately 3 mil-

lion housing units and 7.8 million people.[1] In 2005, after mail responses, computer-assisted telephone interviews (CATI) and a subsample collected by use of computer-assisted personal interviews (CAPI), the ACS had a completion rate of 66 percent (National Science Foundation, 2007, p. 15). This completion rate reflects the design of the ACS. By design, only one-third of the nonmail/CATI respondents are followed up with CAPI. Although the completion rate is important for sampling purposes, it should not be confused with the response rate. The weighted response rate for the 2005 ACS (weighted for the CAPI subsampling) was 95 percent.

Assuming a similar rate in the future, the ACS would yield data for some 2 million housing units and about 5.2 million people annually. Approximately 19 percent will fit the SESTAT population definition (i.e., have a bachelor's degree or higher and be aged 75 years or under). Thus, less than 1 million cases (about 978,640) would be eligible for the NSCG: In comparison, 6.4 million cases were eligible from the 2000 census long-form sample for the 2003 NSCG.

On the basis of an analysis of the full-year 2005 ACS data, NSF has determined that one year of ACS samples (January to December) may contain enough cases to equal or surpass the size of past NSCG postcensal samples for some populations, but it is unlikely to have enough sample to equal the previous NSCG cell size for the more rare populations (such as minority groups). At least 2 years of monthly samples are necessary to provide sufficient coverage of many of these small population groups.[2] Because the Census Bureau processes the ACS monthly samples on a calendar-year basis (12 months of sample are processed together after data collection has closed), NSCG samples may require 2 (or more) years of ACS data if a completely new sample is drawn. If NSF phases in the use of the ACS (e.g., by continuing to use some of the current 2000 decennial sample until the ACS provides sufficient sample for NSCG sampling), it may be possible to initially use 1 year of ACS sample.

[1]This number is based on an average household size of 2.6; average household size was determined from the Census Bureau's *American Fact Finder* with data from the ACS for 2005.

[2]It is unlikely that 12 months of ACS data would be sufficient for approximately one-third of the aggregate sampling cells that NSF has tested. These aggregate cells combined minority groups and used fewer occupational categories than have been used in the past. Using the current sampling cells, several more years of ACS samples may be required to produce sample sizes similar to those achieved with the 2003 NSCG design. The aggregate cells that NSF tested are important because they form the basis for many of the domains for which estimates have been produced in the past. It is possible that they can be achieved with 2 years of ACS samples.

(2) Timing

There are several issues with respect to timing, all of which require some new flexibility with the design of the NSCG. One is the timing of the NSCG reference period. In the past, NSF determined that the NSCG reference period must be consistent with those of the other two SESTAT surveys. Throughout the 1990s, the reference date for all SESTAT surveys was April 15. However, for the 2003 surveys, the reference date was changed to October 1. The change was made to improve population coverage and the precision of the estimates, to improve locating operations, and to provide sufficient time for enhancing survey operations.

The first reason is most important: By moving to an October date, the NSRCG and SDR survey operations were enhanced by allowing a sample of the new S&E and health graduates *after* the respective frames were finalized. With an April reference date, sampling must occur early in the year, when the frame information from input sources for the most recent graduates is not yet final. Therefore, there is missing, incomplete or out-of-date information with which to sample. By moving the reference date to a later time in the year, these issues are resolved, resulting in more accurate sampling and estimation.

One of the principal goals of the SESTAT program is to provide accurate employment data on scientists and engineers in the United States. By collecting the data with an April reference date, employment data may be misleading for recent graduates, who may still be in transition to employment from their most recent enrollment. Pushing the reference date to later in the year may result in capturing a more stable employment profile for these individuals because data will be collected from them after some have completed temporary or summertime employment transitions. The 2003 NSCG data (which used an October reference date) does show such an effect; there was a lower unemployment rate compared with an April reference date, and there were fewer individuals in temporary employment positions, such as postdoctoral positions. This result is similar to trends that were observed in previous decades of the surveys when the data were collected in the fall.

The schedule for processing ACS data also has implications for the reference date for the NSCG and thus for the other two SESTAT surveys. A full calendar year (or years) of ACS data needs to be available sufficiently in advance of the NSCG reference date to allow the Census Bureau time to clean and weight the ACS data as well as to allow for sufficient time to select and prepare the NSCG sample for the field. To have ACS frame data that are as "fresh" as possible at the time the NSCG goes into the field, the ACS collection year would need to end about 8 to 10 months prior to the NSCG survey reference date. A fall NSCG reference date would accomplish this, and the reference date for the 2008 and 2010 SESTAT surveys

is currently planned as October 1. According to the Census Bureau, the 12-month calendar year ACS data would be ready for use in sampling some time before the end of June of the following year.[3] The October SESTAT reference date allows several months to process the files, stratify the frame, select the sample, and create the mailing records.

Such a time schedule has advantages in terms of the age of the data. Typically, there has been about a 3-year lag time between the reference date in the decennial long form and the NSCG postcensal survey. With an October reference date and a sample based on ACS monthly samples for the previous calendar year, some contact data would be less than 12 months old and none would be older than 22 months. (If 2 years of the ACS sample are used, only the oldest data would be similar in age to the long-form data.) Some sample cases will move between the time they were surveyed in the ACS and the NSCG data collection, but many fewer than in the postcensal surveys.

Pooling the monthly ACS samples potentially creates some issues in estimation and determination of NSCG and SESTAT eligibility (e.g., determining whether or not an individual holds a bachelor's degree). In the past, postcensal NSCG eligibility was based on a sample with a single reference date of the decennial census. In the ACS, each monthly sample has a different reference date; moreover, degree data are reported as of the interview date. This difference will require the NSCG to use a different strategy for determining eligibility. For example, degrees are conferred at many points during a year. For those receiving a bachelor's degree during a particular ACS calendar year, NSCG eligibility could depend on which month they were interviewed for the ACS sample. That is, the ACS could be administered before or after degree receipt.

The target population could be defined as those who earn a bachelor's degree before the first month of the pooled ACS samples comprising the NSCG sampling frame. People recorded as having a bachelor's degree but who turn out to have earned that degree after the beginning of that ACS year would be found during the NSCG interview and removed from the NSCG sample. Using such a procedure would result in a very small proportion of sample members being "screened out" as ineligible during

[3]For NSCG sampling purposes, it would be desirable to have the ACS sampling data before June of the year following the reference year. However, if an option that requires more than 1 year of sampling data is selected, the timing of receipt of the data can be relaxed. NSF has developed scenarios based on 2 years of ACS sample units, suggesting the possibility of sampling and fielding the NSCG in two waves—one based on the first of the 2 ACS years, which could be processed much in advance of the survey date, and the second, fielded slightly later, based on the second ACS year. In 2006, both the NSRCG and Survey of Doctorate Recipients (SDR) were fielded in two waves for similar reasons—the late availability of the frame for part of the sample; see National Science Foundation (2007).

the NSCG. Using ACS data from a calendar year and a cutoff month of the preceding December, only a small number of sample cases would have received their first bachelor's degree after December but before the ACS sample cutoff month. A similar approach might be considered for immigrants, for which the target population could be defined as those immigrating to the United States as of a specified cutoff date.

Recommendation 6.1: The National Science Foundation should stipulate that the target population of people with bachelor's degrees be defined as of the beginning of the American Community Survey year.

(3) Cost

Being able to draw a sample and field the NSCG closer to the time the frame data were collected could contribute to reducing costs in several ways. A shorter time period between the frame and NSCG data collection reduces the likelihood of changes in eligibility status between the two dates, such as moving abroad or earning another degree, and should improve the ability to locate individuals for participation. With a shorter time gap for all or most of the sample between the ACS frame data and the NCSG reference date, a smaller fraction of the NSCG sample cases will have moved from where they were living at the time of the ACS in comparison with the long form frame. Additionally, it may be easier to locate individuals who have moved within the United States when the time they have been gone from their previous addresses is shorter. Such factors may reduce the cost of locating, which would cut survey cost and possibly reduce time in the field.

