Subpart A - Economics Analysis and Conservation Planning

610.0 Introduction

A. Purpose and Scope

(1) The NRCS Natural Resource Economics Handbook has been developed as a technical reference for NRCS personnel—primarily economists and field planners—to help them evaluate the efficient and effective use of public investments in conservation programs and to provide sound guidance to land users regarding the economic aspects of planning and implementing conservation systems. Specifically, the handbook is intended to serve as a resource for field planners to improve the quality of the assistance and input they provide to land users as they evaluate the prospective effects of conservation alternatives and make conservation and natural resource management decisions.

(2) Since this handbook has in part been prepared for introducing economic concepts to noneconomist NRCS field planners and staff, only limited economics and financial concepts that comprise the basic economic factors influencing conservation decisionmaking are introduced. These include benefits, costs, market price identification, identification and evaluation of nonmarket benefits, interest, annuities, and several evaluation techniques involving partial budgeting, break-even analysis, cost-effectiveness and marginal analysis methods. The core economic and financial concepts introduced in this handbook have been explained with examples of simple application of economics and conservation practices. This handbook does not address the benefits and costs associated with specific NRCS conservation practices. Rather, it presents more general concepts that can be applied within multiple different conservation planning contexts. More details about the economic analysis of specific NRCS conservation practices will be developed through training workbooks and case studies in the future.

(3) This handbook puts economic analysis in the context of conservation planning. NRCS field planners work with land users to develop conservation plans that, when implemented, will help them meet their personal conservation-related farming or ranching objectives. Those objectives usually include resolving resource concerns while simultaneously improving farm or ranch operations and meeting their economic needs. NRCS planning policy directs field planners to develop at least two different conservation systems for the cooperating land user in order to provide him or her with an adequate range of options from which to choose. As an individual conservation plan is being developed, the field planner assists the land user in understanding and evaluating the potential resource and economic effects of alternative conservation practices and systems.

(4) This handbook treats economic analysis of resource conservation in the context of farm or ranch operations, but it does not engage in the full scale economic analysis of farm or ranch analysis itself. NRCS planners usually do not become involved in financial details of the operations of a farm or ranch. Rather, they engage in more limited conservation-related analysis, completing evaluations that are generally limited to assessing the effects of a specific change in operations, namely the implementing a given conservation practice or system of practices. However, NRCS planners are required to be mindful about the constraints of conservation programs and projects from the general social and economic conditions of the land users.

(5) This handbook provides guidance for NRCS personnel to conduct economic analysis of resource conservation at easy to intermediate complexity. NRCS field planners are expected to be able to independently complete analyses of simple to intermediate complexity, including partial budget and other types of analysis. As resource settings and conservation systems become more complex, the accompanying analyses often require formal assistance from an NRCS regional or national economist. Economic analyses completed as part of the conservation planning process can range in complexity from very simple to extremely intricate. The relative complexity of any analysis should be driven by the corresponding complexity (or simplicity) of the context within which the decision is being made. The goal in providing economic support for conservation planning is to provide to decisionmakers—the land users—enough information for them to make sound decisions regarding their conservation activities. Accordingly, the complexity of the economic evaluation of any conservation plan should hinge on the complexity of the resource setting, the alternative systems being evaluated, and the amount of information needed for the land user to confidently and comfortably decide which conservation system they prefer to adopt.

B. Handbook Organization

(1) Subpart A first introduces the context and basic concepts of economic analysis for conservation planning, and then expands on the subject of economic analysis as a central part of the conservation planning process. This subpart describes the types of natural resources and their conservation needs, NRCS resource conservations and its role in resource conservation, and the basic concepts related to economic analysis of resource conservation, conservation decisionmaking, relative importance of benefits and costs, and Federal regulations on economic analysis for public decisionmaking. This subpart also introduces the NRCS nine-step planning process, the conservation effects for decisionmaking framework and their relationship to economic analysis of resource conservation.

(2) Subpart B explains the basic process of identifying and categorizing the benefits and costs of a conservation project. It also introduces the concept of "T" charts and shows an example of how a "T" chart can be used to evaluate the net benefits provided by a conservation project.
(3) In subpart C, readers are introduced to basic cash flow analysis and other financial analysis techniques often used in benefit-cost analysis. These include discounting, compound interest, calculation of a present net value, and other analysis techniques.
(4) Subpart D addresses additional methods of analysis that can be applied when determining whether a conservation project is worth completing. The techniques presented in subpart D can also be used to determine the most-preferred conservation project when developing and comparing alternative conservation systems. These techniques include partial budgeting, cost-effectiveness analysis, and other formal methods of project evaluation. Even after thorough analysis and thoughtful decisionmaking, it is sometimes the case that a land user will be reluctant to adopt the selected conservation system.
(5) In subpart E, readers are introduced to some of the constraints that face land users and that influence them in determining whether to put conservation systems into practice. A basic knowledge of these obstacles to adoption can help NRCS field planners better understand the land users' perspective and provide ideas for how to help them overcome those obstacles.
(6) Subpart F provides an introduction to statistics for conservation planning to provide readers with a solid understanding of how to properly use statistics to analyze conservation system data. Readers are expected to understand the core economic, financial, and statistical concepts presented in this handbook and to become familiar with their application so that they can offer effective help to conservation planners and NRCS clientele across the country.
(7) Subpart G is the general glossary that gives definitions of the terms included in this handbook.
(8) Subpart H provides a list of reference materials on the subjects presented in the foregoing chapters. These materials serve as sources of more indepth information for interested NRCS economists and planners. Check the economics section of the NRCS Web site to find a list of useful resources for conducting economic analysis of resource conservation, such as reference materials, data, tools, examples, and case studies.

C. Types of Natural Resources

Natural resources can be divided into three primary categories based on their renewability and the degree to which each resource is susceptible to human and other impacts. The risk of resource degradation and the respective need for applying conservation to each resource depends in part on what type of resource it is. These three major resource types are perpetual, renewable, and nonrenewable.

(1) Perpetual Resources.—The availability of perpetual resources is independent from human activity. Examples include solar radiation, tidal forces, and wind energy. It is not physically possible to conserve perpetual resources, although energy and many natural resources produced by them can be stored and conserved. We should replace nonrenewable resource use with perpetual resource use as much as possible so long as the total costs of doing so are justified by the benefits obtained.
(2) Renewable Resources.—Renewable resources reproduce or are replenished by natural processes. Plants and animals are examples of renewable resources. So are fresh water and clean air. Renewable resources have a fixed supply at any given time, but their total stock increases, remains constant, or declines over time, depending in part on human activities. If a renewable resource is used at a rate exceeding its reproduction, growth, or renewal rate, the stock of that resource will decrease. On the other hand, renewable resources can last into perpetuity if they are properly used and managed. Recycling could also play an important role in conserving renewable resources.
(3) Nonrenewable Resources.—Nonrenewable resources are essentially finite in quantity and, within a human time scale, are not renewed by natural processes. Typical examples of nonrenewable resources include fossil fuels and minerals. Nonrenewable resources can sometimes be recycled, but once a nonrenewable resource has been converted to a nonuseful or lower potential energy state (such as when metal oxidizes or fossil fuel is burned), it is no longer available for most human uses. We should use nonrenewable resources efficiently and reuse or recycle them whenever possible. We should also use these resources for investments in technology, education, and productive capital so that future generations will be better equipped to deal with exhausted supplies of some nonrenewable resources.

D. NRCS Resource Concerns and Resource Conservation

(1) NRCS is responsible for leading the effort to conserve natural resources on private land within the United States. When choosing between conservation systems, the degree to which each alternative system meets the conservation goals of the agency at the national, State, and local levels should be taken into consideration. The views and objectives of the land user and others in the local and regional area must also be included in the decisionmaking process for the implemented system to have the fullest potential for success in meeting its resource objectives. Local conservation leaders set priorities among resource concerns based on their understanding of existing resource condition and opportunities. Coordination among conservation partners to take these priorities into account can lead to more economically efficient solutions to natural

resource concerns and achievement of resource sustainability, which is one of the national objectives of NRCS. Economic analysis plays an important role in designing and implementing any conservation systems for the wise use of natural resources.
(2) Title 450, General Manual (GM), Part 401, states in part, "NRCS provides technical assistance to decisionmakers to protect, maintain, and improve soil, water, air, plant, and animal resources and related human considerations." These resource categories have traditionally been referred to within NRCS as the SWAPAE+H resource concerns: Soil, Water, Air, Plant, Animal, Energy, and Human. Title 450 of the general manual places responsibility for the development and maintenance of a national quality criteria template—for States' use in their respective Field Office Technical Guides (FOTGs)—on the National Technical Guide Committee. This template outlines the specific subcategories of and resource concerns and considerations that States are expected to address in conservation planning and in the application of conservation practices at the field level. The detailed resource concerns included in the national quality criteria change from time to time, but the basic natural resource elements addressed by NRCS conservation planning and implementation policies remain largely unchanged for long periods of time. Human considerations are not included in the quality criteria template, but rather are resource considerations they are included in the national Conservation Practice Physical Effects database, and also included in the FOTGs. These quality criteria and resource considerations comprise the basis for conservation effects in the NRCS evaluation process called "conservation effects for decisionmaking" (CED), the output of which is primarily expressed as benefits of conservation activities.
(3) NRCS bases its recommendations for conservation efforts on a list of well-defined conservation practices contained in the NRCS National Conservation Practice Standards database. This list of practices is adjusted and the practice standards themselves are edited periodically as conservation technology and understanding of conservation effects are improved over time. The basic categories of practices and the core conservation practices—intended to address the SWAPAE+H resource concerns—remain relatively stable from year to year. Conservation practices are assembled into resource management systems (RMSs), which are intended to address a full range of the typical resource concerns found within specific geographic areas. The practices within a given RMS are divided into three categories of priority: essential, facilitative, and additional. Generally speaking, management practices such as irrigation water management, prescribed grazing, or nutrient management are considered to be the most important practices for resolving the typical spectrum of resource concerns found on agricultural lands within specific land-use categories such as crop land, grazing land, or headquarters. These would be listed as essential practices. Facilitating and additional practices include sprinkler irrigation system, range planting, access control, and waste storage facility, among many others.
(4) Information on RMSs and State-specific conservation practice standards, and other conservation planning and implementation is included within individual States' FOTG data systems. The detailed criteria and implementation guidelines provided in each conservation practice standard establish the basis for conservation practice costs in CED.

610.1 Economic Analysis of Resource Conservation

A. Economic Analysis and Conservation Decisionmaking

(1) Economic analysis of resource conservation has many aspects and can be conducted from different perspectives. An analysis could focus on a single project, or it could evaluate a program that covers many projects. It could be conducted from a land user perspective or a societal perspective. It could be completed at an individual field, farm, watershed, regional, or national level.
(2) This handbook focuses primarily on the economic feasibility of resource conservation at the individual project level from the land user perspective. As decisionmakers for consumption and production, we weigh the benefits and costs of our decisions. Aspects that cannot be measured in dollars influence many of those decisions. Ultimately, we try to compare the benefits of a purchase or investment to its costs.
(3) Decisionmaking for land users in resource conservation is the same as any other decisionmaking. Once a problem is identified, the physical and monetary effects of alternatives can be compared. One of the land user's important concerns is whether his or her potential benefits from installing new conservation measures would outweigh their costs. Therefore, from this perspective, a field-level economic analysis mainly evaluates the benefits and costs of a specific conservation project. It involves identifying, estimating, and comparing the benefits and costs of the project.
(4) The conservation decisionmaking process consists of first developing a full range of alternatives, then identifying the benefits and the costs of each alternative, evaluating the importance of the benefits of each option, and finally determining which alternative offers greatest net benefit or the smallest costs for the same level of benefits produced. Effective conservation planning must involve both the land user and the conservation planner. Together they need to identify the important physical and economic factors that are to be examined and look into the future to identify any anticipated changes in conditions "with" and "without" conservation. In addition, the land user needs to determine the relevant time horizon for conservation planning, constrained by the planning horizon or physical life of the particular

conservation practices in question. This process enables comparison to eventually select the most desirable option. In short, a typical benefit-cost analysis for any resource conservation practice or activity requires four simple steps for each planning alternative:

(i) Estimate costs
(ii) Estimate benefits
(iii) Convert benefits and costs to "like terms"
(iv) Compare costs and benefits

B. Relative Importance of Benefits and Costs

(1) The conservation decisionmaking process involves the comparison of tradeoffs within and between alternative options. Some conservation effects may have a common denominator, such as a market price, while others do not. Once costs and benefits are identified, they are quantified, given a dollar value (if possible) and converted to "like terms" where possible. Conservation costs and benefits are most easily compared when they are in the same units and evaluated over the same time period. Economic analysis can and should still take place without dollar values, but, where possible, costs and benefits should be described using the same units (i.e., the same denominator). Once costs and benefits can be compared, informed decisions can be made. Specific techniques for economic analysis of conservation will be described later in this handbook. When evaluating a project from the land user's perspective, the land user, not the assisting professional, determines the relative importance of the prospective benefits of alternatives in comparison with their costs to establish which alternative offers the most important benefits per dollar, especially in cases where benefits are difficult to quantify or occur at offsite locations.

(2) Economic evaluations usually involve assigning appropriate unit prices to benefits and costs associated with the alternatives under consideration whenever possible, and when not possible, assessing the relative importance of the non-dollar benefits and costs. Therefore, quantification of effects, gains, and losses will be easier to complete when the evaluation begins with time or physical measures, such as hours, bushels, gallons, and pounds, whenever possible.

(3) Items such as commodities are generally priced based upon future market expectations taking into account previous and current conditions. It is important to not base decisions on relatively short-term spikes or sudden dips in commodity markets. In addition, it is also important to not base decisions on "side-deal" prices, but rather using fair market values in performing an analysis. USDA maintains "normalized" prices for commodities based on 5-year averages.

(4) Conservation costs can generally be categorized as increases in expenses, decreases in income, or undesirable changes in physical conditions. Increases in expenses may include purchasing materials or equipment, or hiring labor. Decreases in income may result from taking land out of production or reducing crop or livestock yields. Data such as labor costs, at times, may not be readily available, even though a labor market exists. Labor required for implementation may not increase out-of-pocket cash costs—such as when the land user or his or her family (sometimes collectively referred to as "family labor") will perform the labor. On the other hand, labor saved by implementing the conservation system might not always be added to cash revenue. This is because savings in labor costs have cash value only when labor cash payments are reduced, or when cash revenue is generated from use of the saved labor in an alternative activity. Certainly, saved labor may provide the benefit of increased leisure time to the laborers. Similarly, commitment of labor has a cash cost only when additional cash payments are made to labor or when committed labor on the part of the land user reduces cash revenues due to being taken out of a higher-paying alternative activity. The example of labor commitment versus changes in cash value demonstrates the economic concept of opportunity cost, which relates the value of a good or service to a prospective alternative use.

(5) Conservation benefits are desirable outcomes of conservation and the opposite of conservation costs. Examples include reductions in expenses or increases in income realized by bringing land into production or increasing crop or livestock yields. Additional benefits include positive changes in resource or other conditions that can't necessarily be calculated in dollar terms. Landscape appearance, quality of life, and the presence of endangered wildlife species are examples where monetary values are either not readily available or are not generally agreed upon. Although the intrinsic values of some characteristics of alternatives may not be quantifiable in dollar terms, they nevertheless need to be included in the decisionmaking process as society has determined that they must be protected.