Cost savings could also be expected by an improvement in the ability to identify people who have changed status during the decade. The NSCG historically has provided the "stock" of scientists and engineers near the beginning of the decade, while the NSRCG and SDR have captured the new flows of those receiving S&E degrees during the decade after the postcensal NSCG.[4] To keep the frames for the three surveys mutually exclusive and to eliminate the possibility of double counting these populations, all NSCG and NSRCG cases that involve people who earned another eligible degree after they were originally sampled in one of the surveys are considered out-of-scope cases for the integrated SESTAT dataset. Reducing the number of such sample cases that are excluded from

[4]A person who was sampled in the NSCG (or the NSRCG) but subsequently earned another degree (bachelor's, master's, or doctoral) in a science, engineering, and health field is eligible for inclusion in the NSRCG or SDR by virtue of that additional degree.

the integrated database will increase the effective sample size and thus improve statistical precision.

While not necessarily a cost-saving measure, a design that would result in taking several samples from the ACS over the decade would smooth over the present "peaks and valleys" spending pattern associated with the present long-form-based design. NSF now has to obtain a large increase in resources just after the decennial census to cover sample design costs and the cost of the large screening sample needed to identify the S&E population.

THE ACS AS A SAMPLE FRAME

The NSCG has evolved over the years into a two-tiered program: a baseline postcensal NSCG followed by subsequent panel follow-up surveys. As described in Chapter 2, the NSCG surveys are complemented by other SESTAT surveys that provide some of the data on new flows of U.S.-educated scientists and engineers to the overall population, including new bachelor's and master's science, engineering, and health graduates from the NSRCG, and new doctorates in these fields from the SED. This practice of a baseline postcensal NSCG with subsequent follow-up surveys has been used for the NSCG for a variety of reasons.

First and foremost, identifying and then locating the stock of scientists and engineers of interest is both difficult and expensive. Having identified them once through the initial baseline NSCG, it is cost-efficient to keep them in the NSCG throughout the decade rather than trying to identify others. Additionally, the use of follow-up surveys provided some stability to the estimates being made. The only alternative to maintaining the NSCG postcensal sample for use throughout the decade was to draw a brand new sample every 2-3 years, but additional screening surveys with large samples would have been very expensive and there would be no improvement in the coverage of the population because the sample frame (the decennial long form) remained the same. Freshly selected samples would not suffer from attrition losses due to panel fatigue, but they would suffer from greater levels of nonresponse due to addresses that become progressively out of date.

The ACS as a sample frame is an attractive replacement for the census long-form-based sample frame. Its records share with the long-form records the ability to be stratified by households or people with specific characteristics. Thus, the ACS can provide an efficient frame for follow-on surveys. The ACS provides a means to include in the NSCG frame those immigrant scientists and engineers who earn all their degrees abroad and then come to the United States and enter the labor force. Similarly, it provides improved coverage throughout the decade of non-S&E gradu-

ates working in S&E or S&E-related occupations, a shortcoming of the present long-form-based sample frame. Finally, the ACS can provide more than identification of people who are in the S&E workforce. Through its paradata, the ACS can also inform the subsequent survey process in ways that would improve the efficiency and quality of the data. For example, ACS mode, number of calls and contact information, and other data about the process could be valuable to the NSCG or other SESTAT surveys that might use the ACS as a sample frame. As the use of the ACS as a sampling frame matures, NSF and the Census Bureau may wish to consider how ACS paradata could be used to improve S&E workforce data collection and analysis.

Even without a change in survey content, the use of the ACS opens the possibility of changing the design of the sample frame for the NSCG in some exciting ways. When the field of degree question is added and current data become available throughout the decade, the range of options expands and the flexibility in NSCG designs expands.

OPTIONS

NSF identified four primary options (combinations of the options are also possible) that are made possible by the ACS continuous survey approach (National Science Foundation, 2007): the current approach, selective updates, continuous updating, and a rotating sample. The panel also discusses a hybrid approach that was offered during the workshop: a rotating design for rare populations. The advantages and disadvantages of each NSF option and the hybrid approach are discussed in this section.

(1) Current Approach

ACS data could be used once a decade to draw a new panel for the NSCG. The existing ACS questions are nearly identical to those found on the decennial census long form, and they are suitable for a screening survey for the NSCG as was done using the census long form. The survey procedures could then follow those previously used in the postcensal NSCG.

The advantage of this option is that it requires the least amount of organizational change, meaning an easier transition. However, there are several disadvantages. One is that it fails to take advantage of the yearly accumulation of ACS cases. Five years of the ACS yields as many cases as the number gathered by the decennial census long form. Unless multiple years of the ACS are used, the Census Bureau cannot provide the oversample of rare groups (e.g., minorities) that were available on the long-form census samples, and the reliability of estimates for these groups of

interest would suffer. This option would also continue the current peaks and valleys in the funding pattern: Costs will be high for one cycle per decade instead of similar in size for each survey cycle.

Conclusion: Replicating the current design is not an efficient way to use the ACS.

(2) Selective Updating

Design option 1 could be modified by using the ACS in later years of a decade as a frame to update the sample for certain domains whose coverage becomes problematic as the decade progresses (e.g., recent immigrants) or for populations of emerging interest. Data items in the ACS could be used to identify subsets of ACS respondents into a frame for targeted group(s). For example, the question on when a person came to the United States could be used to create a subset that contains recent immigrants. The ACS could be used as a frame to examine "real-time" events (e.g., the rise and fall of technology and information technology firms and the impact on information technology occupational employment). Such supplemental frames for special domains could be sampled during any survey cycle rather than once a decade.

ACS data could be analyzed for indicators of meaningful change in categories of interest, such as large increases or decreases in a field, or occupation, or immigration status. Frame updates could be implemented whenever the ACS data signaled there had been a significant change that would warrant an update.

The selective updating approach has its downsides. First, it requires a periodic major redesign (such as every 10 years). Second, it requires the draw of a very large sample periodically from the ACS and so it would compete for resources for ACS over the decade. Third, it opens the possibility of data series discontinuity because there will be a break in series whenever the entire sample is redrawn.

There are some advantages to this option over the once-each-decade option. It allows updating each survey cycle and thus prevents coverage losses associated with an out-of-date frame. It also allows updating to gather data on emerging issues. On the negative side, it retains the serious cost disadvantages of option 1, and, as an operational drawback, it requires continuous access to the ACS as a sampling frame.

Conclusion: The disadvantages of the selective updating design outweigh the potential advantages. However, selective subsamples could be considered to supplement another design to enable the study of subpopulations of emerging interest.

(3) Continuous Sample Updating

A fresh sample could be selected from the ACS for each cycle of the NSCG or at least more frequently than once a decade. With a freshly drawn sample, the coverage of the full population of interest would be more current than at present and it would reduce or eliminate the coverage problems that develop over the decade in the once-a-decade approach, particularly for immigrant scientists and engineers and for nondegreed workers in S&E occupations. This approach would involve screening for eligible scientists and engineers each time a new sample is drawn from the ACS and would require large sample sizes (and thus higher costs) for each survey cycle. This option would pose some operational issues, such as procedures for phasing in any new sample. The total replacement of the sample might not be feasible from a cost standpoint; it might be necessary to phase in the new sample over one or two collection cycles.

The advantages of this option make it extremely attractive. It would maintain the currency of the NSCG sample, permit oversampling of emerging or special interest populations during the decade, prevent discontinuities in the estimates, support trend analysis, and smooth out the NSF budget cycle.