C. Federal Regulations on Economic Analysis for Public Decisionmaking

(1) Federal Government agencies are responsible for evaluating whether their actions will result in efficient resource allocation, generating a net positive balance between benefits and costs. Agencies are charged with considering and properly dealing with all of the elements of sound benefit-cost and cost-effectiveness analyses (Office of Management and Budget (OMB) Circular No. A-94). Public decisionmaking differs from private decisionmaking in that Federal agencies allocate public resources for the benefit of society as a whole. In private sector decisionmaking, only the viewpoint of the private stakeholder matters. In public resource allocation decisionmaking, "the most economically efficient policy is the one that allows for society to derive the largest possible social benefit at the lowest social cost. This occurs when the net benefits to society (i.e., total benefits minus total costs) are maximized" (US EPA 2010).

(2) For most State- and field-level NRCS economic analyses, the principles and policies contained in OMB Circular No. A-94, are to be used. Circular No. A-94 directs economists to consider in their analyses the incremental dollar and non-dollar, quantifiable and unquantifiable, tangible and intangible benefits and costs of each project. (For national analysis, any Federal project defined as economically significant (having an annual effect on the economy of $100 million or more per year or adversely affecting in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities) must be evaluated using the guidelines in OMB Circular No. A-4.)

(3) Further guidance provided in Executive Orders 12866 and 13563 and in Memorandum 11-10 establishes the requirement that agencies may consider and discuss values that are "difficult or impossible to quantify." These values include equity effects, human dignity, fairness, and distributive impacts of Federal actions (from M-11-10). While the majority of Federal policies related to benefit-cost analysis relate to regulatory actions, there are ample resources available that provide clear direction to agencies on how to conduct non-regulatory economic analyses.

(4) Not all NRCS economic analyses are related to normal conservation planning decisions. NRCS also engages in decisionmaking related to water resource projects. For these, NRCS is one of the agencies required to apply the policies contained in "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies" (P&G) (see note below). The guidelines in P&G do not apply to field-level economic analyses. In addition, NRCS has its own water resource economics handbook, found in the NRCS national directives system, Title 200, National Resource Economics Handbook, Part 611.

Note: The P&G was initially designed under the Water Resources Council (WRC) in 1973 and was revised several times. The Council of Environmental Quality is leading another revision of the document beginning in 2011.

610.2 NRCS Conservation Planning

A. Objectives of the NRCS Conservation Planning Process

(1) Economic analysis is a part of the NRCS's conservation planning process. Title 180, National Planning Procedures Handbook (NPPH), Part 600, is used by NRCS to guide the conservation planning process (180-NPPH, Part 600, Subpart A, "Framework or Planning"). Through conservation planning, NRCS helps land users make informed decisions in the use and conservation of resources to achieve both their own objectives and those of society for sustained use of soil, water, air, plant, animal and energy resources. In particular, by involving land users in the planning process, NRCS aims to—

(i) Help protect, conserve, and enhance natural resources.
(ii) Design alternatives that meet local resource quality criteria for identified resource issues.
(iii) Include the consideration of human concerns toward achieving sustainable agriculture.
(iv) Consider the effects of planned actions on interrelated geographical areas (i.e., looking offsite, beyond the planning unit boundary).
(v) Consider and explain the interaction between biological communities and society.
(vi) Focus on ecological principles.
(vii) Consider the effects and interactions of planned systems and practices on the natural resources, as well as economic and social considerations.
(viii) Assist with development of plans, regardless of scale, that will help achieve the client's and society's objectives.
(ix) Identify where knowledge, science, and technological advancement are needed.

(2) Beyond the NRCS conservation planning objectives, by working with individual land users, conservation planners can—

(i) Help land users understand their resources and resource management needs, potentials, and problems.
(ii) Identify opportunities and alternative solutions to problems.
(iii) Determine effects of alternative solutions, including comparison of effects expected if the problems remain untreated.
(iv) Choose alternative solutions that are consistent with the land user's objectives.
(v) Implement and maintain feasible solutions as rapidly as is practical.

B. The Nine-Step Planning Process

(1) NRCS uses a three-phase, nine-step planning and implementation process for conservation systems (figure 610A-1). This process is used in all instances where assistance is provided to land users or clients, regardless of the expected outcome or scope of the planning effort, the type of conservation treatments involved, or the source of funding to be used for implementation of conservation treatments.

(2) The degree of detail used in the planning process varies with the type, method, and scope of assistance; the complexity of the planning situation; and the different approaches toward planning preferred by the recipients of technical assistance. Using the process creates a consistent planning method nationwide. The steps are as follows:

(i) Phase I: Collection and Analysis

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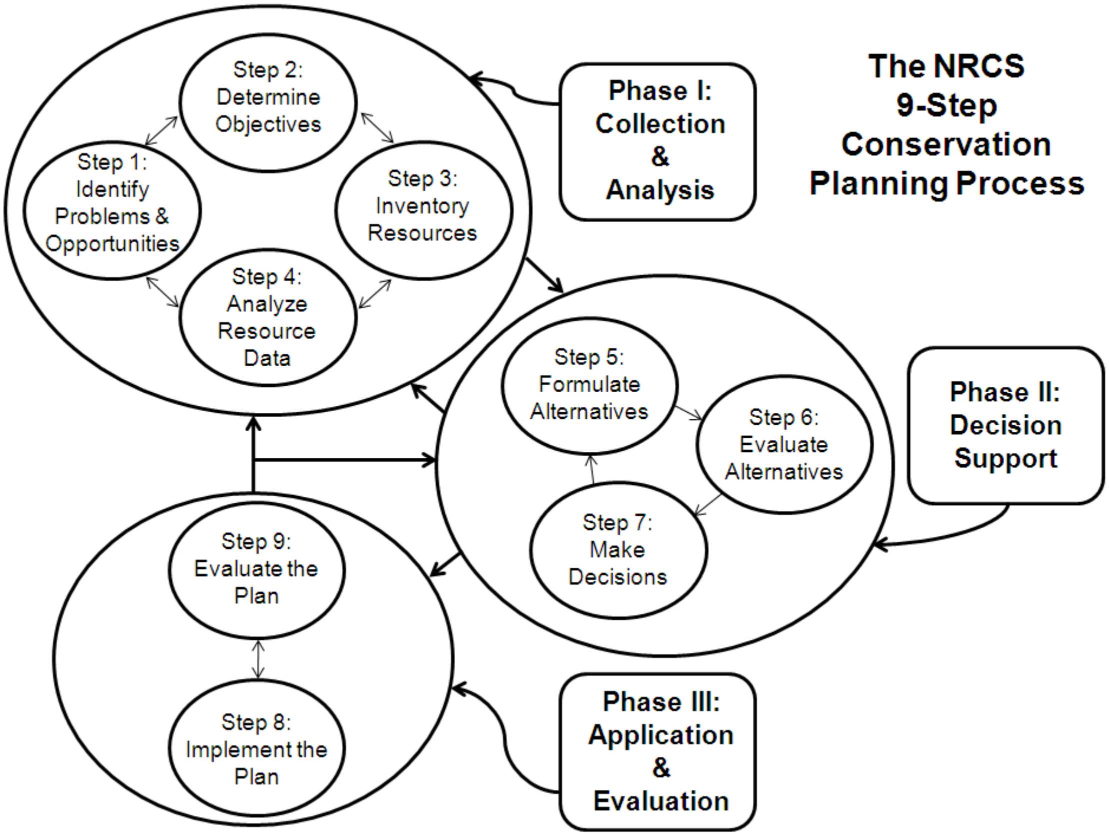
FigureA-1 – Conservation Planning



Step 1. Identify problems and opportunities.
Step 2. Determine objectives.
Step 3. Inventory resources.
Step 4. Analyze the resource data.

(ii) Phase II: Decision Support
Step 5. Formulate alternatives.
Step 6. Evaluate alternatives.
Step 7. Make decisions.

(iii) Phase III: Application and Evaluation
Step 8. Implement the plan.
Step 9. Evaluate the plan.

(3) While the nine steps are shown in sequence, the process is very dynamic and interactive. This planning process requires the use of skills from many disciplines, such as economics, agronomy, soils, and engineering, to achieve the highest quality of assistance. Economic analysis should play an important role throughout the planning process. It enters into the process most heavily during phase II for formulating alternatives of choice based on economic concepts and principles to develop conservation plans (step 5). Key factors for consideration are the relationships between the costs of the conservation treatments and changes in resource conditions that will occur after the implementation of the treatments. Evaluations of the costs of treatments and their effects on the resource lead to formulation of cost-effective alternatives prior to decisionmaking. Economic principles and methods are necessary to evaluate multiple conservation alternatives (step 6).

(4) Technical references and policy for guiding conservation planning include the following:

(i) National Planning Procedures Handbook
(ii) National Food Security Act Manual (NFSAM)
(iii) Field Office Technical Guide (FOTG)
(iv) Natural resources quality criteria
(v) Resource management system guidance
(vi) Conservation practice physical effects
(vii) Conservation effects for decisionmaking
(viii) General Manual
180-GM, Part 409, "Conservation Planning Policy"
190-GM, Part 410, "Compliance with NEPA and Endangered Species"
420-GM, Part 401, "Cultural Resources"
(ix) Title 440, Conservation Programs Manual, Part 500, "Locally Led Conservation"

Click here for a copy of Figure 610A-1: Conservation Planning

610.3 Conservation Effects for Decisionmaking

A. Introduction

(1) Purpose and Scope

(i) Phase II of the NRCS nine-step planning process comprises steps 5 through 7, which are "Formulate Alternatives," "Evaluate Alternatives," and "Make Decisions." In on-the-ground conservation planning, these three steps are often repeated in an iterative process as alternatives are developed, analyzed, and either adopted, adjusted, or discarded. Economic analysis is an important part of the evaluation and decisionmaking steps in conservation planning. Within the phase II process, the CED model provides a formal framework to guide NRCS planners and economists through the economic evaluation of each alternative. This model enables NRCS planners to display and evaluate the effects of various conservation options available to land users (180-NPPH, Part 600, Subpart F, Exhibit 14, and Subpart D, Exhibit 42). This is the point in the conservation planning process where the techniques of economic analysis are most often applied.

(ii) The CED process can be used to assist land users with their conservation decisions by—

Providing a framework in which to organize and present information that facilitates comparison of the positive (gains) and negative (losses) effects of a conservation option.

Permitting consideration of all physical, sociological, and economic values pertinent to the evaluation.

Encouraging the employment of analytical tools at appropriate levels of sophistication to provide information.

Capitalizing on the knowledge and experience of our agency professionals and clients to foster interaction throughout the decisionmaking process.

(2) The Planning Process

(i) The CED process is an integral part of the planning process outlined in the National Planning Procedures Handbook. CED is not a new system, but a method of thought organization. It provides a way to evaluate the continuum of all alternatives available to the land user, and is intended to make conservation planning and application easier and more efficient. The central concept of conservation planning is to develop a list of practices that, when implemented, will address the resource concerns found to exist during the resource inventory process, as well as helping the land user to meet his or her conservation and

production objectives. A thorough process of developing conservation system alternatives will also include an evaluation of the potential cumulative and interactive effects of the proposed conservation practices. Some of these effects can be identified by referring to the Conservation Practice Physical Effects database found in section V of the FOTG.

(ii) NRCS planners develop alternative RMSs—also known as conservation management systems (CMSs)—to present land user with different ways in which to address existing resource concerns on the planning land unit. A conservation planner working with a land user can be faced with any of several planning contexts leading to different conservation system types. Ideally, the planner will develop a conservation plan that will adequately address all resource concerns on all land units within the operation controlled by the cooperating land user. A plan developed at that level of completeness and that is expected to result in all resource concerns meeting NRCS quality criteria is an RMS. At times, however, the land user will be interested in developing a plan that addresses only a limited number of resource concerns—or even a single resource concern alone. In this case, the planner will develop what is called a "progressive management system." NRCS planners are encouraged to develop RMS-level conservation systems as often as possible rather than resorting to "progressive" conservation planning. Progressive planning is generally limited to situations in which a land user simply does not have the time or the interest to contribute to a planning effort that addresses all resource concerns at an RMS level.

(iii) In the past, basic conservation systems (BCSs) and alternate conservation systems (ACSs) were part of an effort to bring land users operating on highly erodible lands into compliance with provisions of the Food Security Act (1985). While these types of conservation systems are still applicable within certain planning contexts, their use declined after most farmers participating in USDA financial assistance and support programs were brought into compliance. Each alternative conservation system will contain different conservation practices and, therefore, will be expected to generate different conservation effects. The CED process is intended to formalize the evaluation these effects and to provide clear information to inform the land user's choice of a conservation system.

(3) Collecting and Recording Information

(i) The collecting and recording of effects information for the CED process is not new; it has been the major thrust of CMSs, and of planning in general. The CED evaluation process links the planning process with economic input and emphasizes the end objective. Identifying the expected effects from applied conservation allows decisions to be made and actions to be taken. The CED framework is applicable to all NRCS programs and planning situations. Consequently, it is also the theme and organizational tool for this handbook, which has an explanation of the steps in the process of evaluation, a diagram of the decisionmaking process, and examples of evaluation approaches. Subsequent subparts explain the various economic principles, tools, and techniques available for use if one wishes to carry evaluations to a more detailed level of analysis.

(ii) The relationship between CMSs and CED-based evaluation is captured in Title 190, National Biology Handbook, Subpart B, "Conservation Planning," which states that the expected output of the conservation planning process includes a set of practical CMS alternatives compatible with client and NRCS objectives; a CED worksheet for each alternative, displaying effects and impacts for the client to consider and use as a basis for making conservation decisions; and technical assistance notes reflecting discussions between the planner and the client.

(4) The Framework.—The CED framework combines information from many disciplines so the effects of implementing a prospective conservation system can be comprehensively and effectively evaluated. For more information about CED analysis and the conservation planning process, consult 180-NPPH, Part 600, Subpart D, Section 600.42, "Support Guidance for Conservation Effects."

Click here for a copy of Figure 610A-2: Conservation Effects for Decisionmaking

B. Steps in the CED Process

(1) Benchmark

(i) Field-office-level planning efforts should always first identify the benchmark condition. The planner and land user work together to develop a picture of existing conditions, trends, problems, opportunities, and objectives. The assistance provided is based upon soil, water, and other natural and cultural resource information. The description of benchmark conditions could include—

- Other inventories and evaluations.
- Description of current crops, farming practices, livestock type and condition, and available equipment.
- Consideration of sociological and economic characteristics.

(ii) Planning objectives and the complexity of each situation determine the level of detail necessary for inventories and evaluations.