A serious disadvantage of this approach is that it would likely require continuous access to the entire ACS sample for all years to derive the desired sample sizes for rare populations. The Census Bureau cannot commit to providing that level of access to the ACS in an ongoing manner. Total sample replacement each survey cycle might also not be cost efficient because the NSCG incurs highest per unit costs in its first data collection due to higher tracing and locating costs and the need to screen out people who are ineligible for the study.

Drawing new samples more frequently than once a decade would also reduce (or eliminate) the longitudinal feature of the ACS. If the sample were redrawn every survey cycle, the NSCG would become a series of cross-sectional surveys. One result would be considerably more variation in the estimates from cycle to cycle than with the current longitudinal design. This phenomenon would be especially noticeable in important small domain estimates, such as estimates by field by race and ethnic group.

It should be recognized that there is considerable risk to NSF in committing the agency to this option. As discussed in Chapter 3, there is no firm guarantee that the ACS would be made available for such sampling. The overall costs would likely be higher than at present because data collection and data processing operations would be more expensive due to the need to locate and screen the freshly selected sample.

Conclusion: A freshly selected sample from the ACS in each cycle of the NSCG is not an efficient design, particularly for small populations. If rare populations were to be effectively studied, extensive and continuous use of the ACS sample would be required, which might preclude use of the ACS for other survey purposes.

(4) Rotating Sample

The ACS affords the opportunity to convert the NSCG to a rotating sample design.[5] Rotation designs are often recommended in longitudinal surveys when there is a problem with sample attrition due to respondent fatigue. With three survey cycles per decade, the NSCG has experienced declining response rates as each decade progressed, as well as increasing refusal rates. The rotating sample approach would offer virtually all of the advantages associated with continuous sample updating, plus some additional advantages.

For example, the 2003 NSCG sample could be initially divided into several equal-sized panels. A new panel would be drawn from the ACS to replace one of these NSCG panels. Each survey cycle a new ACS panel could replace an old NSCG panel until the entire 2003 NSCG was rotated out. Then the oldest ACS sample panel could be replaced by a draw from the most recent ACS year(s), one each NSCG survey cycle. This approach incorporates all of the coverage advantages of options 2 and 3 plus the additional advantage that the process of screening to identify scientists and engineers would be spread more evenly over time.

The duration of the transition process of phasing in ACS panels could be lengthened or shortened depending on the size of the NSCG panels to be replaced (or replacing multiple 2003 NSCG panels in one or more survey cycles). During the transition phase, a larger draw might be taken the first time. The rotation schedule for the transition to the ACS need not be the same as that established for the longer term once the NSCG consists entirely of ACS panels.

To use this design, NSF would need to negotiate with the Census Bureau for assured continuous access to the ACS sample for NSCG frame building. With a sufficient number of panels (say four to five rotating panels) and biennial data collection, NSF should be able to build its sample frame for selecting each cycle's incoming panel from a random subsample of about 20 to 25 percent of the ACS sample (translating into four or five rotations), which would enable other studies to build valid sampling frames from the remainder.

[5]For a discussion of using multiple frames for the NSCG design, see Fecso et al. (2007a).

There are several advantages to this option. There are obvious cost efficiencies in that replacing only a portion of the sample each survey cycle would smooth out data collection costs across time and avoid ballooning costs once a decade. The 2-year periodicity can be designed to avoid the decennial moratorium by returning to surveying in odd-numbered years. Rotating panels allow retention and accumulation of rare subgroups of special policy interest. Replacing only a portion of the ACS each survey cycle would allow NSCG to build its frame from only a subsample (say, 25 percent) of each annual ACS rather than the entire sample each year. This design would also permit embedding methodological experiments to address quality issues

The disadvantages include the fact that rotating panels lead to lower response rates in comparison with a freshly selected sample each cycle, due to survey attrition, panel fatigue, and conditioning effects. And, as with other options, the Census Bureau would need to commit to allowing NSF to sample from a designated subsample of the ACS every year but without the greater perturbations of the sample that would occur under the options that require a once-each-decade (or other frequency) sample draw. Finally, the rotating sample design will limit the ability to do longitudinal analysis. Although the rotating panels maintain the capacity to do longitudinal analysis as each panel will have data collected for a specific number of years, the longitudinal data will not be available for the full sample for all time periods.

Conclusion: The rotating sample approach is the most promising of all the NSCG design options and a biennial survey cycle with four or five rotating panels is the most efficient and cost-effective use of the ACS as a sampling frame.

In addition to the four NSF options (summarized in Table 6-1), the committee considered a hybrid approach suggested by Graham Kalton at the October 2007 workshop. This option would implement a rotating design for rare populations only, while using a cross-sectional strategy for the more populated groups of interest. With this hybrid approach, it would be possible to accumulate a sufficiently large number of sample cases for relatively rare populations to produce reliable estimates and to capture the strength of the large number of sample cases to produce current estimates.

The hybrid approach would have drawbacks. Because most sample units would be refreshed each year, there would be limited ability to follow respondents over time, thus limiting the ability to develop a longitudinal database. The rare population cases that are followed on a periodic basis would also have problems of sample attrition and might be prone

TABLE 6-1 Summary of Options for Sample Design

Option	Description	Advantages	Disadvantages	Conclusion
Continue current approach	Use the ACS once each decade for a sample draw.	Requires least amount of organizational change, easier to make the transition.	Fails to take advantage of the yearly accumulation of new cases; limited ability to oversample rare populations.	Replicating the current design is not an efficient way to use the power of the ACS.
Selective updating	Use the ACS in later years of the decade to update the sample for problematic domain coverage.	Allows updating each survey cycle and limits losses due to out-of-date frame.	Retains the serious cost disadvantages of the current approach and requires continuous access to the ACS to draw samples.	Disadvantages outweigh the advantages. However, selective subsamples could be considered to study subgroups of particular interest.
Continuous sample updating	Drawing a fresh sample from the ACS for each cycle of the NSCG, at least more frequently than once a decade.	Maintains the currency of the NSCG sample, permits oversampling of special interest groups during the decade, supports trend analysis.	Requires continuous access to the ACS sample for all years and may not be cost efficient; would reduce or eliminate longitudinal feature of the ACS.	Not an efficient sample design and would limit use of the ACS for drawing samples for other surveys.
Rotating sample	Refresh the once-per-decade sample replenishment with rotating panels.	Incorporates the cost efficiencies and advantages of the prior updating options and permits screening to identify S&E workers over time.	Rotating panels lead to lower response rates due to sample attrition; will require a decision about whether to bring in a new sample all at once or by multiple panels in the transition.	**This is the most promising of the design options. A biennial survey with four or five rotating panels is most efficient solution.**

to problems of panel conditioning over time. Comparisons of population groups might be adversely affected by differential time-in-sample effects across the population groups.

Conclusion: A hybrid approach using a rotating design for rare populations would have the drawback of not keeping time-in-sample constant across subpopulations and thus might lead to differential levels of nonsampling bias across subpopulations.

Recommendation 6.2: If the National Science Foundation wishes to consider continuation of the National Survey of College Graduates with the sample drawn from the American Community Survey, the agency should use a rotating panel design.

TRANSITION PHASE

The length and difficulty of the transitioning from a frame based on the census long form to one based on the ACS will be dictated by the design option that is selected. The transition process is critically important and the planning for a transition phase needs to begin almost immediately. For example, if data collection is to be initiated in 2011, sample cases from the 2009 and 2010 ACS would be required. Indeed, it would make sense, given the relatively limited size of the ACS for rare populations, to retain a portion of the 2008 NSCG panel as a carryover panel to supplement the ACS sample draw. There is precedence for this, as use of a carryover sample was a part of the post-2000 decennial census sample design also.

Recommendation 6.3: The National Science Foundation should work with the Census Bureau to develop plans for using the American Community Survey as a sampling frame for a transitional period as well as for the continuing design.

ACS PROCESSING STEPS: SWAPPING AND IMPUTATION

In the course of discussing NSCG design options in the panel's October 2007 workshop, the issues of data swapping and imputation and their effects on the sampling process emerged. These technical processes are regularly used by the Census Bureau, and they have an effect on the efficiency and accuracy of the estimation of survey values.

The Census Bureau uses the technique called data swapping to create public-use datasets (a decision based on their overall disclosure policies). Data swapping is a technique for ensuring data confidentiality in which,

during processing of the survey data, records are exchanged for a subset of cases by selecting a sample of households, matching them on a set of selected key variables with households in neighboring geographic areas that have similar characteristics (such as the same number of adults and the same number of children), and swapping data elements.

If the swapped data are used to produce estimates, there is little effect on the data since the swap usually occurs within a neighboring area so as to have no effect on the marginal totals for the area. But if the swapped data are used to identify households or people for sampling for the NSCG, the use of swapped data could greatly reduce stratification efficiency.

The committee favors use of the edited ACS file, before swapping, for weighting and creation of the NSCG sampling frame even though the use of unswapped data may mean that a customized weight would have to be developed if only the ACS base weight is available at the time that NSCG frame is built. The problem of loss of stratification efficiency holds sway. There is precedence for the use of unswapped data as the Census Bureau allowed use of unswapped data from the 2000 Decennial Census long form for sampling for the 2003 NSCG.

Recommendation 6.4: The Census Bureau should use unswapped American Community Survey data (with sample weights) for drawing a National Survey of College Graduates sampling frame.

Another technical concern is the use of imputed data from the ACS. The panel concludes that imputed educational attainment level data (labeled "allocated data" by the Census Bureau) should not be used for sampling. Imputed data creates an unacceptable amount of undercoverage of those with a bachelor's degree—estimated at 3 to 7 percent according to Finamore, Hall, and Fecso (2006)—as well as sampling inefficiency because, in some cases, those with an imputed education level of a bachelor's degree could turn out not to have a bachelor's degree. To assist in arriving at an informed decision on imputation, the committee urges that records that have imputed an education level should be put aside prior to sampling and a small sample of these ACS cases should be sampled to collect actual records, i.e., documentation of claimed degrees, in order to measure the data quality and undercoverage.

Adding a field-of-degree question to the ACS would create an entirely new issue related to imputation. It is unclear how imputation should be done for missing field-of-degree information. For individuals with an S&E or S&E-related occupation, field-of-degree imputation might perform well. For other occupations, it is not obvious that an acceptable imputation model can be developed. It may be that such cases will need to be treated as missing and reweighted. Depending on the severity of the

problem, special attention could be focused on following up on missing field-of-degree responses in the research program envisioned in Recommendation 5.2, above.

Recommendation 6.5: The National Science Foundation and the Census Bureau should initiate a program of research on imputation and nonresponse treatment for missing field-of-degree and education-level responses.

ACCESS TO THE ACS SAMPLE FRAME

The recommended option of a rotating panel design for the NSCG does not come without risk. Although this design would eliminate periodic demands for a very large sample from the ACS because the entire sample will not be redrawn every cycle, it would require several draws during the decade in contrast to just one at the beginning of the decade. It thus would require assured access on a continuous basis to a subsample of the ACS sampled cases. The Census Bureau has indicated reluctance to guarantee continuous access to the entire ACS (personal communication, Howard Hogan, U.S. Census Bureau). Assured access to a *subsample* of the ACS may be possible.

The reluctance of the Census Bureau is based on constraints that are faced in allocating access to the ACS as a sample frame for other surveys, which also involves a number of unknowns. This constraint will not pose a problem for 2009, as the Census Bureau is not aware of any other potential requests for access to the ACS as a sample frame in that year. However, there is discussion of using the ACS as a sampling frame for the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) in 2010 and thereafter, although the design and sample requirements for that survey have not yet been specified. Several other survey operations are known to be considering use of the ACS as a frame, including the Survey of Income and Program Participation (SIPP), the American Housing Survey (AHS), and a possible new health survey. In anticipation of a situation in which multiple surveys are vying for access to the frame, the Census Bureau has developed and promulgated a policy on using the ACS as a frame for reimbursable follow-on surveys (U.S. Census Bureau, 2007, p. 2). The policy includes provision for informing ACS respondents of the possibility of being included in follow-on surveys and a priority scheme that stresses reduced costs and the difficulty of screening for rare populations.

This major problem for the Census Bureau stems from the Bureau's policy that precludes an ACS household that has been selected into the sample of one non-ACS survey from being contacted again for another

non-ACS survey. Under this policy, the selection of an individual for the NSCG will exhaust the eligibility of the whole household for further survey contacts. Therefore, it becomes more difficult to draw a nationally representative household sample for other surveys after the sample for the NSCG has been drawn. To the extent that the NSCG will oversample rare populations, the possibility of having sufficient sample units for these smaller groups is further constrained.

There are some technical fixes to this problem that can be explored. NSF and the Census Bureau are considering the possibility of allocating access to the ACS sample by month. Other procedures to enable the NSCG sample draw while preserving sample for other surveys may well be developed with additional research.

Recommendation 6.6: The National Science Foundation and the Census Bureau should sponsor a research program to explore means of permitting a sample draw from the American Community Survey for a rotation panel for the National Survey of College Graduates while preserving American Community Survey sample units for other surveys.

7

The ACS and SESTAT in the Future

The addition of a field of bachelor's degree question to the American Community Survey (ACS) will quickly, profoundly, and permanently change the prospects for analysis of the science and engineering (S&E) workforce in the United States. It will facilitate analysis of several of the key science and engineering workforce questions directly from ACS data, enable more efficient design of the National Survey of College Graduates (NSCG) and specially targeted surveys, and open the door to targeted surveys of specific subgroups, such as immigrants or dual career households with both spouses in the S&E workforce. Having a field-of-degree question on the ACS will also provide the National Science Foundation (NSF) with a unique opportunity for strategic planning regarding its priorities for studying the S&E workforce. This planning will necessarily involve all of the components of the Scientist and Engineers Statistical Data System (SESTAT) and may involve rethinking the relevant questions to ask.

In this chapter the panel discusses some of the exciting opportunities raised and suggests promising venues of research and analysis of the S&E workforce that will be possible when the ACS field-of-degree information is available.

THE ACS AS A DATA SOURCE

It is important to note that ACS data do not presently contain the rich set of S&E background and outcome variables now collected in the

SESTAT surveys. Nonetheless, the ACS data do contain basic information about the occupations and earnings of people with bachelor's degrees in science and engineering as well as other fields. With the addition of the field-of-degree data, the ACS information could be tabulated to directly support NSF's mandated indicator reports.

The use of the ACS for this purpose will bring advantages of increased reliability from large sample sizes and significantly improved timeliness, though these advantages are counterbalanced by some loss in detail. The large ACS sample sizes will be particularly valuable when addressing issues of relative employment conditions among rare populations, such as scientists or engineers from groups that have been traditionally underrepresented in S&E fields and occupations. This feature is important, given the NSF mandate to monitor the employment status of women, minorities, and persons with disabilities who have college-level training in S&E fields.

Recommendation 7.1: The National Science Foundation should use current data from the American Community Survey to evaluate the degree to which the American Community Survey with the field-of-degree question would allow for the production of mandated indicator reports in the future.

The ability of NSF to address questions about the S&E workforce beyond the production of indicators will also be enhanced by having the ACS with a field-of-degree question. In the past, analysis of relationships among college major, career choices, and career access were limited to snapshots provided by occasional large surveys. A sufficiently detailed field-of-degree question will enable NSF to track the employment status of rare populations of bachelor's level scientists and engineers, with relative levels, trends, and fluctuations in both employment and earnings on a continual basis, using the ACS alone.