(iii) The objectives of the land user will usually affect the kind and amount of information gathered and evaluated. The formulation of planning objectives, however, requires that the objectives of society, as well as those of the land user, be considered. The planning process should also identify opportunities. This creates a broader view that goes beyond the search

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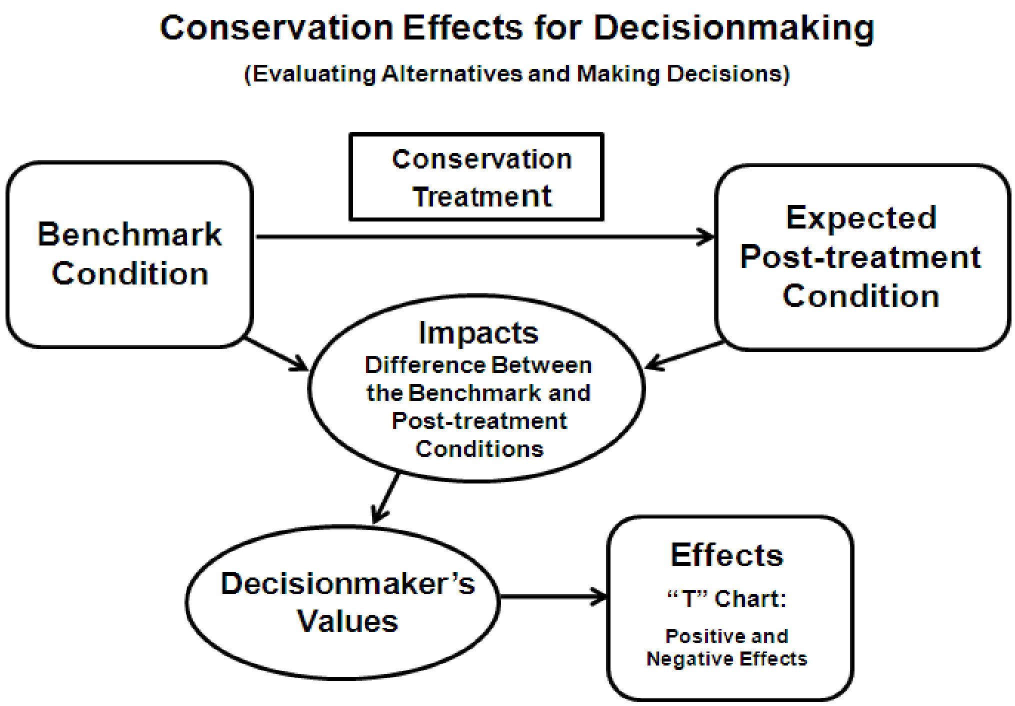
Figure A-2 Conservation Effects For Decisionmaking



for resource problems in order to recognize where resource enhancements may be achieved. For example, if a given area does not have a significant soil resource problem onsite, opportunities may still exist to make on-farm improvements that could increase efficiency and profitability, while at the same time reducing negative water or air quality effects offsite. The benchmark condition scenario is also known as the "with condition" or the "future with project."

(2) Alternatives

(i) Alternatives that meet both individual and societal objectives need to be considered after a picture of the benchmark situation and expected future trends have been developed. The RMS formulation process will normally be used to develop alternatives that provide alternatives that will address a comprehensive range of the resource challenges faced by the land user.

(ii) Proposed alternatives enable planners to develop a picture of the conditions that could exist on the farm or ranch with conservation treatment. Alternatives represent the world of possibilities, a vision of what could be, based on predictive models, professional judgment, and experience with the expected effects of each action or set of actions considered. They are the different options that are proposed to deal with current and future resource concerns arising from the existing situation.

(iii) An alternative is generally a RMS, but could also be an ACS for plans developed for the 1985 Food Security Act. The alternative could consist of a single practice or simply be an adjustment to present farming operations. Proposed alternatives must be consistent with sections III and IV of the FOTG and must be approved at the requisite level of authority. Apart from the FOTG, the experience and knowledge of the planner and decisionmaker are the main sources of information to be used for selection of a resource system.

(iv) To achieve the goals of a specific alternative, certain steps or actions need to be taken. Examples of potential actions include a change in cropping sequence, land use, time of seeding, tillage, or timing of cultivation; structural improvements to the farm; or simply lowering the speed of a single tillage operation.

(v) Each individual conservation planner has a different experience base that can be increased through on-the-job training, specialized training courses, field trials, or the use of models. A useful learning experience for planners is to visit land users with successful conservation treatments already applied. Technology transfer through exposure in this manner rapidly broadens an employee's perspective and improves his or her expertise and confidence. If successful on-farm experiences are documented and shared as case studies, the knowledge base of others within and outside the agency could also be easily enhanced. Such experiences should be recorded first in physical and biological terms rather than monetary ones, because monetary values are simply a translation of the former and can be expressed in current dollars at any time. Experience gained by a conservation planner in any of these ways can result in improvement of future analyses completed by that planner.

(3) Impacts

(i) The completed alternative is compared with the benchmark condition to estimate the impacts of the actions. The impacts of applied conservation options are the differences between the benchmark or current condition and trends and the proposed alternative situation. This future condition is known alternatively as the "with condition" or "future with project." Quantification of the impacts is dependent upon the degree of detail used to describe or measure the benchmark and expected alternative conditions. The impacts should be described in narrative form at a minimum, and in quantitative terms to the extent possible. They should also be recorded in an easy to understand manner for consideration by the decisionmaker.

(ii) Conservation effects or impacts (see note below) worksheets can be used to record this information. Differences in erosion rates, habitat values, water quality, acres farmed, bushels harvested, labor and fuel requirements, pesticides used, etc., should all be documented to the extent that such information is needed by the land user or is required by the agency. The timeframe when the impacts occur might also be identified, because certain actions such as pasture improvements can result in immediate costs, but the resulting yield increases may be delayed and then occur for an extended period of time.

(4) Values

(i) The term "values," as used within the CED process, is best understood as referring to the viewpoints and preferences of the cooperating land user. Each individual's preferences will affect the value they place on an impact as well as determining whether that impact is viewed as a positive or negative difference in conditions. For example, the addition of 10 more quails to a land unit may be viewed as a positive impact by one person and as a negative impact by another, depending on their individual preferences; although the first would enjoy listening to the additional birds' singing, the other would be annoyed by the additional birds, viewing them as a nuisance.

(ii) A land user's views and personal values may be in harmony with society's best interests or they may be in direct conflict with the needs and preferences of their community or society at large. The conservation planner has a responsibility to convey to the land user the positive effect that their decisions could potentially have on the surrounding landscape as well as benefits that could be generated for society. Regardless, in field-level conservation planning, the cooperating land user's viewpoint is used to assess whether a resource impact is treated

as positive or negative change. The land user's viewpoints also serve as the basis for assessing the relative importance of the benefits and costs associated with each alternative conservation system.

(iii) Once the land user's preferences and values have been applied to the impacts of each conservation alternative, the positive and negative attributes of a proposed conservation practice or system can be displayed for evaluation in a format called a "T" chart, as explained in subpart B. The level of detail included in the "T" chart, as well as the level of detail of the overall analysis, usually depend on the amount of information required for the land user to make an adequately informed decision about whether and which conservation system to adopt.

Note: In most NRCS publications, as well as within common usage, the terms "effects" and "impacts" are used interchangeably. Within the NRCS Conservation System Guide (CSG) system, however, the term "effect" is defined as the resulting condition after a conservation treatment is applied ("future with conservation" in the context of this document). This handbook does not follow the CSG convention and, in keeping with standard usage, treats the terms "impact" and "effect" as synonyms.

(iv) It is important to note that we do not ignore market prices in favor of using the land user's own ideas about prices of the inputs required to implement a conservation system. Rather, we use objective information on quantities and prices, not the land user's ideas about them. Where the land user's preferences come in is in terms of preference ordering and determination of whether a characteristic is viewed as positive or negative, especially with respect to non-market goods and qualitative characteristics of conservation alternatives.

C. Identify and Measure Conservation Effects

(1) The correct identification and accurate accounting of conservation effects due to conservation treatments is very important for purposes of comparing and selecting among alternative conservation options. Undesirable resource conditions, such as high erosion rate or low yield level, can be improved by adopting certain actions or activities of conservation practices. The estimated future condition without conservation practices should be compared to the condition expected with their implementation. The difference between the "without" and "with" options is the impact of conservation. The benchmark condition and "future without" condition serve as the bases of comparison for the analysis. Identifying the benchmark condition is the first step in assessing conservation effects for decisionmaking.

(2) Conservation effects should be stated objectively and must be made in reference to time. Consider an example where current management is causing an accumulation of salts in the root zone. Without treatment, continuing accumulations are expected to cause reduction in crop yield (see line AB in figure 610A-3). With adoption of a conservation system, salt accumulated in the root zone will be reduced and crop yields will be maintained (see line AC in figure 610A-3). The area ABC is the change in yield resulting from adoption of the conservation system when evaluated over the 15-year period. Costs other than those for upfront practice installation need to be considered to accurately evaluate the effects of the conservation system. For example, if a one-time, upfront labor cost is the only cost of implementing the conservation system, and annual yield change is the only gain, determination of the net benefits of adoption can be made by comparing the value of the annual gain in yield to the annualized cost of installation labor. If, however, yearly operation and maintenance costs will be incurred, those costs should be added to the annualized labor costs when completing an economic evaluation of the conservation system.

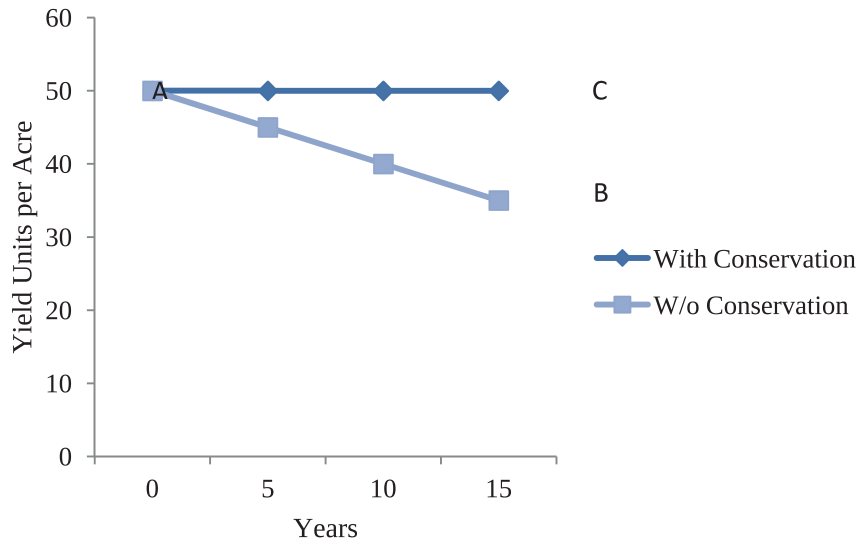
Click here for Figure 610A-3: Expected Yield Levels Over Time With and Without Conservation Treatments

(3) Estimates of future conditions, with and without treatment, are commonly made by using the benchmark inventory of the current situation as a starting point. Based on historical trends and current data, future trends can then be projected while scenarios regarding the current relationships and foreseeable developments are considered. Projections of future "with" and "without" treatment conditions should reflect the views and expectations of the decisionmakers as well as being based on information acquired from library research, local and professional judgment, data sources such as soil surveys, and other sources of published and anecdotal information.

Part 610 – Natural Resource Economics Handbook

Subpart A – Economic Analysis and Conservation Planning

Figure A-3 Expected Yield Levels Over Time, With and Without Conservation Treatments



Subpart B - Benefits and Costs of Conservation

610.10 Introduction

A. When completing an economic analysis of alternative conservation systems, conservation planners and land users must first identify all relevant benefits and costs. Then they must measure those benefits and costs so that they can develop a meaningful estimate of the net benefits of each alternative. This subpart addresses basic issues related to the identification and measurement of benefits and costs as a first step in the process of completing formal benefit-cost analysis. Benefits and costs involved in an economic analysis of conservation often are not compatible in kind, place, or time. An economic analysis needs to take into account these factors and make appropriate adjustment when necessary. Similarly, actions taken in one period may have effects in another. For example, reducing soil erosion in the current time period may affect the ability of future generations to produce food and fiber; and a sludge application now may impact the options for future cropping alternatives. A responsible, complete economic analysis should take into consideration these types of possible effects.

B. An important consideration in the economic analysis of conservation practices is who pays the costs and who receives the benefits. They are often not the same person. In standard public benefit-cost analysis, all benefits and costs are to be included in the evaluation, to whomsoever they may accrue. In order to assist a land user in deciding whether to personally incur the costs necessary to implementing a given conservation system, however, the analysis must identify to whom any prospective gains and costs will accrue, including both monetary and non-monetary benefits and costs.

C. In benefit-cost analysis for conservation, it is important to avoid jumping to the conclusion that the decisionmaking land user values only those benefits accruing directly to him or her. On the other hand, some costs, such as installation cost, can be greatly offset by Government cost-share dollars or by favorable income tax treatment of incurred costs for conservation projects. Such offsets can directly reduce the out-of-pocket costs to land users and need to be taken into account in economic analysis for conservation.

D. The concept of externalities is used by economists to describe a situation in which some or all of the benefits of a private action are enjoyed by (or costs paid by) someone who was not directly a party to the market transaction generating those benefits (or costs). A classic example of an external cost is air pollution emitted by a factory whose output is sold in an overseas market. Local citizens who have no connection with the factory—such as being employed there or owning stock in the company that operates the facility—are said to be incurring some of the costs of production without compensation. This is defined as a negative externality.

E. In conservation work, externalities can exist in several different ways: benefits or costs can accrue to the public when a private land user implements a conservation system, and benefits or costs can occur on land that was not included in the original conservation plan or the area where the project was implemented. In addition, benefits or costs are often distributed over time. In some cases, this means that the land user will need to take future impacts into consideration when evaluating conservation alternatives. It may even be necessary to consider that future generations could enjoy benefits or incur costs associated with current conservation activities. It is important for conservation planners and land users to keep these concepts in mind as they go through the process of identifying and measuring the benefits and costs of alternative conservation systems.

F. As stated in subpart A, in some circumstances, the planning environment is relatively uncomplicated and only a simple evaluation of benefits and costs is needed by the land user in order to make sound decisions about which conservation alternative to adopt. In that case, the information contained in this subpart should be sufficient to completing an adequate analysis. In other circumstances, a more complicated planning environment and more complex financial implications of adopting a prospective conservation system will dictate completing a more sophisticated economic analysis. In that case, information presented in subsequent subparts will need to be understood and applied in order to complete an adequate benefit-cost analysis. For example, in the process of selecting the most desirable conservation option, several additional factors can significantly affect the feasibility of the alternatives from the standpoint of the land user and can also alter which alternative is deemed best. Such factors include the useful life of conservation practices, period of analysis, depreciation, interest rates, and inflation. These subjects will be addressed in subpart C.

610.11 Identification of Private and Public Benefits of Conservation

A. An essential question that must be asked when evaluating a conservation system is, "who will benefit from its implementation?" The adoption of conservation systems causes changes in natural resource conditions. If all of the benefits of these improvements were enjoyed solely by the land users installing and maintaining natural resource conservation measures, there would be no need for public financial support for planning and implementation of conservation systems. In reality, however, implementing a RMS invariably generates benefits that cannot be captured by the land user and are, instead, enjoyed by neighbors, the community, or society in general. Because of the existence of these external benefits, without the involvement of NRCS the amount of completed conservation work

would not reach a socially optimal level. Accordingly, both land users and society can benefit from NRCS involvement in both conservation planning and the adoption of conservation practices.

B. Private Benefits

Private benefits accrue to the land user and are not shared by the public in general. An example of a private benefit of conservation is the financial reward enjoyed by a land user who produces higher crop yields and a higher quality of agricultural product as a result of taking steps to improve soil condition.

C. Public Benefits

Public benefits are either shared by the land user with his or her community or society in general or they are enjoyed entirely by the public although generated by the private land user. An example of a public benefit of conservation is a beautified landscape that occurs as a result of vegetation planted by a farmer to reduce blowing dust on her farm and that is enjoyed by passers-by who view the farm. The question of who will benefit is one aspect of completing a benefit-cost analysis for a conservation system.

610.12 Identification of Onsite and Offsite Benefits of Conservation

A. Another aspect of evaluation is the question of the physical location where conservation benefits will occur. Benefits from conservation work may occur at both onsite and offsite locations. Onsite benefits occur at or close to the location of the conservation activity and generally are directly beneficial to the user or owner of the resource where the conservation activity was undertaken. These benefits can be divided into at least two types: maintaining or restoring productivity and decreasing production costs. Additional onsite benefits include non-dollar benefits, such as an improvement in living conditions on a farm or ranch. Offsite benefits occur in different locations than that of the conservation activity and may occur to different resource users and owners and to the general public. It is also possible that implementing a conservation system in one location will lead to detrimental effects in another location or on other natural resources. External effects can have a long-lasting impact on other land units. It is important to always check for potential negative cross effects and unintended consequences. A guide of conservation effects that can be expected in specific resource settings is listed in sections III and V of the local NRCS Field Office Technical Guide (FOTG).