Because the ACS is a household survey, it further expands the types of analyses that can be done with respect to the S&E workforce. For example, the study of dual-career households is possible with existing ACS data, but only for groups defined by occupation and education level. The field-of-degree question on the ACS will add a new dimension, allowing special consideration of dual-career households in S&E fields. The household data will provide additional analytic opportunities as well, especially with in-depth household information not currently collected on the NSCG.

The timeliness of ACS data will provide annual information on the S&E workforce close to the reference period. These more timely data provide NSF with a powerful new ability to analyze the effects of real-time

events on the college-educated population. For example, does a particular labor market fluctuation have different effects on workers with different fields of college training?

The large sample sizes and ongoing design mean that the ACS data will be useful to many researchers interested in understanding different aspects of the S&E workforce over time. For example, what are the effects of recent immigration on the S&E workforce? Are the effects different in different fields? Why do gender differences in career choices persist, and are there places or time periods in which these differences narrow?

The ACS could also be used in other ways to improve the timeliness and relevance of the S&E workforce information. For example, the ACS could provide a frame to do more frequent (and smaller) special topic surveys on topics and groups of special interest. Moreover, the Census Bureau is considering adding supplemental questions that appear one time or rotate in and out of use on subjects of current interest for the whole sample or for subpopulations of special interest.

Recommendation 7.2: If the American Community Survey is selected to produce indicator reports, the National Science Foundation and the Census Bureau should develop a supplemental program of special, targeted surveys to obtain information on topics and groups of interest.

ACS EFFECTS AND SURVEY DESIGN

Chapter 6 details how the ACS with a field-of-degree question as a sample frame could positively affect the NSCG. As noted, the ACS offers the ability to allocate resources efficiently in designing the sampling frame for the NSCG's more detailed questions. Not only can people with science or engineering college majors be oversampled from the ACS frame, it will be also possible to identify specific majors from within this group for particular attention.

In thinking beyond the improvements that can accrue to the current NSCG, the ACS itself could be used to suggest improvements to NSCG content or to suggest specific targeted surveys. In the future, issues that cannot be identified with data from the Current Population Survey (CPS) or the decennial census data should be visible from the ACS in time to allow each NSCG wave to add new questions or to target particular groups to address current policy concerns. For example, if it is noted that a given economic contraction has strong effects on workers with a particular undergraduate major, such as when computer sciences were affected by the technology sector retrenchment in the early 2000s, that group could be oversampled in the following wave of the new NSCG. Similarly, if

large changes in migration or immigration in one scientific field appear, those changes could be monitored continuously in new waves of ACS data, and relevant questions could be added to the new NSCG to fill in the details. In the same vein, the ACS can help identify dual-career S&E families and provide information to design a supplemental sample to the NSCG to provide deeper information on dual-career issues. The availability of these data will enhance the ability of NSF to provide a timely picture of a wide variety of emerging workforce issues.

In much the same way, the ACS lends itself to serving as the basis for drawing samples of subgroups of interest in order to test and evaluate questions (much as is currently accomplished through the content test program) and sample design and methodology improvements. Such testing and evaluation of NSCG content and methodology is especially natural if NSF and the Census Bureau adopt the panel's recommendation for a rotating panel design.

Use of the ACS for the NSCG affords NSF a unique opportunity for continuous improvement. An ongoing program of developing carefully crafted experimental panels would provide the basis for testing the next generation of advances in collection and estimation methodology for the NSCG (and other surveys of its kind).

Recommendation 7.3: The National Science Foundation and the Census Bureau should consider establishing a continuing experimental panel program to support testing and development of techniques and methods for the National Survey of College Graduates.

LINKING CENSUS, ACS, AND NSCG DATA

There are many reasons for researchers to want NSCG data that are linked to census and ACS data for the same person. Such a linkage was successfully implemented in a match of the 1993 NSCG with information from the 1990 census. The decision of how much of the linked data to release involves tradeoffs between the competing goals of producing data that can be used for meaningful statistical analysis, protecting the confidentiality of participants, and avoiding the necessity of asking participants to answer the same questions they have already answered on a previous survey. Linking data from the NSCG to outside sources provides an efficient means to study labor market dynamics on short time scales and to understand how NSCG respondents compare with other college graduates. It would be particularly useful to be able to link NSCG responses to common labor market measures, including occupation (using census categories), previous year's earnings, and the number of weeks and hours per week worked in the previous year. Demographic

information is easier to collect in a new survey wave, but detailed census demographic measures (race, ethnicity, immigration status, and timing of immigration) are valuable in some studies. Finally, it is vital in some analyses to have access to the census variables that are considered in the decision to include people in the NSCG sample, e.g., educational attainment at the time of the ACS interview, age, sex, and broadly aggregated race and ethnicity.

The panel recognizes that the data involved in the linking operation are highly confidential and that access must be carefully controlled by the Census Bureau to ensure that the data are protected. Today, such protections are afforded through the Census Bureau Research Data Centers. In the future, alternative means of improving access to the data in a manner that assures that data confidentiality is protected, such as data enclaves, may be judged adequate by the Census Bureau.

Recommendation 7.4: The National Science Foundation should sponsor the development of a matched sample of American Community Survey and National Survey of College Graduates respondents for research purposes with access provided to researchers through the Census Bureau's Research Data Centers.

STRATEGIC PLANNING FOR SESTAT

The field-of-degree question on the ACS, in addition to using the ACS for sampling purposes, provides a unique opportunity for NSF to engage in strategic planning for the SESTAT system. Therefore, it seems appropriate to examine each element of the SESTAT data system to determine how to best integrate and configure data collections and optimally expend available resources given the available resources. The bulk of the panel's report addresses integration of the ACS and the NSCG. In this section the committee discusses the potential effects of the ACS on the other SESTAT components.

Science and Engineering Doctorates

The stock and flow of science, engineering, and health doctorates are well covered by the Survey of Doctorate Recipients (SDR). The SDR has great value as a stand-alone survey, enabling longitudinal analysis of the careers of these doctorate holders.

Previous sample frame research conducted for NSF has recognized that the SDR is different, with separate sampling justified by the desire to increase the sample of earned doctorates above the small number of U.S. doctorates in the NSCG and to elicit comprehensive information about

this group (Fecso et al., 2007a, p. 4). Currently, those with U.S. doctorates contained in the NSCG are not included in the SESTAT integrated database; people with U.S. doctorates are drawn from the SDR survey. Only those sample cases in the NSCG who have doctorates from institutions outside the United States are included in the SESTAT integrated database.

The use of the ACS as a frame for the NSCG is unlikely to change the value of and need for the SDR survey for several reasons:

- The ACS will not provide a sufficient sample of doctorate recipients unless multiple ACS years are combined, and such a combining of multiple years would nullify many of the quality enhancing features of using the ACS.
- The desire for small-domain estimates for these people (e.g., doctoral field by race or ethnicity by sex) and the ready availability of the Survey of Earned Doctorates (SED), a census of all U.S.-earned science, engineering, and health doctorates, for a sampling frame makes continued use of a separate SDR survey a very efficient approach for the doctorates of interest.
- The ACS does not contain information about the date a person receives a degree. Data on age, which are available from the ACS, are not a good proxy for determining year of degree. Data from the 2003 National Survey of Recent College Graduates (NSRCG) show that more than 50 percent of bachelor's degree recipients in science, engineering, and health in 2001 and 2002 earned their degrees when they were 25 years of age or older, and more than 50 percent of master's degree recipients in those fields earned their degrees when they were 30 years of age or older. Therefore, age is an inefficient indicator for selecting recent graduates.