B. Onsite Benefits

(1) Onsite benefits are those benefits realized on the physical land unit where the conservation system is implemented.

(i) Maintaining, Restoring, or Increasing Productivity

In a farm setting, maintaining or restoring productivity means maintaining or restoring crop yields by protecting the soil from erosion as well as conserving water. Crops need sufficient soil nutrients and water. The soil needs adequate tilth and organic matter for adequate root growth. Where erosion occurs, crops often cannot absorb basic needs from soil. Through the removal of topsoil, wind erosion reduces the capacity of the soil to hold moisture and degrades the soil profile. Water erosion similarly removes topsoil, reducing the quality and quantity of the soil and causing nutrients to be lost. It can also cause onsite crop damage by forming gullies and depositing sediment. Both of these effects lower productivity by reducing and sometimes eliminating crop stands in certain locations of a field.

(ii) Conservation practices are designed to keep soil, nutrients, and water where they are needed. Where conservation practices are used to reduce soil loss and conserve moisture, yields can be maintained and restored, or even enhanced. Increased crop yields are a primary benefit of some conservation practices, often resulting in increased income and offset conservation costs to producers.

(2) Decreasing Production Costs.—Some conservation practices are beneficial to the land user because production costs may be reduced. Practices, such as conservation tillage and no-till, reduce the number of trips over the field, saving the farm operation time, fuel, and machinery wear (see note below). Weed and insect control costs may, however, be increased. Other measures that convert row crops to other land uses permit the land user to use less fertilizer and fewer chemical inputs. Examples are field borders and grassed waterways. These measures could involve converting low yielding row crop areas, such as end rows and watercourses, to grass. The land user saves production expenses because these converted areas usually require less input than the row crops they displaced, thus reducing the total production costs.

(3) Other Onsite Benefits.—Some onsite benefits are not directly measured in dollar terms. Increases in wildlife visits, enhanced local air quality, and improved opportunities of recreation use are some examples of onsite changes in resource conditions that can be the result of implementing a conservation system.

C. Offsite Benefits

(1) Sometimes when conservation practices are installed, they reduce offsite resource or environmental damages, thus providing economic benefits that should be considered in the decisionmaking process. For example, a change in a feed crop resource may positively impact offsite grazing resources, or an erosion-control project intended to improve plant condition and crop yields on a particular farm field may improve downstream water quality and, as a result,

improve recreational use of the water body. These offsite benefits may occur on land owned or operated by the land user, or they may occur on land owned by another producer or by the public.

(2) Offsite resource concerns, such as sediment deposition and reduced water quality, are created as eroded soil is transported and deposited by the actions of wind or water. The sediment can fill in ditches, plug culverts, reduce the useful life of reservoirs and ponds, destroy fences, destroy and damage crops, and transport contaminants, such as pesticides and fertilizers, to waterways or offsite. Through conservation, the transport of material that pollutes the ecosystem, damaging wildlife and aquatic habitat, can be dramatically reduced.

(3) The most effective way to avoid offsite pollution is to keep soils from eroding and keep fertilizer and chemicals on the fields where they are applied. Practices that reduce soil loss, sediment, and chemical pollutants may be useful in maintaining or improving water quality even though offsite water quality was not an intended objective of implementing those practices.

Note: Some analysts use "custom rates" as an estimate of the operating costs for machinery and labor costs for field operations. A custom rate indicates the typical cost to hire a piece of machinery and its operator, usually on a per-acre basis.

610.13 Identification of Private and Public Costs of Conservation

A. Private Costs

Most costs associated with implementation of conservation systems are private costs. These include private expenditures such as the land user's share of implementation costs, operation and maintenance (O&M), replacement costs, and foregone private income. Some costs potentially incurred by the land user are not easy to identify, but they should be included in any complete economic analysis.

B. Public Costs

Public costs associated with implementation of a conservation system include the obvious category of public share of implementation costs. Less obvious public costs include any undesirable external costs such as effects on the immediate neighbors, community, or society in general due to the project's completion. Examples include negative aesthetic impacts to landscapes, reductions in previously-existing stream flows, and temporary or permanent displacement of wildlife that had previously been viewed and enjoyed by recreational visitors to the affected farm or ranch.

610.14 Identification of Onsite and Offsite Costs of Conservation

A. As in the case of onsite and offsite benefits, onsite and offsite costs are related to the physical location where costs are incurred. And as in the case of benefits, offsite costs may occur on land controlled by the cooperating land user but outside of the area where the conservation system is being implemented.

B. Onsite Costs.—Onsite costs are those costs of implementation that are directly associated with the land unit where conservation practices are to be applied.

(1) Installation and Other Direct Implementation Costs

(i) The most obvious costs are the expenditures associated with initially installing the practice or conservation system. These include costs for obtaining inputs such as the materials, land, labor, and equipment necessary to get the conservation practice on the ground according to standards and specifications. Sometimes these costs occur upfront, and sometimes they are distributed over time. Another potential type of cost is losses such as deaths of desirable small wildlife that occur as part of constructing a physical facility as part of a conservation system or reduced enjoyment of the on-farm landscape by the land user because of tree-cutting necessary to system implementation. The implementation costs listed above are usually easy to recognize. These are called "explicit costs."

(ii) Other costs are not so easy to identify. They are called "implicit costs" and include less-visible opportunity costs. An example is the land user spending his or her time implementing the conservation project rather than working at an income-earning job, finishing a project that was competing for attention, or spending time with family members. At times, depreciation of conservation practices is not accounted for or properly accounted for, and unpaid labor contributed by land users, or even volunteers, could also be unaccounted for. These more subtle costs are still costs for conservation, and should be included in the derivation of the total costs for investing in a conservation practice, or a system of conservation practices.

(2) Operation and Maintenance

(i) Expenditures for O&M are costs that occur throughout the lifetime of the practice, usually on a year-by-year basis. O&M outlays are expended to ensure that conservation practice continues to function properly. Fertilizing an established waterway, operating a pump, and reseeding a terrace back slope and maintaining fences are examples of O&M outlays.

(ii) Changing tillage practices may cause other costs to be incurred. For example, in some soils, applications of fertilizers and pesticides must be increased when switching to conservation tillage or no-till. Increased production costs must be accounted for in these situations. These costs may be partly offset by fewer operations, better timing of operations, and lower equipment repair costs resulting from the elimination of gullies.

(3) Foregone Income

Another cost for some conservation practices is a reduction in net revenue because of lost production. When certain practices are installed in certain areas of a farm, previous production from the area is foregone. Waterways, certain types of terraces, and changes in crop rotation can reduce yields or take land out of production altogether. If the yields from these areas are initially low, then the loss will be small. However, if previous yields are high, then the cost of installing waterways will also be high in terms of lost production. Foregone income should always be accounted for when evaluating the costs of a proposed conservation project.

C. Offsite Costs

Offsite costs are those costs that are incurred outside of the immediate project area. These generally include cross-effects impacting non-targeted resources. For example, displaced wildlife may begin feeding in previously unaffected areas, leading to undesirable secondary resource effects. Or, alternatively, wildlife may be attracted to the treated land unit, creating an increased hazard to motorists on an adjoining highway. In another example, if the underlying soil on a farm is susceptible to leaching problems, then implementing conventional no-till residue management—with its accompanying increased use of herbicide and pesticide—may exacerbate an existing groundwater pollution problem.

610.15 Identification of the Temporal Distribution of Benefits and Costs

A. Benefits and costs of conservation systems do not necessarily occur at the same time, nor do they necessarily occur in a single time period. Once some conservation practices are adopted, their benefits are spread over many years. For some practices, such as annual management practices, the majority of benefits only exist for the year during which the practice is actively being implemented. Benefits are sometimes only fully realized several, or even many, years after a practice is implemented. From the cost perspective, there are one-time costs, distributed costs, annual costs, and so on. Some costs are constant and some vary over time. The same is true of benefits. These factors affect the financial feasibility of the project and its comparison with alternatives.

B. Identification, quantification, and valuation of effects over a given period of analysis may quickly lead to conclusions regarding feasibility and the identification of an economically best alternative, but other considerations are important. A close examination of the timing of gains realized and losses incurred may reveal that short-term financial demands exceed short-term ability to pay. Comparing the timing of marginal benefits and costs to determine the financial feasibility of a proposed conservation system arises out of the financial concept called "cash flow." Alternatives that require high near-term costs in order to achieve long-term benefits may not be financially feasible, even though total benefits over the life of the project are expected to exceed total costs.

C. The concepts related to the time value of money and the methods for the comparison of gains and losses on an equal time basis are described in subpart C. A variety of methods for completing indepth evaluations of alternative conservation systems is provided in subpart D.

610.16 Measurement of Benefits and Costs

A. Benefits and costs could be either quantitative or qualitative. Where benefits and costs can be readily quantified, that should be done as a first step toward establishing market values for them. Some benefits and costs, however, can in theory be measured but in practice are impractical or impossible to measure or quantify. When it is difficult or impossible to numerically quantify benefits or costs that are important to the planning process, national policy states that rather than leaving those factors out of the decisionmaking process, those benefits or costs should be included in the analysis in descriptive qualitative terms.

(1) Some examples of quantified benefits include increased crop yields in tons, bushels, pounds, hundredweight, etc.; decreased water consumption in acre feet or gallons; increased irrigation efficiencies in percentage points; reduction in energy use in kW, and so on. Some examples of qualitative benefits that would be difficult or cost-prohibitive to measure in quantitative terms include improvements in on-farm air quality; increased palatability of forage for wildlife; and reduction of negative impacts on pollinator insects.

(2) Qualitative data should be recorded in descriptive terms that provide sufficient details to capture the preferences of the land user and the rationale behind labeling the conservation effect as a benefit or a cost. Descriptive terms such as "large reduction in offensive odors" and "moderate increase in wildlife visitation," and comparative terms such as "much greater enhancement of aesthetic enjoyment" and "slightly bigger improvement in ease of operations" can be used to describe and compare qualitative benefits. It is important for the land user or future conservation planner to be able to understand the logic supporting the evaluation and the decision to which it led.

B. Benefits and costs can also be categorized by whether or not they are traded in any market. For example, increased crop yields are traded in commodity markets; improved air quality is not. When market prices can be identified, it is relatively easy to quantify them in dollar terms. When no market price exists for a benefit or cost, it is more difficult—but not impossible—to estimate its dollar value for use in calculating net benefits. Identification of proxy market values will be addressed later in this

section.

C. Market Benefits and Costs

(1) There are several possible approaches to and methods for identifying market prices for benefits and costs of conservation. The first step is to determine whether an easily identified market exists for the benefit or cost. For example, a dollar value can be assigned to an increase in corn yield that results from a conservation project by using any of several sources of market data: first, extension crop budgets can be used to estimate increase production costs associated with the increased yield; then data from the National Agricultural Statistics Service (NASS), a State agricultural agency, or an agricultural commodity industry source can be used to establish a multiyear average price for the type of corn in question.
(2) It's important to recognize that finding an exact market price is not always possible or even useful. Because prices are continually changing, it is better to use longer-term average prices for any aspects of the analysis that will be distributed over multiple years. The timespan to use depends on the expected life of the conservation practice, the objectives of the land user, and other relevant factors determined at the time the analysis is completed. Similarly, if a conservation system will be adopted over several years, with construction projects occurring in each of those years, current-year prices of inputs may or may not be helpful in determining the overall net benefits of the project. On the other hand, if the project will be completely installed during the current year, existing market prices may be all that the land user needs to complete their decisionmaking process. Choosing which market prices to use is sometimes more of an art than a science; it becomes easier and more intuitive with increased experience in the economics of conservation planning.
(3) There are many sources of market price data that are easy to access and easy to use: Online agriculture industry newsletters, the NASS Web site, Bureau of Labor Statistics online data sources, and so on, are a few examples of good sources of market prices. The references section of this handbook includes a list of possible sources of data.

D. Nonmarket Benefits and Costs

(1) There are multiple ways in which estimated or proxy market prices can be established for non-market benefits and costs. The most common of those that apply to conservation planning analyses include the replacement cost method, the opportunity cost approach, the travel cost method, the hedonic pricing method, and contingent valuation methods.
(2) Replacement Cost Method.—In the replacement cost method, the analyst develops an estimate of how much it would cost to provide the benefit or mitigate the cost being evaluated. For example, if a conservation project will protect an existing wetland, the estimated cost of creating a similar wetland can be used as its proxy market value. Or if a conservation practice will require removing several old trees, the cost of replacing those trees can be used as a market value of the tree-related cost of that practice.
(3) Opportunity Cost Approach.—While this process is sometimes not considered to be a valuation method, it can serve the purpose of providing important, dollar-denominated information about the impacts of a project. In this method of evaluation, the decisionmakers determine what the benefits of the project would have to be to offset its impacts. For example, the land user can set a minimum increase in pollinator activity that would be required in order to justify the loss of net returns (gross returns minus total costs) to the crop land taken out of production. In this case, the reduced crop revenue can be used as a proxy value for the required increase in pollinator activity.
(4) Travel Cost Method.—The travel cost method is most often applied to benefits or costs related recreational visitors, hunters, or fishermen to an area. For example, if a conservation project will benefit a nearby trout-fishing stream and lead to increased trout populations, then fishermen who are visiting a trout stream somewhere else within the regional area can be interviewed to find out how much money they each spend on travel costs such as hotels, meals, transportation, and equipment purchases in conjunction with their typical fishing trips. Those costs can then be used to extrapolate a value of the expected improvement in the fishery. Similarly, enhanced habitat for songbirds, which attracts birdwatchers, can be valued using the travel cost method through interviews of birders. Conversely, degradation of habitat that leads to losses of visitation can be valued as a cost using the same methodology.
(5) Hedonic Pricing Method.—The objective of the hedonic pricing method of valuation is to identify a change in the price or value of some asset that is affected by a change in resource conditions. The most common example is a change in property values that can be attributed to a change in the aesthetic environment. Within the context of a conservation project, if implementation of the conservation system alternative is expected to greatly improve and enhance the physical beauty of the surroundings of a farm or ranch house, that improvement can be expected to increase the market value of the house. That change in market value can then be used as a proxy market price for that specific benefits provided by the conservation system.
(6) Contingent Valuation.—In contingent valuation, individuals are asked to place their own subjective market values on environmental or resource benefits. There are two primary methods of contingent valuation: willingness to pay, and willingness to accept (compensation required). In the "willingness to pay" method, survey participants are asked to identify how much they would be willing to pay to obtain (prevent) a prospective natural resource benefit (cost). In the "willingness to accept" method, participants are asked how much they would have to be paid for

them to consent to losing (putting up with) the prospective benefit (cost). Both of these methods are subject to problematic distortions, including income effects, "strategic voting," and others. In spite of these drawbacks, contingent valuation can serve as valuable sources of proxy market values for non-market benefits and costs of conservation projects.

610.17 Developing and Presenting Benefits and Costs Information

A. Decisionmaking by land users about conserving natural resources is the same as any other decisionmaking process. Once a problem is identified and alternative solutions developed, the physical and monetary effects of alternatives can be compared to determine whether the potential benefits from installing new conservation measures would outweigh the costs. The conservation planner's objective is to assist the land user in identifying and understanding the effects—both positive and negative—of a conservation practice or activity. The land user then incorporates that information into a decisionmaking process that will lead him or her to either adopt or reject the proposed conservation system. The conservation effects for decisionmaking (CED) framework assists the land user in making conservation decisions by providing a method for organizing and evaluating information on benchmark conditions, resource concerns, conservation system effects, and other factors related to adoption of conservation practices.