Recent College Graduates

The NSRCG has twin objectives. One, discussed in Chapter 2, is to generate data to inform the public of the flow of new bachelor's and master's degree recipients (from U.S. institutions) into a science, engineering or health field. NSRCG data are useful for employers and government to understand and predict trends in graduate school enrollment, employment opportunities, and salaries for recent graduates in S&E fields. The NSRCG provides direct information about the employment and continuation into further education of recent bachelor's and master's recipients in those fields. Another objective of the NSRCG data is to serve as a key component of the SESTAT system, in that it provides the flow of new U.S.-educated science, engineering, and health bachelor's

scientists and engineers to add to the stock of scientists and engineers from the NSCG.

The availability of annual ACS data with field-of-degree information raises the question of how much the ACS and the NSRCG overlap. Clearly, there is some overlap between the NSRCG and the ACS (with a field-of-degree question) in that the ACS will naturally incorporate recent graduates, but there are differences, too. For example, the ACS alone has no questions that can directly discern recent college graduates or those with a science, engineering, and health master's degree.

The advisability of implementing a new ACS-based approach to capture the population currently covered by the NSRCG must take into account not only the relative importance of the two functions that the NSRCG currently serves in the set of SESTAT surveys, but also technical issues. For instance, if the rotating panel sample design option recommended in this report is adopted, it would be possible to fulfill the second function of the NSRCG with the NSCG alone because the flow of new degree recipients would occur naturally. It would also be possible to fulfill this function if subsamples from the ACS were drawn with some frequency to capture new graduates. (It should be kept in mind that data on recent college graduates need to be collected with some frequency because the workforce experience of this group is particularly sensitive to labor market conditions.) However, the use of the ACS to identify recent college graduates would not fulfill a primary function of the NSRCG—providing detailed information on this population. The NSRCG is now used to make estimates for small domains, such as recent college graduates by field, race and ethnicity, and gender.

Using the ACS frame to produce direct information about recent graduates would require a larger sample for the NSCG and oversampling (and screening) to identify a sufficient number of recent graduates to derive estimates that approach the precision of those currently yielded by the NSRCG. The ACS does not have information on the year of a degree, so to maintain the current coverage of the NSRCG, NSF would have to substantially oversample older people whose highest degree was a bachelor's or master's degree. Most of these older graduates would not have recent degrees. To avoid such costly and inefficient oversampling would require an undesirable revision in the scope of the NSRCG.

Currently, the NSRCG samples approximately 9,000 graduates from each graduating class (about two-thirds from bachelor's degree recipients and one-third from master's degree recipients). Obtaining a sample of this size with appropriate demographic oversampling may be difficult to achieve with 1 or 2 years of ACS data, even with a field-of-degree question. For sampling purposes, the NSRCG obtains reasonably accurate degree data from colleges and universities of recent graduates in science,

engineering, and health in order to target sampling of recent graduates. Although only limited demographic information on each school is available as part of the sampling characteristics that are used, there is sufficient information on past graduates and each school's profile to target the population accurately. In addition, schools are able to provide relatively current contact information on recent graduates, along with detailed degree information. The foregoing discussion suggests that there would be some benefit to considering how the ACS can be used to improve the efficiency of the NSRCG as a part of an overall reconsideration of the design of the SESTAT data system.

Recommendation 7.5: The National Science Foundation should use the opportunity afforded by the introduction of the American Community Survey as a sampling frame to reconsider the design of the Scientists and Engineers Statistical Data System (SESTAT) Program and the content of its component surveys.

FUTURE OPPORTUNITIES

The previous section discusses gains in efficiency and analytical power for understanding the S&E workforce as currently defined that arise from the addition of the field-of-degree question on the ACS. In this section the committee discusses the potential of the ACS with field-of-degree question to contribute to a rethinking of the economic concept of the S&E workforce and the science of measuring and tracking this workforce.

In a previous review of NSF's efforts to track the national infrastructure of human capital in science and technology, Kelly et al. (2004) raised several issues that should be taken into account in developing a data system that would enhance understanding of the science and technology enterprise.[1] One major point that the authors raise is that the composition of the human capital pool used by the S&E sector reflects choices that are made by both firms and workers. Based on the remuneration in other sectors and the costs of other productive inputs, S&E industries will change the field of study and the intensity of training they require for the employees they hire. As wages in different sectors change and rise or fall relative to one another, workers may switch out of or into S&E sectors. Given these employment flows, the S&E employment pool will change over time.

[1]Although the Kelly et al. (2004) study addressed what they characterized as "science and technology," it is a concept very similar to what is characterized in this report as "science and engineering," and the basic arguments apply.

With limited resources, NSF has to date appropriately focused on a clearly identifiable and highly relevant slice of the labor force—those with bachelor's or higher degrees in S&E and S&E-related fields. To its credit, NSF was able to expand the scope of the NSCG to include non-S&E fields in recent years but much more needs to be done to collect information on a larger part of the workforce in more detail and in a more timely manner. NSF does not currently have the capability to inventory S&E skills in all workplaces, nor is it apparent that SESTAT can produce what is and will be desired to analyze the patterns and trends that are embedded in the many choices made by workers and employers.

The availability of the ACS with field-of-degree information offers a breakthrough opportunity for gaining a better understanding of the total S&E enterprise and all of the national labor force resources that contribute to innovation and technical change and the economic growth they generate. This requires thinking expansively about the S&E workforce. Occupations and training levels that might have once put a worker unambiguously inside or outside the S&E sector may no longer serve such a discriminant function. For example, a narrowly trained technician from a community college may, under the current definition, be counted as a science and technology worker if working in the right industry. It may not take a remarkably higher wage to move this worker from a job in the science and technology sector to one in retail trade, in a technical support position, and hence no longer a technology worker. Similarly, if that same worker is employed in retail trade as a support person and hence not a technology worker, a change of sector as a result of a higher wage offer could move that person into classification as a technology worker.

NSF's ability to study the S&E infrastructure in the United States using the expanded concept of a large potential S&E workforce would be enhanced with the availability of additional descriptive data, such as data on earnings. This larger view of the workforce and associated data would permit better analysis of such issues as the S&E worker shortage hypothesis. A professed shortage of workers alongside a decline in their earnings relative to workers with similar levels of education in different fields would help understanding of whether a perceived shortage of S&E workers was localized to a field, part of a more widespread phenomenon, or reflected not a shortage but the presence of better opportunities in different industries. The ACS and, as discussed below, the CPS offer data on workers and earnings that provide such additional analytic opportunities for studying the condition of the S&E labor market.

The availability of the ACS with field of degree will finally allow analysts to explore the dynamism of the concept of the S&E workforce. Most current analyses rely on comparing workforce participants based on the occupations they hold, leading to what is sometimes known as choice-

based sampling. That is to say, the determination of whether someone belongs to a category is a result of choices made by that individual. The statistical properties of such samples can be somewhat complex.

If NSF oriented its sampling around degree and field to define S&E workers, then NSF would be able to devote resources to sampling a larger number of potential S&E workers. (As the panel notes above, degree and field also reflect individual choices; however, once a degree is earned, the possession of that degree and its fields are characteristics of an individual that do not change in response to market dynamics.) The resulting ability to broadly focus on fields without the distraction of current occupation will enhance understanding of how changing relative wages and changing demands in the markets can change the number and composition of S&E workers and, in the process, help to explain innovation.

The ACS could also be used to generate a very powerful longitudinal study capacity, much more robust than the current limited longitudinal capacity of the NSCG. At the present time, the ability to track the movement of workers through the labor force is the province of such studies as the National Longitudinal Survey, the Panel Study of Income Dynamics, and the New Immigrant Survey. These sources certainly help understanding of the dynamics of all workers, but their limited sample sizes and scopes circumscribe their ability to understand the dynamics of the S&E workforce. The SED and similar data resources help understand the flow of highly trained people into the labor force, but they lack the panel attribute that would enable them to contribute to an understanding of dynamics. A small, well-executed panel survey of college graduates below the doctoral level, drawn from those identified in the ACS, would aid in understanding the labor force dynamics of highly trained workers, even if it did not have the large sample size needed to explore these dynamics in detail for all demographic categories. If supplemented with a longitudinal sample of immigrants with advanced degrees, obtained with the cooperation of the Customs and Immigration Services, a comprehensive understanding of the dynamic labor market would evolve.