B. When developing a list of expected effects, it is important to make sure that all relevant resource impacts are included as well-defined benefits and costs, and to also make sure that none of the effects are double-counted. A simple method for achieving these objectives is to identify as many benefits and costs of an alternative as possible and then to use the CED process to quantify impacts where possible (and to develop qualitative descriptions where quantification is not possible), search through them to eliminate duplication, and then continue on with more detailed analysis where needed. The point of this process is to make sure all effects are considered and that none are double-counted. If pertinent information is left out, the land user may not adequately understand the prospective attributes of the proposed project, leading him or her to make an erroneous decision.

C. It is important for planners to be aware of potential diminishing returns. These exist, for example, when spending additional money beyond the minimum required to implement a conservation practice—in order to increase quality or add features to the practice beyond the basic version—results in additional but incrementally smaller conservation benefits. It is often the case that implementing a relatively simple version of a given conservation practice will result in the achievement of a majority of the conservation benefits that can be obtained through installing that specific practice. Adding additional features or levels of quality to the practice may result in increased conservation benefits, but as the overall level of benefits approaches the maximum possible, more and more money must be spent to achieve the same incremental increase in benefits. In this situation, additional expenditures of money are likely to realize more conservation benefits if spent on additional practices that would address other resource concerns.

D. Conservation Effects for Decisionmaking Revisited

(1) The need for conservation planning is based on the notion that one or more natural resources is currently, or is expected to be, in a condition that is less than desirable. The objective of conservation planning is to improve resource conditions. Success in conservation implementation is measured by comparing the current "benchmark condition" to the expected future "with treatment" condition of the resource and by identifying the resulting conservation impacts. When making a conservation decision, land users apply their own preferences and values to benefits and costs to weigh the importance of conservation impacts.

(2) For example, imagine a farm field that has a soil erosion resource concern. The benchmark condition is 8 tons per acre per year of erosion and 60 bushels per acre per year in wheat yields. The proposed conservation treatment is no-till crop residue management, which will reduce soil erosion to 5 tons per acre per year and which will increase wheat yields to 62 bushel per acre per year. The project is also expected to double the amount of goose use of the field as temporary habitat during spring migration. The impact is a 3-ton reduction in soil erosion, a 2-bushel increase in wheat yield, and doubled goose-grazing on new wheat growth. From the land user's perspective, the reduction in erosion, the increased crop yield, and the improved wildlife habitat are positive impacts, and the cost of implementing residue management is a negative impact. If this information is sufficient for the land user to determine that he or she wants to adopt the plan, he or she may be comfortable with moving forward with implementation. However, another land user, with different values, may consider the improved goose habitat and the resulting increase in good-grazing as a negative impact because they view the prospective presence of twice as many geese temporarily living on their field as a nuisance. This serves as a reminder that whether a resource impact is viewed as negative or positive depends on the land user's viewpoints, preferences, and values.

(3) The resource impacts serve as the basis for making a decision to accept or reject a conservation treatment. This process is repeated for each alternative that is developed. Once again, the effects can be environmental, social, economic, or some combination of these.

E. Presentation of Conservation Effects Using a "T" Chart

A simple way to present conservation impacts and economic information identified in the CED process is with a "T" chart. The "T" chart is a tool that organizes information and simplifies the

conservation planning and decisionmaking process. The "T" chart describes the resource setting, resource concerns, and conservation system and lists the benefits (good or positive results) and costs (bad or negative results) of the proposed conservation action. The information included in the "T" chart may come from the land user, the planner's experience and education, research, and NRCS technical resources. Using the information from the no-till example above, figure 610B-1 displays a typical "T" chart.

Click here for a copy of Figure 610B-1: "T" chart Example for Conservation Treatment Effects

F. "T" Chart Guidelines

(1) It is sometimes difficult to know which benefits and costs to include in the "T" chart, especially when both onsite and offsite benefits and both explicit and implicit costs are expected to occur if the conservation system is implemented. It helps to remember that the goal is in completing a "T" chart is to achieve completeness, to eliminate repetition or double-counting, and to prevent missing any benefits or costs in the display of effects. Once the effects have been organized, the land user can evaluate the relative importance of the benefits and costs given his or her viewpoint and preferences.

(2) This subpart has discussed how identify, collect, measure, and display benefit and cost information for evaluating a conservation project. Although a positive benefit-cost ratio (the ratio is equal or bigger than 1, which occurs when the total benefits are greater than the costs) does not necessarily mean that a project is worth implementing, in some planning settings, simply seeing a comprehensive display of the project's expected benefits and costs and finding that the net benefits are positive is sufficient information to induce the land user to adopt the project. In other, more-complex, settings, correspondingly more-complex evaluation techniques may need to be used in order to complete an adequate analysis. When the dimension of multiple time periods is added to the situation, the discounting and compounding techniques presented in subpart C may be necessary in order to reach a sound decision in the conservation planning setting. Subpart D presents additional techniques specific to economic analysis of conservation practices such as partial budgeting, value analysis, and other advanced methods of analysis.

Part 610 – Natural Resource Economics Handbook

Subpart B – Benefits and Costs of Conservation

Figure B-1 "T" Chart Example for Conservation Treatment Effects

CONSERVATION TREATMENTS: Crop Residue Management – No-Till	**RESOURCE PROBLEMS:** Sheet & Rill Soil Erosion
BENEFITS	**COSTS**
Reduced Costs: Reduced passes over the field Reduced labor, fuel, machinery 5 Passes x $15/Pass = **$75/Ac/Yr** ***Increased Revenue:*** Wheat yield increase 2 Bushel* $6.00/Bushel = **$12/Ac/Yr** ***Other:*** Assist meeting environmental goals Improved soil & water quality Wildlife recreation opportunities Additional time to pursue other activities **Total Dollar Benefits = $87/Ac/Yr**	***Increased Costs:*** Residue Management Purchase no-till equipment $259,000 6%, 20 Years, 500 Acres = $45/Ac/Yr (Possible wildlife management costs) ***Reduced Revenue:*** None ***Other:*** Increased risk with new crop management Increase in trespassing to view wildlife **Total Dollar Costs = $45/Ac/Yr**

Note: The conservation management unit is a small grain cropland. The field is located on a major migratory waterfowl flyway. Before any conservation treatment, the field is being cultivated under a conventional wheat-fallow crop rotation and management.

Part 610 – Natural Resource Economics Handbook

Subpart C – Discounted Cash Flow Analysis

610.20 Introduction

A. Benefits and costs of conservation practices do not necessarily occur at the same time. Certain costs and benefits (such as installation costs, which occur only during the installation period) may occur at one point in time, while other costs and benefits may occur over an extended period of time. A one-time value can occur today or at some point in the future. Costs and benefits that occur over an extended period are called annual cash flows, or annuities. Annuities can be constant, decreasing, or increasing over time, depending on their characteristics. Many of the benefits from conservation occur as annuities.

B. The time value of money means that cash flows at different points of time differ in value and thus are not directly comparable. Discounted cash flow (DCF) method is a tool commonly used in investment analysis to evaluate projects with benefits and costs occurring at different time. In DCF analysis, benefits are considered positive cash flows and costs are considered negative cash flows. To compare them, we would need to discount all future cash flows back to the present to find their present values (PV).

C. In this subpart, we will first introduce the DCF method and then apply the DCF method to analyzing conservation practices. We will also discuss about how to conduct DCF analyses using Microsoft Excel spreadsheets (see note below). Excel is a convenient tool for conducting a DCA analysis. It has 90 separate financial functions that can be used for DCA, with the Excel help function explaining each.

Note: All Excel functionalities described in this handbook are based on Microsoft Excel 2007 edition.

610.21 Decision Criteria

A. Net Present Value Approach

(1) The economic evaluation of prospective conservation systems requires a comparison of the benefits and costs of the alternatives under consideration. The standard criterion for deciding whether a conservation project can be justified on economic principles is net present value—the discounted monetized value of expected net benefits from the project (i.e., discounted benefits minus discounted costs).

(i) Net present value is computed by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. Discounting benefits and costs transforms gains and losses occurring in different time periods to a common unit of measurement.

(ii) Projects with positive net present value increase social resources and are generally preferred. Projects with negative net present value should generally be avoided (technical details about discounting are discussed in the next sections).

(iii) When comparing two or more alternative projects, the project with the greatest net present value is generally the preferred alternative.

(2) Although some benefits and costs cannot be expressed in dollars, efforts to measure them can produce useful insights as demonstrated in figure 610C-1. In these cases, a comprehensive enumeration of the different types of benefits and costs, monetized or

not, can be helpful in identifying the full range of project effects. Other summary effectiveness measures can provide useful supplementary information to net present value, and analysts are encouraged to report them also. Examples include a project's internal rate of return, threshold or break-even cost or benefit, payback ratio, etc. Analytical details for these measures will be discussed further later.

B. Cost Effectiveness Approach

(1) A conservation project is cost effective if, on the basis of cost analysis of competing alternatives, it is determined to have the lowest costs expressed in present value terms for a given amount of benefits. Cost-effectiveness analysis is appropriate whenever it is unnecessary or impractical to consider the dollar value of the benefits provided by the alternatives under consideration (Office of Management and Budget (OMB) Circular No. A-94). This is the case whenever either of the following apply:
(i) Each alternative has the same conservation benefits expressed in monetary terms.
(ii) Each alternative can produce the required conservation effects, but monetary values cannot be assigned to their benefits.

(2) Cost effectiveness analysis can also be used to determine the least cost alternative to deliver the same amount of benefits at the same time period, regardless of whether we know the monetary values of the benefits. In addition, cost-effectiveness analysis can be used to compare projects with identical costs but differing benefits. In this case, the decision criterion is the discounted present value of benefits. The alternative project with the largest benefits would normally be favored.

(3) When using cost-effectiveness analysis, the landowner must be cognizant of the economic factors described in the previous section. Differences between alternatives in potential conservation effects can be evaluated by first identifying the respective future with and without conditions of the alternatives and by then comparing those alternative conditions on an equal time basis.

(4) Example – Water Quality.—Consider an example in which laws, such as the 1972 Clean Water Act as amended (section 208), are used to enforce minimum standards for water quality and maximum standards for permissible discharge. For a landowner such as a dairy operator to stay in business, the range of alternatives may be reduced to bringing the operation into compliance, facing a substantial fine, or being sentenced to jail. Assuming that neither paying a large fine nor spending time in jail is a desirable option, the conservation alternative is to find the least-cost option for bringing the operation into compliance.

610.22 Major Factors for Discounted Cash Flow Analysis

A. The Useful Life of Conservation Practices

(1) Official NRCS conservation practice lifespans are contract lifespans that are established and maintained in the NRCS Conservation Practice Standards (CPS) Web application. A contract lifespan of a conservation practice is defined as the time period in which the conservation practice is to be used and maintained for its intended purposes as defined by NRCS technical references. All conservation practices established through a NRCS financial assistance program contract are expected to be maintained for their established contract lifespans.

(2) The useful lifespan of a practice, however, may extend beyond the length of the program contract. The life expectancy of a conservation practice will impact the estimation of the stream of expected benefits of the conservation practice and will also impact the estimated annual cost and the depreciation of the practice. Therefore,

consistently defined life expectancy of conservation practices or systems is important in the evaluation of benefits and costs of applying proper conservation, especially in comparing alternatives with benchmark scenarios. When applying a system of conservation practices to treat a specific resource concern or problem, the local actual useful life of the system should be determined by careful identification and evaluation of the critical practices within the system.

B. Period of Analysis

(1) The length of time over which costs and conservation effects are considered is called the period of analysis. Two analytical concerns in decisionmaking are determining the period of analysis and using a standard time horizon. The period of analysis determines the length of the analysis, whether it is 1 year or 10 years, for example. The standard time horizon determines how to partition the period of analysis, whether the analysis is done by monthly, quarterly or annually, for example.

(i) A period of analysis is established so that gains and losses may be compared on the same or equivalent time basis. A standard time horizon assures that these effects are considered on a common time basis. For example, benefit-cost analysis of a conservation project can be done for a time period of 2012-2022 with annual data.

(ii) For a private benefit-cost analysis, the landowner is responsible for identifying the period of analysis. General factors affecting the landowner's decision on the period of analysis include demographic data, such as the age of the landowner and his children or heirs, and whether the landowner's children or heirs will continue to farm.

(iii) A short-term analysis usually refers to an analysis with a period of time during which the land user is committed to at least one fixed cost of production, such as a lease or a loan payment, that is not adjustable. If all production costs are variable, the analysis period is defined as long-term.

(2) Economic factors that constrain the period of analysis include the physical deterioration of capital investment (farm equipment and conservation practices) and prospective obsolescence due to technology improvements. The period of analysis should not exceed the shorter of the planning horizons, such as the repayment period or the physical life of the alternative. If the selected planning horizon is shorter than the physical life of the alternative, however, any benefits that accrue beyond the period analyzed must still be carefully analyzed.

C. Treatment of Inflation

(1) An increase in the general price level of an economy is called "inflation." The inflation rate is the percent annual increase in the general price level. Inflation occurs when the quantity of money in circulation and the velocity (frequency) of money in circulation rise relative to the quantity of goods and services available. Inflation erodes the purchasing power of income and investments. The inverse of inflation is deflation, as occurred in 2009. Deflation has not occurred for longer than 2 years since the early 1930s.

(2) It is recommended that, in most cases, economic analyses for conservation projects and programs are conducted using real values, rather than nominal values. Using real or constant values allows the analyst to avoid making risky estimates of future inflation rates and to simplify the analytical procedures. Where future benefits and costs are given in nominal terms, however, the analysis should use these values rather than convert them to constant dollars. Nominal and real values must not be combined in the same analysis. Logical consistency requires that analysis be

conducted either in real dollars or in terms of nominal values. This may require converting some nominal values to real values, or vice versa.

(3) Such conversion between nominal and real values can be accomplished using gross domestic product (GDP) deflator or price indexes.

(i) The GDP deflator measures the ratio of the nominal (or current-price) GDP to the real (or chain volume) measure of GDP and is produced by the Bureau of Economic Analysis.

(ii) A price index is a weighted average of the prices of preselected baskets of goods and services. Price indexes usually use a specific year (e.g., 1991) as the price base year by assigning that year the index value of 100 (e.g. 1991=100). Indexes could be adjusted to a new base by dividing the prices for all other years into the prices for the selected base year.

(iii) The Consumer Price Index (CPI) and the Producer Price Index (PPI) are the two most common economy-wide price indices in the United States. The PPI measures inflation for the producer goods such as machinery. The CPI measures inflation for the consumer goods such as food and clothes. The CPI and PPI are both generated by the Department of Labor Bureau of Labor Statistics.

(4) The conversion between nominal and real values using the GDP deflator, CPI or PPI assumes that inflation will affect equally the values of all goods and services used to derive these costs and benefits. In most cases, the value differences between these indexes are very small. More selective conversions of benefits or costs of conservation programs and projects between nominal and real values can be accomplished using sector-specific price indexes. The most commonly used of such prices include the Producer Prices Paid by Farmers Index (PPPI), the Producer Prices Received by Farmers Index (PPRI), and the Engineering News Record – Construction Cost Index (CCI).

(5) Both the PPPI and the PPRI are calculated monthly by the National Agricultural Statistics Service (NASS). These indexes are published in the Agricultural Prices Report by NASS and are available on its website. The PPPI can be used to convert conservation costs between nominal and real values, and the PPRI can be used to convert conservation benefits. The CCI is commonly used to convert costs in watershed plans and similar types of projects. When using more than one price index for a conversion between nominal and real values, it is important that the indexes are applied using the same base year to make the adjusted total costs and total returns readily comparable.