In the process of moving away from the selection of respondents based on occupations that are choice-based (that is, influenced by current and potential earnings and training cost considerations), cross-sectional, general-purpose surveys such as the CPS could be enlisted to provide a broad picture of the employment status for scientists and engineers and also make direct comparisons with other fields. As part of the evolution from a focus on occupations to a focus on fields, it would be useful to enhance the ability of the CPS to supplement the new information from the ACS on a more current basis and contribute to the study of the S&E workforce by adding a field-of-degree question to the survey. The addition of a field-of-degree question to the CPS would enable NSF to assess

S&E workforce trends on a monthly basis in the same manner as the aggregation of ACS cases will provide on an annual analysis, although it is recognized that the CPS will not provide the sort of detail on S&E workers by disability and gender that the current mandates require and thus will not substitute for the ACS.

In sum, the ACS is a promising option for efficiently fulfilling a major part of NSF's mandate. However, the ACS affords much more than an opportunity to do business-as-usual better. It provides an opportunity to repurpose SESTAT to overcome some of the current conceptual limitations that cause analysts to view S&E workers as a well-defined and time-invariant segment of the labor force. The ACS would permit measuring all workers who could, at some set of wage rates and product demands, become S&E workers. In the process, NSF would be able to fulfill its mandate to understand the S&E labor force in a more efficient and timely manner that would release resources to invest in more policy-relevant work.

CONCLUSION

The ACS with a field-of-degree question can affect the mission of NSF with regard to S&E workforce data; indeed, the ACS with field-of-degree information may eventually provide much of the data needed by NSF to produce its mandated reports. If so, then NSF would be afforded a unique opportunity to redesign SESTAT in support of innovative analysis to enhance understanding of the key issues regarding S&E human resources.

A redesigned SESTAT may include its current components, such as the NSCG, for which the ACS could have a large impact as a more efficient sample frame; or SESTAT may become more reliant on the ACS, supplemented by a series of targeted surveys based on trends visible with ACS data, or it may include both. A redesigned SESTAT may even integrate CPS (if a field-of-degree question were added) to provide timely information on income data to frame the important questions of the S&E workforce. It is not too early to begin thinking about the many exciting possibilities that are emerging with the inclusion of a field-of-degree question on the ACS.

Recommendation 7.6: The National Science Foundation should conduct a careful assessment of internal and user priorities for studying the science and engineering workforce to capitalize on the expanded analytical opportunities afforded by the addition of field-of-degree question to the American Community Survey.

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Appendix A

Workshop Summary and Agenda

The Panel on Assessing the Benefits of the American Community Survey for the NSF Division of Science Resources Statistics held a public workshop on October 5, 2007, in Washington, D.C., to discuss NSF, Census Bureau, and data user needs for the Scientists and Engineers Statistical Data System (SESTAT), particularly the National Survey of College Graduates (NSCG). The workshop goals were to

- clarify issues concerning alternative approaches to using the ACS as a sampling frame for the NSCG;
- identify issues related to the use of field-of-degree information on the ACS with regard to statistical methodology, data quality, and data products;
- consider the use of field-of-degree and other information from the ACS as a screening element for subsequent surveys such as the NSCG, which until now has used level of degree information from the decennial census long form; and
- consider relevance and adequacy of ACS products for meeting current and emerging data needs for NSF.

The workshop agenda is at the end of this appendix.

Among the highlights of the workshop, NSF provided a background discussion on the range of workforce surveys in SESTAT, including the NSCG, National Survey of Recent College Graduates (NSRCG), Survey of

Doctorate Recipients (SDR), and the Survey of Earned Doctorates (SED). These surveys offer a comprehensive and integrated system of information on employment, education, and demographic characteristics of scientists and engineers in the United States. The three sample surveys consist of more than 100,000 respondents combined, representing a population of over 21 million who have science and engineering (S&E) or S&E-related degrees or occupations. The NSCG, which is the survey of interest to the panel, captures data on people with at least a bachelor's degree, who account for 85-90 percent of the SESTAT population and is the only source of information on people with non-U.S. degrees.

NSF staff also reviewed the several mandates under which the agency operates. Under the 1950 act that created the agency, it is mandated to be a clearinghouse of information on the S&E enterprise. The amended act calls for NSF to collect and analyze demographic and education information on individuals with degrees in science and engineering and to design, establish, and maintain a data collection and analysis capability for the purpose of identifying and assessing the number and characteristics of scientists and engineers in the United States. Additional congressional mandates require NSF to produce the *Women, Minorities, and Persons with Disabilities in Science and Engineering* and *Science and Engineering Indicators* biennial reports.

The panel heard from five SESTAT data users, including three of the panel's own members, on the various uses of and needs for the data. The uses range from reconstructing answers from the census long form to evaluate the quality of the Census Bureau's imputation of education, assessing gender and racial earning gaps, evaluating the relationship between work activity and earnings, and determining the contribution to U.S. science from foreign-born versus native-born workers. The NSCG is especially useful to researchers interested in determining how the labor force is changing and the effects of immigration.

The users stressed that within confidentiality and privacy limits, particularly under Title 13, data linkages between the ACS and the NSCG and links from the SDR and the NSCG to the U.S. Patent and Trademark Office database would be helpful in answering additional research questions. The latter of these linkages would facilitate research into the role of entrepreneurial activities in the fields of science and engineering.

The Census Bureau provided a comprehensive overview of the content testing planned for the field of bachelor's degree question. There are two versions of the question: categorical or forced choice, and open-ended. Each version of the question was mailed to 15,000 housing units in July 2007, and nonresponse follow-up was conducted by telephone and personal visit in August and September. A content follow-up reinterview was conducted by telephone to assess the reliability of the responses. This

reinterview attempted to speak to the original respondent and asked both versions of the field-of-degree question.

There are several decision criteria that will be used by the Census Bureau as evaluation measures for the ACS content test. They include comparing the content test results (distributions and percentages) to the NSCG, evaluating item missing data rates and the estimates' reliability (gross difference rates and the L-fold index of inconsistency), assessing the response correspondence and rate of inconsistencies between the open-ended and categorical questions, determining the general impact to NSCG's sampling frame, and comparing item nonresponse rates for the educational attainment question that precedes the field-of-degree question. The preliminary results from this evaluation process are expected in early 2008 with the goal to have approval by the U.S. Office of Management and Budget (OMB) by July 2008.

Census Bureau personnel also addressed issues associated with using the ACS as a sample frame for other surveys. Based on the current ACS OMB terms of clearance, surveys that previously used decennial long-form data, such as the NSCG, may use the ACS as a sampling frame. To clarify the rules of access to ACS data, the Census Bureau has developed a policy that describes the criteria for determining appropriate uses of the ACS as a frame for reimbursable follow-on surveys. Thus far, NSF is one of only two survey sponsors that have officially requested the use of the ACS for this purpose.

There are several technical issues associated with using the ACS as a sample frame for the NSCG. First, the ACS sample over a 12-month period does not capture enough of the rare populations needed in the NSCG. Most populations require two annual cycles of the ACS, while the rarest populations may need up to five rounds. NSF personnel offered their thinking regarding four options for drawing the NSCG sample from the ACS:

1. Draw the sample once a decade (the current approach).
2. Conduct selective updates, oversampling to capture certain populations with a regularly scheduled major redesign.
3. Design rotating panels by dividing the survey into multiple panels in a 2- to 3-year cycle.
4. Create rotating panels.

The panel also solicited comments from Graham Kalton at the workshop regarding the options provided by NSF. An additional option stemming from that conversation was to design rotating panels for the rare populations and cross-sections for the rest of the population.

Panel on Assessing the Benefits of the American Community Survey for the NSF Division of Science Resources Statistics

October 5, 2007
The Keck Center of the National Academies
500 Fifth Street, N.W.
Washington, D.C. 20001
Room 101

WORKSHOP AGENDA

Friday, October 5

8:00-8:30 am	**Call to Order and Introductions** Hal Stern, *Chair*
8:30-10:30 am	**Session 1: Future Design of the NSF Workforce Surveys** Moderator: Dan Black Mary Frase, Deputy Director, Division of Science Resources Statistics, NSF
10:45 am-12:15 pm	**Session 2: Requirements for the National Survey of College Graduates** Moderator: Cathy Weinberger Roundtable Discussion of Uses by Panel Members Using NSCG Data in Wage Inequality Research Donna Ginther, University of Kansas (by phone) Using NSCG Data in Assessing the Quality and Composition of the Scientific Workforce Sharon Levin, University of Missouri, Kansas City (by phone)
12:15-1:00 pm	**Working Lunch:** Roundtable Discussions of User Needs

1:00-2:30 pm	**Session 3: Use of the American Community Survey as a Sample Frame and for Analytical Purposes** Moderator: Chet Bowie Plans for Methods Panel and Testing FOD Question Jennifer Tancreto, Chief, ACS Data Collection Methods Staff Access to ACS Data for Sample Design and Analysis Cheryl Landman, Chief, Demographic Surveys Division
2:45-4:00 pm	**Session 4: Sample Design Options and Criteria** Moderator: Robert Santos Discussion of Options Stephen H. Cohen, Chief Statistician, Science Resources Statistics Division, NSF
4:00-5:30 pm	**Open Discussion and Summary** Hal Stern, Chair Guest Panelist: Graham Kalton, *Chair*, NRC Panel on the Functionality and Usability of Data from the American Community Survey

Appendix B

Bibliographical Sketches of Panel Members and Staff

Hal Stern (*Chair*) is a professor and founding chair of statistics at the University of California at Irvine. Prior to joining the Irvine faculty in 2002, he held academic appointments at Iowa State University and Harvard University. An expert in Bayesian modeling and techniques, he is coauthor of *Bayesian Data Analysis*. A fellow of the American Statistical Association (ASA), he has served as editor of the association's magazine, *Chance*, and as chair of the association's section on Bayesian science and the section on statistics in sports. He has M.S. and Ph.D. degrees from Stanford University.

Dan A. Black is a professor at the Harris School of the University of Chicago. His research interests are labor economics, applied econometrics, and program evaluation. He has been a visiting professor of economics at the H. John Heinz III School of Public Policy and Management at Carnegie Mellon University. He has used the National Survey of College Graduates data in his research. He received B.A. and M.A. degrees in history from the University of Kansas, and M.S. and Ph.D. degrees in economics from Purdue University.

Chester (Chet) Bowie is a senior vice president at the National Opinion Research Center (NORC) at the University of Chicago. He is a survey statistician with more than 30 years experience designing and conducting cross-sectional and longitudinal household, educational institution, and business surveys for federal and state governments and academic

institutions. His work covers a broad range of substantive areas, including education, employment, health care, health insurance, outdoor recreation, disability, aging, alcohol and drug use, crime, homelessness, housing, program participation, long-term care, and income, as well as methodological research. Previously he worked at Market Strategies, International and as division director of the Demographic Surveys Division at the U.S. Census Bureau. While at the Census Bureau, he worked on the National Survey of College Graduates and the Survey of Recent College Graduates. He is a member of the ASA where he was chair of the Government Statistics Section, and the American Association for Public Opinion Research. He holds a master's degree in governmental administration from the George Washington University.

Brenda G. Cox is survey research leader in the Arlington, Virginia, office of Battelle Memorial Institute. She has 30 years of experience in sample design and implementation for national, state, and local surveys on diverse topics, including education and career outcomes, health care utilization and expenditures, customer satisfaction and access to care, alcohol and substance abuse, crime victimization, nutrition and the homeless, emergency food assistance, child support enforcement, agricultural production, small business finances, and the environment. Since 1993, she has served as a senior statistical adviser for the Scientists and Engineers Statistical Data System (SESTAT) fellow of the ASA. Dr. Cox has served as chair of the Survey Research Methods Section, chair of the Council on Chapters, and as a member of the board of directors. She has also served as president of the Washington Statistical Society and of the North Carolina and Princeton-Trenton Chapters of the ASA. She holds a Ph.D. degree in statistics from Virginia Polytechnic Institute and State University.

Randall J. Olsen is a professor of economics at the Ohio State University, where he is director of the Center for Human Resource Research and director of the Initiative in Population Economics. His fields are econometrics, labor economics, and economic demography. He is interested the problem of design effects in surveys, job mobility and a variety of issues relating to survey data collection. He has been the project director of the National Longitudinal Surveys of Labor Market Experience (NLS) since 1987, overseeing instrument design, field work, and data preparation for this group of surveys. He has also overseen the transition of the NLS from legacy data collection systems to an integrated system for handling all phases of survey work, from instrument authoring through data dissemination. He has served as an associate editor for *Evaluation Review*, *Journal of the American Statistical Association and Demography*. He holds a Ph.D. from the University of Chicago.

Robert Santos is senior institute methodologist at the Urban Institute in Washington, DC. Previously he worked at NuStats, NORC at the University of Chicago, and the Survey Research Center at the University of Michigan at Ann Arbor. His professional credits include more than 40 reports and papers and leadership roles in survey research associations. He has served as a member of the Census Advisory Committee of Professional Associations and on the editorial board of the *Public Opinion Quarterly* and held numerous elected and appointed leadership positions in both the ASA and the American Association for Public Opinion Research. He is a fellow of the ASA and a recipient of the 2006 ASA Founder's Award for excellence in survey statistics and contributions to the statistical community. He received an M.A. degree in statistics from the University of Michigan.

Lowell Taylor is a professor of economics at the H. John Heinz III School of Public Policy and Management at Carnegie Mellon University. Prior to joining the Carnegie Mellon faculty, he taught in the economics departments at Miami University and the University of Texas at Austin, and worked as a senior economist for President Clinton's Council of Economic Advisers. His general research interests are labor markets, economic incentives within firms, and economic demography. His papers span a wide range of topics, including the economic impact of minimum wage policy, the causes of racial disparity in U.S. labor markets, the economics of gay and lesbian families, and the nature of physician incentives in health maintenance organizations. He holds an M.A. degree in statistics, an M.A. degree in economics, and a Ph.D. degree in economics, all from the University of Michigan.

Catherine Weinberger is a research scholar affiliated with the Department of Economics at the University of California at Santa Barbara and the Institute for Social, Behavioral, and Economic Research. Her research focuses on early educational experiences and later labor market outcomes, specializing in high school mathematics preparation, high school leadership experiences, the science and engineering workforce, and gender differences in labor market outcomes, and earnings growth in college graduate labor markets. She has used the National Survey of College Graduates data in her research. She has a B.S. degree in mathematics from the University of Wisconsin at Madison and an M.A. degree in mathematics and Ph.D. degree in economics from the University of California at Berkeley.

COMMITTEE ON NATIONAL STATISTICS

The Committee on National Statistics (CNSTAT) was established in 1972 at the National Academies to improve the statistical methods and information on which public policy decisions are based. The committee carries out studies, workshops, and other activities to foster better measures and fuller understanding of the economy, the environment, public health, crime education, immigration, poverty, welfare, and other public policy issues. It also evaluates ongoing statistical programs and tracks the statistical policy and coordinating activities of the federal government, serving a unique role at the intersection of statistics and public policy. The committee's work is supported by a consortium of federal agencies through a National Science Foundation grant.