(6) The process of converting benefits or costs between nominal and real values using a price index is explained here with an example. Assuming the installation cost of a conservation practice is $3500.00 in 2010 nominal value, to convert it into a 1991 based real value using the PPRI so that it can be comparable with the real values of other costs and benefits of the project, we need to multiply $3500.00 by the PPRI for 1991 (100.00), and then divide it by the PPRI for 2010 (159.00), as follows:

$$\$3,500.00 \text{ x } \frac{100.00}{159.00} = \$2,201.26$$

D. Depreciation of Assets

(1) Depreciation is the anticipated reduction in the value of an asset over time, caused through physical use or obsolescence. In accounting, depreciation refers to the process of amortizing or allocating a portion of the original cost of a fixed asset, such as a tractor, to each accounting period. The value is gradually used up (written off) during the estimated useful life of the asset. Allowance may be made for the ultimate

estimated resale or salvage value of the fixed asset (its residual value) expected to remain at the end of its useful life. There are several different depreciation methods (or schedules). The two principal types of depreciation methods are:

(i) Straight-Line Depreciation.—Allocates the cost of a fixed asset in equal amounts for each accounting period.

(ii) Accelerated Depreciation.—Allocates a larger proportion of the original cost to earlier accounting periods and a smaller proportion to later periods.

(2) Depreciation of assets is linked to the assumption that as each productive asset is worn out over time, its owner will simultaneously set aside money or an alternative financial asset into an interest-bearing account—a sinking fund—so that when the asset has been depreciated down to zero, the account will contain sufficient funds to replace the asset without its owner having to borrow money.

E. Discount Rate Policy

(1) Time Value of Money and Discounting

(i) Money can be invested to make more money over time. One dollar invested in a worthy project today could be worth more than one dollar a year from now. This is known as the time value of money. Invested money increases in value over time because of the extra value generated from the use of production factors such as machines, land, and labor. When a landowner considers investing in conservation, the time value of money concept applies. Because money spent on conservation work could be spent on an alternative investment, the interest cost for the money invested in a conservation practice must be considered as part of an economic analysis of the project.

(ii) Interest is the measure of earning power of money, the value of money when in use. It could be either what someone would pay you for the use of your money, or the rent you are willing to pay for the use of someone else's money. If a landowner borrows to pay for a conservation practice, the interest cost will be the interest that must be paid on the loan. Otherwise, the interest cost is equal to the best return that the money would have earned on some other investment. In economic analyses of conservation projects, interest is usually expressed as an annual rate or a monthly rate. You can convert an annual rate to a monthly rate by dividing it by 12.

(iii) When reinvested, interest from invested capital will in turn become a part of the capital stock and will itself earn interest. This process is called compounding. With compounding, the earned interest in one period is immediately added in the subsequent period, resulting in a larger principal, on which an even larger amount of interest is earned for that period.

(iv) In order to compute a net present value, it is necessary to discount future benefits and costs. Discounting reflects the time value of money and is compounding in reverse. Discounting is the process of calculating the initial investment capital needed to generate a certain amount of future value. In standard analysis, benefits and costs are usually treated as if they are worth more if they are experienced sooner. When analyzing conservation practices, all future benefits and costs, including non-monetized benefits and costs, should be discounted. The higher the discount rate, the lower is the present value of future cash flows or non-monetized returns. For typical investments—with costs concentrated in early periods and benefits following in later periods—raising the discount rate tends to reduce the net present value.

(2) Real Versus Nominal Discount Rate

The proper discount rate to use depends on whether the benefits and costs are measured in real or nominal terms. A real discount rate is one that has been adjusted to eliminate the effect of expected inflation and should be used to discount constant-dollar or real benefits and costs. A real discount rate can be approximated by subtracting expected inflation from a nominal interest rate. A nominal discount rate that reflects expected inflation should be used to discount nominal benefits and costs. Market interest rates are nominal interest rates in this sense and should not be used in place of a real discount rate.

(3) Public and Private Investment

(i) Discount rates for either public or private investments should reflect the shadow price of capital, or the opportunity cost of money (i.e., the rate of return for the alternative best investment project), to evaluate benefits and costs. To define discount rates accurately, the analyst must be able to compute how the benefits and costs of a program or project affect the allocation of private consumption and investment.

(ii) When preparing an economic analysis for projects or programs with public investment, the analyst should use the appropriate discount rate from OMB Circular No. A-94, or a different discount rate approved by OMB. For NRCS water resource projects, one should use the currently approved discount rate for Federal water resource project analyses, which is issued each fiscal year by the U.S. Department of the Treasury.

(iii) The discount rate used for evaluating private investments should reflect the reality of the landowner or land user in question. When resources owned or borrowed by the landowner are committed to the implementation of a conservation option, the potential earnings of those resources in their best alternative use must be forgone. Therefore, the rate of return for the forgone alternative best investment project will be the appropriate discount rate.

(iv) When considering using a loan interest rate as discount rate, it is important to understand that loan interest rate is a nominal rate and it needs to be converted to real term before it can be used as a real discount rate.

(4) Other Discount Rates

(i) After performing an economic analysis with an appropriate discount rate as discussed above, the analysis should show the sensitivity of the discounted net present value and other outcomes to variations in the discount rate. The importance of these alternative calculations will depend on the specific economic characteristics of the conservation project or program under analysis.

(ii) Analyses may include among the reported outcomes the internal rate of return implied by the stream of benefits and costs. The internal rate of return is the discount rate that sets the net present value of the program or project to zero. While the internal rate of return does not generally provide an acceptable decision criterion, it does provide useful information, particularly when budgets are constrained or there is uncertainty about the appropriate discount rate.

610.23 Discounting Formulas

A. Basic Discounting Formulas

(1) Present Value

(i) There are four variables involved in discounting. They are the present value (PV) and future value (FV) of invested capital, the discount rate (r), and the number of investment periods (n). Any one of the four variables can be

calculated from the other three variables. For example, the present value formula is:

$$PV = FV \frac{1}{(1+r)^n} \tag{C-1}$$

(ii) This formula can be used to calculate the present value of any future cash flows.

(iii) Example: $4,000 will be needed 5 years from now. Assuming the interest rate is 10 percent, what is the amount of initial investment needed?

(iv) Using the present value formula, the present value of the future value is $4,000 / (1 + 10%) ^ 5 = $2,483.69.

(2) Future Value

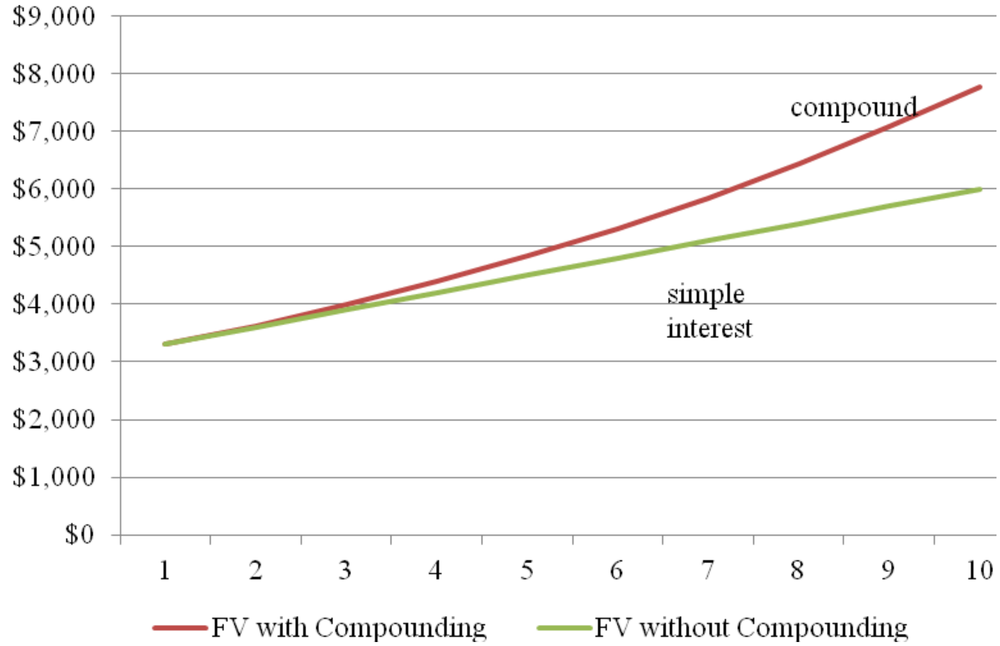
(i) Equation C-1 is the basic discounting formula. Several other formulas that are useful in DCF analysis can be derived from the basic discounting formula. Among them, formulas for future value, annuity, and capitalization are explained below.

(ii) Using the same notation as in equation C-1, the future value (or compounding formula) is:

$$FV = PV(1+r)^n \tag{C-2}$$

(iii) Example: For a $3,000 loan with 10-percent annual interest rate, what will be the total capital and interest at the end of 10 years? Using the future value formula, the borrower will need to pay $3,000 * (1 + 10%) ^ 10 = $7,781.23 at the end of 10 years, without paying anything before that. If the borrower pays all interest accrued each year, the simple interest formula applies. The total capital and interest the borrower will need to pay according to the simple interest formula is $3,000 + $3,000 * 10% * 10 = $6,000. See figure 610C-1 for a comparison of the capital accumulation process with compound interest and with simple interest in 10 years. The comparison shows the power of compounding. The difference of the two lines can be quite significant. A longer investment period will amplify the compounding effect.

Figure C-1 Comparison of Compound and Simple Interests over 10 Years



(iv) For time value of money calculations, you should always use compound interest. You must adjust the interest rate and the number of periods to be consistent with compounding periods. For example, a 6-percent interest rate, compounded semiannually for 5 years, should be entered as 3% (6 / 2) for 10 (5 * 2) periods. When using a calculator, a 6-percent interest rate is expected to be entered as the whole number 6, whereas formulas typically use a decimal value of 0.06.

(3) Annuity

(i) An annuity, or periodic constant payments, is defined as a "series of payments at fixed intervals, guaranteed for a fixed number of years or the lifetime of one or more individuals" such that the same level of cash flow occurs repeatedly over time at a fixed time interval. In the DCF analysis for conservation practices, certain cash flow items such as annual maintenance cost, and annual benefits may be the same over a certain period. The formulas for the future value and present value of annuity are (where FV is the future value, PV is the present value, A is the annuity, r is the interest rate, and n is the number of years since first payment):

$$FV = A\frac{(1+r)^n - 1}{r} \qquad \text{(C-3)}$$

$$PV = A\frac{(1+r)^n - 1}{r(1+r)^n} \qquad \text{(C-4)}$$

(ii) Example: A conservation project with a useful life of 10 years needs $75 annual maintenance fee. Assuming a 10 percent discount rate, what is the present value and the future value of the total annual maintenance fee of the project? Using the formula for the future value of annuity, the future value of the total maintenance fee at the end of the project is $75 * ((1 + 5%) ^ 10-1)/5% = $943.34. Using the formula for the present value of annuity, the present value of the total maintenance fee at the beginning of the project is $75 * ((1 + 5%) ^ 10-1)/(5%*(1+5%)^10) = $579.13. Note that the total cash flow of the maintenance

fee for 10 years is $75*10= $750, which is smaller than the future value and bigger than the present value of the annuity, demonstrating the power of compounding in the future value formula and the power of discounting in the present value formula.

(iii) Given the future value or present value of an annuity, the amount of an annuity can easily be derived from the two equations above.

$$A = FV \frac{r}{(1+r)^n - 1} \qquad \text{(C-5)}$$

$$A = PV \frac{r(1+r)^n}{(1+r)^n - 1} \qquad \text{(C-6)}$$

(iv) When the number of investment periods is infinitely large, equation C-4 reduces to:

$$PV = \frac{A}{r} \qquad \text{(C-7)}$$

(v) This is called the capitalization formula. Using the capitalization formula, we can calculate periodic constant land rents from the land value and the interest rate, or we can calculate the land value from periodic constant land rents and the interest rate. For example, if a piece of cropland with $50 per acre in annual net income is converted into a wildlife reserve, assuming a 5-percent discount rate, the farmer's lost land value with losing crop production on the land is $50/5 percent=$1,000/acre.

B. The Net Present Value (NPV) Criterion

(1) An NPV is the summation of all positive and negative present values for an investment project. This is the sum of the present values discussed above; namely, the present value of benefits minus the present value of costs. The NPV of a project is also called the net worth of the project. If N is the number of cash flows in a project, the formula for NPV is:

$$NPV = \sum_{i=1}^{N} \frac{FV_i}{(1+r)^i} \qquad \text{(C-8)}$$

(2) Note that this formula is the aggregated PV formula in equation C-1 with both the positive and negative cash flows of a project.

(3) An investment project is feasible if its NPV is positive. For two or more exclusive investment projects, the one with the highest NPV is the best choice. This is called the NPV criterion.

(4) In addition to the NPV criterion, there are other criteria that can be used for evaluating a conservation practice, which will be discussed later in this subpart. The NPV criterion is a better criterion than the internal rate of return for ranking investment decisions.

C. Internal Rate of Return

(1) An internal rate of return (IRR) is the discount rate that sets the NPV of a series of cash flows equal to zero over the period of analysis or specified time period. Some State agencies require calculation of the IRR in the analysis of proposed conservation projects.

$$IRR = r(NPV = 0) = r(\sum_{i=1}^{N} \frac{FV_i}{(1+r)^i} = 0) \qquad \text{(C-9)}$$

(2) To calculate the IRR of a project, set the NPV of the project to zero and solve for r, as the cash flow amounts and the years at which they occur are known variables.

(3) A simple example: Assume only one initial capital investment of $100 in conservation tillage for an expected conservation benefit of $120 at the end of the first year. The calculation of R could be: 120/(1+R) -100 = 0. Thus R = 120/100 – 1 = 1.20 – 1 = = 0.20, so the internal rate of return is equal to 20 percent. Note: Care must be taken when calculating IRR; there may be two solutions because i is solved for on both sides of the equation.

610.24 Excel Financial Functions

A. Microsoft Excel and other spreadsheets and financial calculators have many powerful financial functions that simplify financial analysis. We would like to introduce the five most common Excel financial functions that will be used in the investment analysis for conservation practices in this handbook. These functions are PV, FV, PMT, NPV, and IRR. We will cover the basics of these functions in this handbook. More details about these and other financial functions can be found in Excel Help. Once you are familiar with these five Excel financial functions, it will be easy for you to learn other Excel financial functions. Many “smart” “smart phones” also have free financial calculator apps with these basic financial functions available for download.

B. PV Function

(1) PV (rate, nper, pmt, fv, type)

(i) Rate.—The interest rate per period.

(ii) NPER.—The total number of payment periods in an annuity.

(iii) PV.—Specifies the present value, or the total amount that a series of future payments is worth now; also known as the principal.

(iv) PMT.—The payment made each period and cannot change over the life of the annuity. Typically, pmt includes principal and interest but no other fees or taxes. For example, the monthly payments on a $10,000, 4-year car loan at 12 percent are $263.33. You would enter -263.33 into the formula as the pmt. If pmt is omitted, you must include the fv argument.

(v) FV.—Specifies the future value, or a cash balance you want to attain after the last payment is made. If omitted, 0 is assumed.

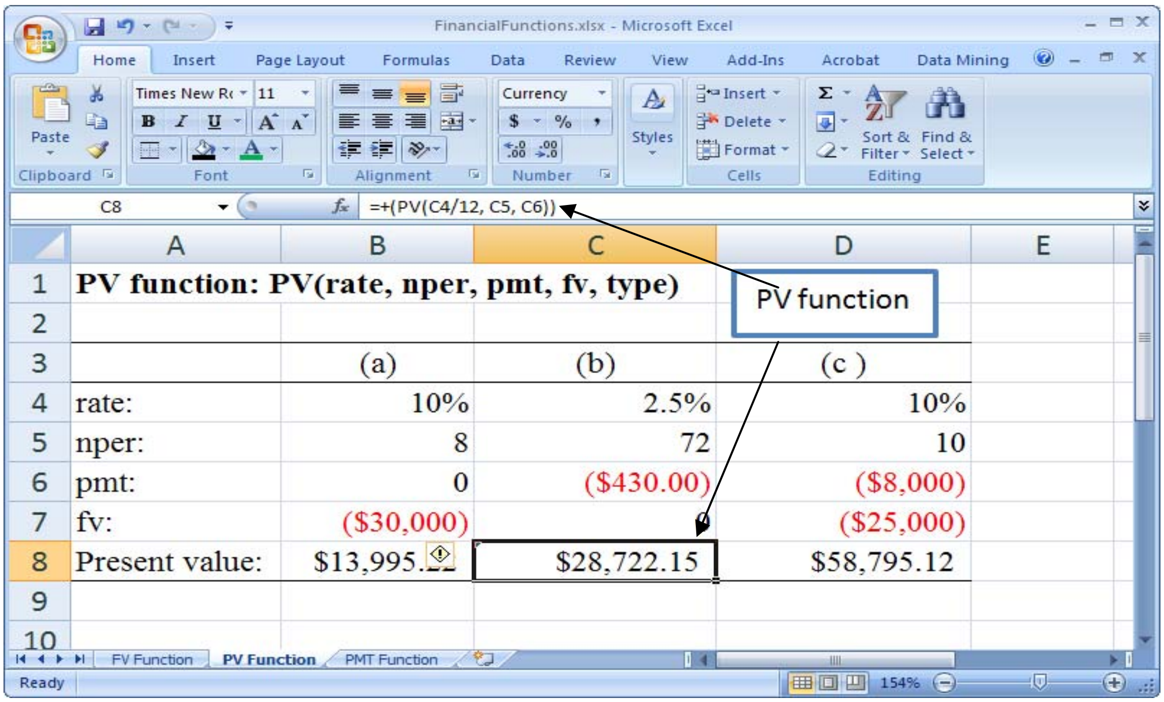
(vi) Type.—Enter 0 if payments are due at the end of the payment period, or 1 if payments are due at the beginning of the period. If omitted, 0 is assumed.

(vii) The PV function can be used for calculating an annuity or periodic constant payments for a present value, future value, or both. We will use the following three examples to demonstrate the three situations:

- Example: Use the PV function to calculate the amount of principle needed to generate $30,000 by the end of 8 years, assuming a 10-percent annual rate of return. The PV function takes the form: “=PV (10%,8,0,-30000)”. Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $13,995.22. This is the total capital needed to generate the future value (figure 610C-2a).
- Example: Use the PV function to calculate the amount of loan principle for a monthly payment of $430, with 2.5-percent annual interest rate for 6 years. The PV function takes the form: “=PV (2.5%/12, 6*12, -430)”. Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $28,722.15. This is the total capital for the monthly payments (figure 610C-2b).

- Example: Use the PV function to calculate the present value of an investment project with an annual payment of $8,000 for 10 years and a one-time payment of $25,000 by the end of the project, assuming a 10-percent discount rate. The PV function takes the form: "=PV (10%,10,-8000,-25000)". Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $58,795.12. This is the total capital needed to generate all the payments in the example (figure 610C-2c).

Figure C-2 Examples Using PV Function



(2) Note that the invested money is negative in the PV function. In Excel financial functions, a negative number means money paid out or invested, and a positive number means money received or entitled. This arrangement could be convenient in some settings, but troublesome in others. If necessary, we can use the ABS function to return the absolute value of a financial function. For example, "=ABS (PV(10%,10,8000,25000))" will generate the same positive value as using a negative pmt and fv value in the example above.

C. FV Function

(1) FV (rate, nper, pmt, pv, type)

(i) RATE.—The interest rate per period. For example, if you obtain a car loan at a 10-percent annual interest rate and make monthly payments, your interest rate per month is 10%/12, or 0.83 percent. You would enter 10%/12, or 0.83%, or 0.0083, into the formula as the rate.

(ii) NPER.—The total number of payment periods in an annuity. It needs to be an integer number. For example, if you get a 4-year car loan and make monthly payments, your loan has 4*12 (or 48) periods. You would enter 48 into the formula for the number of payments.

(iii) PMT.—The payment made each period and cannot change over the life of the annuity. Typically, pmt includes principal and interest but no other fees or taxes. For example, the monthly payments on a $10,000, 4-year car loan at 12 percent

are $263.33. You would enter -263.33 into the formula as the pmt. If pmt is omitted, you must include the pv argument.

(iv) PV.—Specifies the present value, or the total amount that a series of future payments is worth now; also known as the principal. For example, when you borrow money to buy a car, the loan amount is the present value to the lender of the monthly car payments you will make. If omitted, 0 is assumed.

(v) TYPE.—Enter 0 if payments are due at the end of the payment period, or 1 if payments are due at the beginning of the period. If omitted, 0 is assumed. For consistency and simplicity, we assume all payments are due at the end of the payment period and omit this variable in all Excel functions.

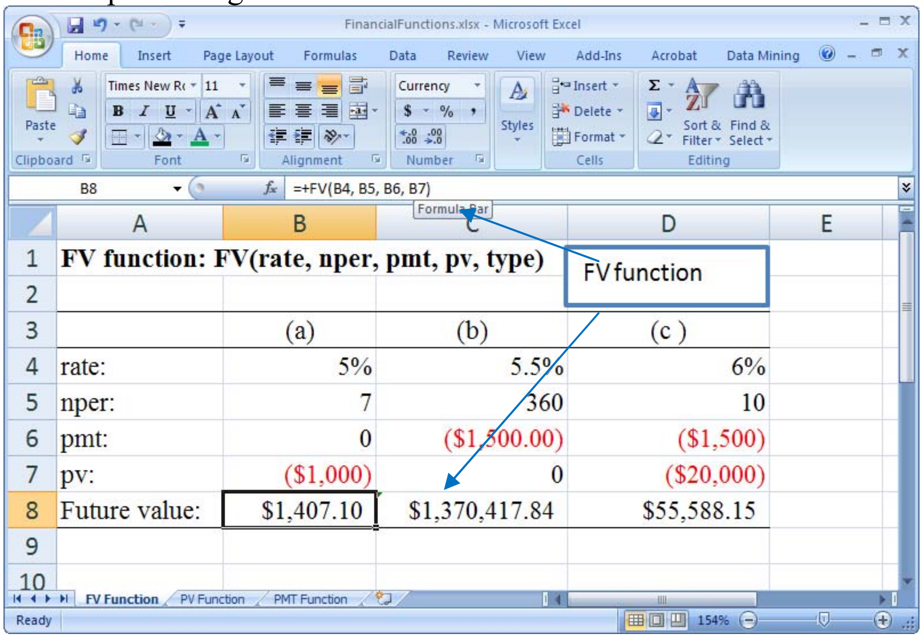
(2) The FV function can be used for calculating the future value of a one-time investment, an annuity, or both. We will use the following three examples to demonstrate the three situations:

(i) Example: Use the FV function to calculate the future value of a one-time investment of $1,000, at 5-percent annual interest rate, for 7 years. The FV function takes the form: "=FV(5%,7,0,-1000)". Copy everything inside the quotation marks into an Excel spreadsheet cell; the FV function returns a value of $1,407.10. This is the total capital and interests that the investor should receive by the end of the investment period (figure 610C-3a).

(ii) Example: Use the FV function to calculate the total future value of a mortgage payment of $1,500 per month, at 5.5-percent annual interest rate, for 30 years. The FV function takes the form: "=FV(5.5%/12, 30*12, -1500)". Copy everything inside the quotation marks into an Excel spreadsheet cell; the FV function returns a value of $1,370,417.84. This is the future value of all mortgage payments. It is equivalent to the total amount that the mortgagee would have received by the end of the mortgage term if he or she had put the same monthly payment into an investment account with the same interest rate (figure 610C-3b).

(iii) Example: Use the FV function to calculate the future value of a conservation practices with $20,000 installation cost and $1,500 annual maintenance cost, at 6-percent annual discount rate, for 10 years. The FV function takes the form: "=FV (6%, 10, -1500, -20000)". Copy everything inside the quotation marks into an Excel spreadsheet cell; the FV function returns a value of $55,588.15. This is the future value of all investment payments in the project (figure 610C-3c).

Figure C-3 Examples Using FV Function



D. PMT Function

(1) PMT(rate,nper,pv,fv,type)

(i) Rate.—The interest rate per period.

(ii) NPER.—The total number of payment periods in an annuity.

(iii) PV.—Specifies the present value, or the total amount that a series of future payments is worth now; also known as the principal.

(iv) FV.—Specifies the future value, or a cash balance you want to attain after the last payment is made. If omitted, 0 is assumed.

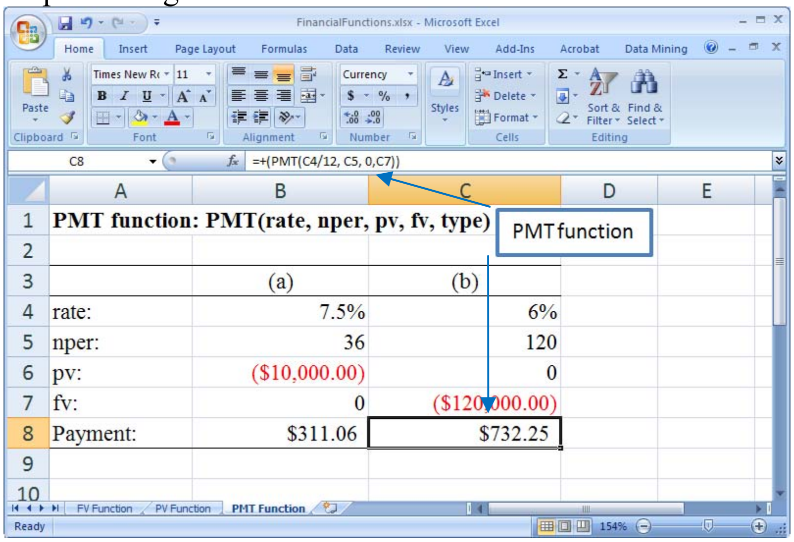
(v) type.—Enter 0 if payments are due at the end of the payment period, or 1 if payments are due at the beginning of the period. If omitted, 0 is assumed.

(2) The PMT function can be used for calculating the constant payments for a loan principle or a certain future amount desired. We will use the following two examples to demonstrate both situations:

(i) Example: Use the PMT function to calculate the monthly payments for a $10,000 loan, assuming a 36 month term for the loan with an annual interest rate of 7.5 percent. The PMT function takes the form: “=PMT(7.5%/12,36,-10000)”. Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $311.06. This is the monthly payment for the loan (figure 610C-4a).

(ii) Example: Use the PMT function to calculate the constant monthly investment needed for a $120,000 college fund in need 10 years from now, assuming a 6 percent rate of return on the investment. The PMT function takes the form: “=PMT(6%/12, 10*12, 0,-120000)”. Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $732.25. This is the constant monthly payment for the future fund (figure 610C-4b).

Figure C-4 Examples Using PMT Function



E. NPV Function

(1) NPV (rate, value1, value2, ...)

RATE: The discount rate over the investment period. Value1, value2, are values representing positive and negative cash flows. Value1, value2, must be equally spaced in time and occur at the end of each period.

(2) The NPV function returns the net present value of a series of future cash flows in an investment project. The setup of the cash flows for applying the NPV function must follow three rules:

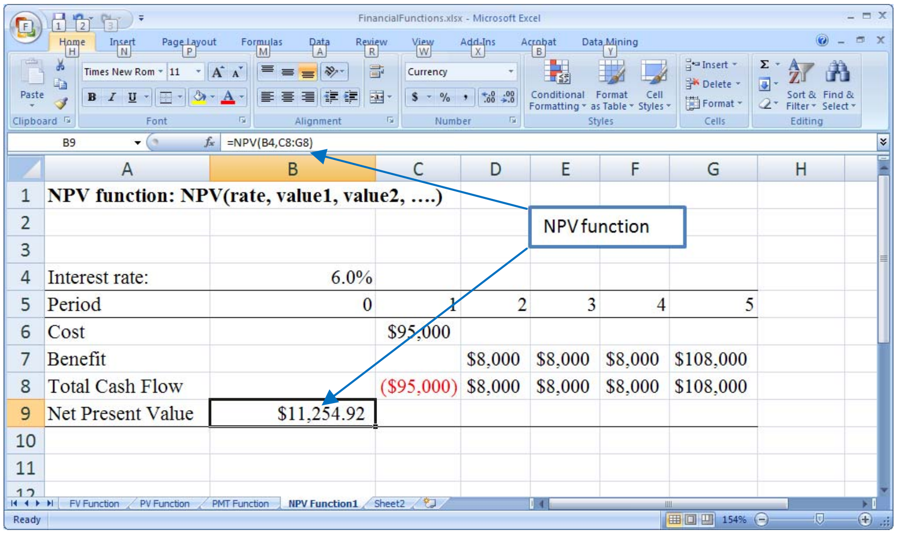
(i) Benefits are represented by positive cash flows and costs are represented by negative cash flows;

(ii) The NPV function uses the order of value1, value2, to interpret the order of cash flows. Cash flows must be equally spaced in time. If there is no cash flow during a period in the investment project, the period should still be included and use 0 as a place holder.

(iii) The investment begins one period before the date of the value1 cash flow and ends with the last cash flow in the list. If your first cash flow occurs at the beginning of the first period, the first value must be added to the NPV result, not included in the values arguments.

(3) Example: Suppose that Susan's son Eric is going to college 1 year from now and Susan is considering buying a condo 1 year from now for Eric to live in during his 4-year college and selling it afterwards. The purchase price of the condo 1 year from now is $95,000 and its expected selling price 5 years from now is $100,000. By living in the condo, Eric will avoid paying $8,000 in annual rent for an apartment for 4 years. The mortgage rate is 6 percent, which will be used as the discount rate in this case. Use the NPV function to analyze the financial feasibility of the investment project. The NPV function takes the form: "=NPV(6%, -95000, 8000, 8000, 8000, 108000)". Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $11,254.92. This is the NPV of the project. The positive NPV of the project shows that purchasing the condo is a worthwhile investment in comparison with renting. See figure 610C-5, which shows how the setup follows the three rules of applying the NPV function.

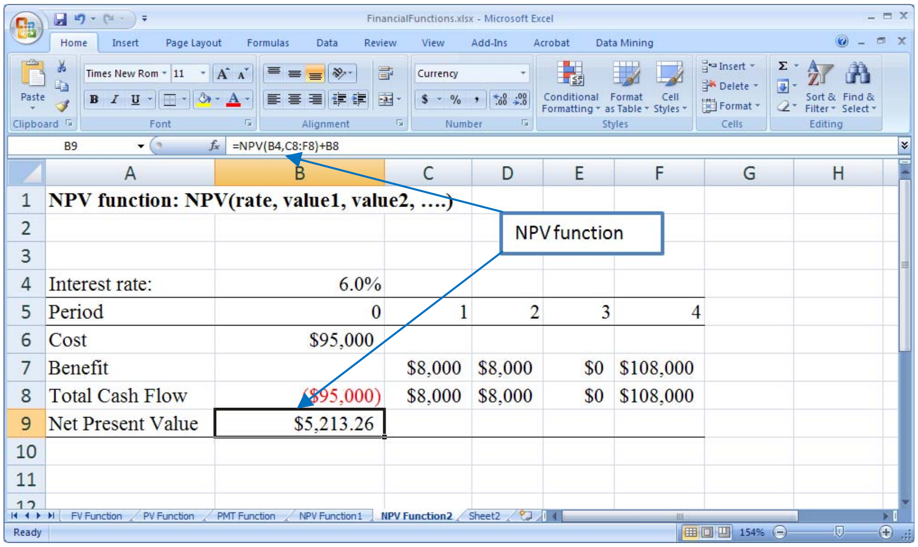
Figure C-5 Example No. 1 Using NPV Function



(4) Example: Suppose that Susan's son Eric is going to college now, rather than a year from now. Again, Susan is considering buying a condo immediately for Eric to live in during his 4 years of college and selling it afterwards. The purchase price of the condo today is $95,000 and its expected selling price 5 years from now is $100,000. By living in the condo, Eric will avoid paying $8,000 in annual rent for years 1, 2, and 4. Eric will be participating in an exchange student program in another city during his third year of college, and the condo will not be occupied during that year. The mortgage rate is 6 percent, which will be used as the discount rate in this case. Use the NPV function to analyze the financial feasibility of the investment project. The NPV function takes the form: "=NPV(6%, 8000, 8000, 0, 108000) -95000". Copy everything inside the quotation marks into an Excel spreadsheet cell; the function returns a value of $5,213.26. This is the NPV of the project. The positive NPV of the project shows that purchasing the condo is a worthwhile investment comparing to renting (figure 610C-6).

(5) There are two important differences between these two NPV examples. In the first example, the purchase cost of the condo occurs at the end of year 1 and thus is included inside of the NPV function. However, in the second example, the purchase cost of the condo occurs at the end of year 0 (now), and is added on outside of the NPV function. Also, the second example, although the avoided rent in year 3 is zero, we still need to include the value zero in the NPV function as a placeholder for year 3. Otherwise, the function would not know the $108,000 occurs in year 4, which would lead to a wrong result.

Figure C-6 Example No. 2 Using NPV Function



F. IRR Function

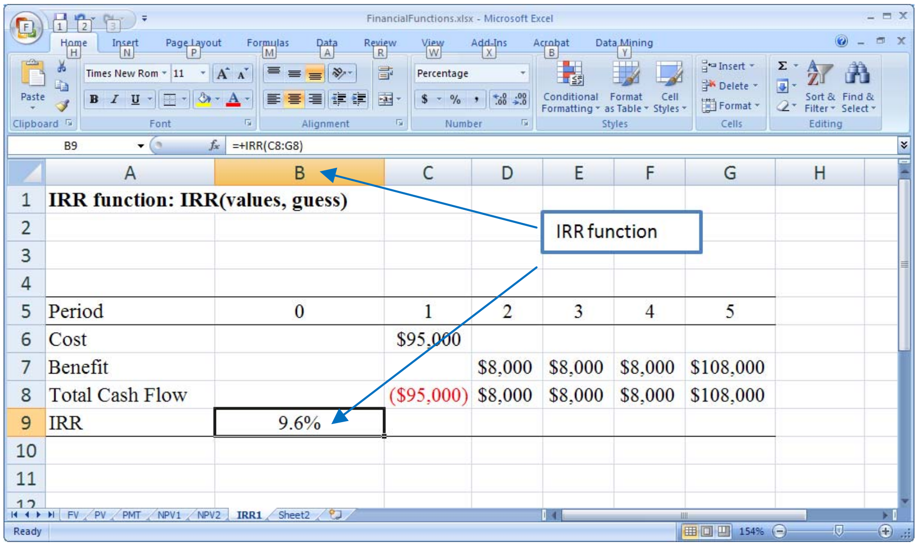
(1) IRR (values, guess)

(i) Values.—An array of positive or negative cash flows. Values must be equally spaced in time and occur at the end of each period and must contain at least one positive value and one negative value to calculate the internal rate of return.

(ii) Guess.—A number that you guess is close to the result of IRR. It is for assisting Excel in its iterative technique for calculating IRR. In most cases you do not need to provide guess for the IRR calculation. If guess is omitted, it is assumed to be 0.1. If IRR gives the #NUM! error value, or if the result is not close to what you expected, try again with a different value for guess.

(2) The IRR function provides the internal rates of return for a series of income or cash flows represented by the numbers in values. An IRR is the rate for which the NPV equals zero: NPV(IRR(), ...) = 0, or IRR()=r(NPV()=0). As is the case with the NPV function, these cash flows do not have to be even, but they must occur at the equal intervals, such as annually, monthly or daily. The resulting IRR will be at the same time intervals. For example, if you use annual cash flows, you will receive a annual IRR; and if you use monthly cash flows, you will receive a monthly IRR. You may convert monthly IRR to annual IRR by multiplying 12. Figure 610C-7 shows the calculation of an IRR for example no.1 showing in figure 610C-5.

Figure C-7 An Example Using IRR Function



610.25 Discount Factors

A. The standard compounding and discounting formulas and the Excel financial functions provide two methods for calculating the compounding or discounting effects of cash flows. In addition to these two methods, there is a third method for finding unknown cash flows and financial variables. In this method, various financial terms are converted from one form to another by means of "discount factors" as shown in figure 610C-8. For example, a PV can be converted to a FV by multiplying the PV by the applicable discount factor, which in this case is 1.6289. Each conversion factor is derived by one of six unique equations, also shown in figure 610C-8, in which the interest rate and period of investment are key terms. One may observe that each of equations C-1 to C-6 includes the interest rate and period of investment term $(1 + r)^n$ on its right-hand side. The right-hand terms of the six standard financial equations are used to calculate the conversion factors. Assuming that the converting-from variable is X and the converting-to variable is Y, and the discount factor is d, then the relationship between the variables is the following:

Y=X*d

B. If the value of d can either be obtained from a standard discount factor table or be easily calculated using a calculator or a spreadsheet (based on the interest rate and the period of investment), then the exercise of compounding or discounting becomes a straightforward multiplication problem as shown in the above equation. The table below includes all six discount factors and their calculation formulas (with r=5% and n=10), corresponding to equations C-1 to C-6.

Figure C-8 Discount Factors

Fund Type	Value Conversion	Discount Factor Value (d)	Discount Factor Formula	Discount Factor Formula in Excel©
One-time	FV → PV	0.6139	$(1+r)^{-n}$	=PV(r,n,0,-1)
One-time	PV → FV	1.6289	$(1+r)^{n}$	=FV(r,n,0,-1)
Annuity	A → PV	7.7217	$((1+r)^{n}-1)/(r(1+r)^{n})$	=PV(r,n,-1)
Annuity	A → FV	12.5779	$((1+r)^{n}-1)/r$	=FV(r,n,-1)
Annuity	PV → A	0.1295	$r(1+r)^{n}/((1+r)^{n}-1)$	=PMT(r,n,-1)
Annuity	FV → A	0.0795	$r/((1+r)^{n}-1)$	=PMT(r,n,0,-1)

A calculator in the form of the table above is available in an Excel workbook on the NRCS Web site. The calculator computes discount factors automatically with the changes of interest rate and number of investment periods. Discount factor tables with common interest rates and investment periods are also available in the same Excel workbook for printing.

Subpart D - Evaluation Techniques

610.30 Introduction

This subpart discusses partial budget analysis as the most common analytical framework for economic analysis of resource conservation. It describes several evaluation techniques in the partial budget analysis framework that can be used for economic analysis of conservation programs and projects. These techniques include net present value criteria, break-even analysis, cost effectiveness, marginal analysis, conservation effects for decisionmaking, and economic threshold analysis, among others.

610.31 Partial Budgeting

A. Types of Budgets

(1) A budget is a planned list of future revenue and expenses. Budgeting is the process of creating a budget. A farm budget is fundamental to any financial analysis of a farm operation. Although NRCS planners are advised to avoid delving into the financial details of cooperating producers, budgeting at multiple levels can be a very important evaluation tool in conservation planning for making sound conservation decisions.

(2) A farm budget can range in scope from a total budget that covers the planned revenues and expenses of an entire farm, to an enterprise budget that covers the planned revenues and expenses of a particular farm operation, such as a row crop (corn), forage and hay, grains and oilseed, herbs and specialty crops, livestock (dairy), etc., to a partial budget that only considers the planned revenues and expenses related to specific changes in a farm operation for a particular purpose. NRCS economists and planners do not usually engage in total budget or enterprise budget analysis. Partial budget analysis is the default choice of economic analysis of resource conservation. However, understanding of total budget and enterprise budget analysis serves at least two purposes:

(i) Conservation systems are a integral part of farm operation and thus total budget and enterprise budget analysis are relevant to analysis for conservation planning in certain situations as explained below.

(ii) Published information on total budget or enterprise budget analysis—cooperative extension crop budgets, in particular—can provide valuable inputs to partial budget analysis for resource conservation. All three types of budgets are tools for farm management and are relevant to conservation planning. A total budget can be relevant to conservation planning for even one practice because of the potentially important spillover effects to other parts of the farm. For example, some farmers have found that converting to no-till residue management saves them so much time that they can start a new off-farm business. The new off-farm business has implications for the whole farm financial picture. Thus, when looking at even one conservation practice, it might be important to keep the total farm in mind.

(3) Enterprise budgets can be relevant because conservation practices are usually implemented within farm enterprises. For example, the practice Residue and Tillage Management, No-till/Strip Till/Direct Seed (329) is implemented within a crop enterprise, and Forage and Biomass Planting (512) is implemented within a livestock enterprise. Thus, during conservation planning we need to consider not only the cost of installing and maintaining the practice, but also the impact that the practice could have on the enterprise within which it is installed. To do so, it is critical to be knowledgeable about the typical revenues and costs of the enterprise. These can be identified by developing an enterprise budget.

(4) A partial budget is the most common type of budget used in conservation planning. Only the changes in benefits and costs directly related to a conservation practice or set of practices are considered in a partial budget for conservation planning. This technique simplifies data collection and analysis while simultaneously examining how the benefits and costs of a conservation practice or set of practices stack up against each other. It also simplifies the process of determining the potential change in net farm income that would be caused by the proposed change in operations.

(5) Because of the importance of budgeting in farm decisionmaking, agricultural cooperative extension programs, land grant universities, and private vendors have produced many farm budgets that represents typical revenues and expenses for different farm operations within a defined geographical area. Many enterprise crop budgets are available to the public on the web, making them easy to use in the budgeting process for conservation planning. It is easy to find crop budget information on the Web for any specific State by combining the State’s name with search key words such as “crop enterprise budget,” “farm enterprise budget,” or “farm partial budget ” in any standard Internet search engine. Figure 610D-1 is one example of the types of crop budgets provided by Cooperative Extension Service programs to assist farmers in evaluating their own production enterprises. Enterprise budgets such as this one are usually designed in such a way as to facilitate easy updating of key variables over time as market and resource conditions change within a local or regional area.

Click here for a copy of Figure 610D-1: Enterprise Budget

B. Partial Budgeting: Net Present Value Criteria

(1) A Partial Budget Template

Partial budgeting for conservation planning helps to answer such questions as how much will—

The conservation practice or practices cost?
Revenues change as a result of implementing a conservation practice or practices?
Net income change?

(2) Figure 610D-2 is a partial budget worksheet template showing how to display the changes in revenues and costs associated with one or more planned conservation practices. Figure 610D-2 has two columns, with the left-hand column for positive effects and the right-hand column for negative effects of the conservation practices under consideration. The positive effects of a conservation practice include any expected additional revenues and reduced costs, and the negative effects include additional costs and reduced revenues. The expected change in net income is the difference between the positive and negative effects and is displayed at the bottom of the table.

Click here for a copy of Figure 610D-2: Partial Budget Worksheet Template

(3) A Partial Budget Example

(i) Buy or rent problem: A farmer has made the decision to convert from conventional tillage to no-till cultivation of 600 acres of cropland. A seeding drill is needed for no-till operations. The farmer can either rent a drill or buy a new drill. The rental cost for a drill is $7.50 per acre. A new drill would cost $24,000, with a useful life of 10 years and a residual value of $4,000. The same tractor would be used to pull either drill so there will be no change in tractor costs. Annual repairs on the purchased drill are estimated at $300, and taxes and insurance will be about $50 per year. Should the farmer purchase the new drill? (Purchasing would be the change.)

(ii) An example of partial budgeting used to answer the buy or rent problem is shown in Figure 610D-3. Figure 610D-3 uses the partial budget template in figure 610D-2 with an additional time dimension. The analysis in figure 610D-3 shows that the net present value of the purchasing decision is -$42.22. This means that the farmer is better off renting instead of buying a new drill. The IRR of the purchasing decision is 9.96 percent, which is smaller than the discount rate of 10 percent. The conclusion from the IRR is consistent with that of the NPV analysis.

Click here for a copy of Figure 610D-3: Buy or Rent Example

610.32 Partial Budgeting: Break-Even Analysis

A. Method

(1) Economic evaluation of conservation alternatives produces information that can be used by decisionmakers to determine the feasibility of the alternatives or to determine the most desirable alternative. In any evaluation, four variables must be considered:

(i) Cost of installation, including operation and maintenance
(ii) Benefits from the alternative
(iii) The time period during which the alternative will be evaluated
(iv) The interest rate used for the evaluation

(2) If all four variables are known, the benefits from an alternative can be compared to the cost of the alternative to determine its feasibility. If three variables are known, the fourth variable can be calculated by setting the net present value of the project to zero. This is called break-even analysis.

(3) Break-even analysis provides useful information when small changes in specific conservation situations are being evaluated. This technique can be used to determine how much of an investment can be made based on the expected returns. Examples of break-even questions include the following:

(i) How much can I afford to spend, or what is the break-even cost?
(ii) How much should I gain to justify the spending, or what is the break-even benefit?
(iii) How long will it take to get my money back, or what is the payback period?
(iv) What rate of return will I receive, or what is the internal rate of return?

B. Break-Even Examples

(1) Example: Break-Even Cost

How much can a rancher afford to spend on a stock water development if the trough life is 20 years, the interest rate is 8 percent, and the value of the increase in animal unit months (AUMs) produced each year is $140?

Solution: Using Excel PV function, the breakeven cost = PV(8%, 20, -140) = $1374.54. The answer can be calculated by multiplying the value of the annual benefit with the present value of an annuity of 1 for an 8-percent discount rate in a 20-year period: $140 x 9.818. The rancher will profit from the stock water development at any cost below the breakeven cost of $1,374.54.

(2) Example: Break-Even Benefit

For the same project as in example 1, what must an AUM be worth to break-even when the

capital cost is $1,400, the evaluation period is 20 years, and the benefits are discounted at 11-percent interest rate, assuming the annual AUM production from the project will be 20 AUMs.

Solution: Using Excel PMT function, the break-even annuity = PMT (11%, 20, -1400) = $175.81. The unit price per AUM = $175.81/20 = $8.82/AUM. The same annual AUM value can be calculated by multiplying the capital cost with the amortization factor for an 11-percent discount rate in a 20-year period: $1,400 x 0.126. Unit price of AUM: $175.81/ 20 = $8.82 per AUM

(3) Example: Break-Even Time (Payback Period)

What is the period of capital recovery or minimum life expectancy for the proposal if the capital cost is $1,000, an 8-percent interest rate is used, and the value of the change in AUMs produced is $120 per year?

Solution: Using Excel NPER function, the break-even period = NPER(8%, 120, -1000) = 14.3 years. Therefore, the break-even time is about 14.2 years.

(4) Example: Break-even discount rate (internal rate of return):

What is the break-even discount rate or internal rate of return when capital cost is $1,000, the effects are evaluated over a 20-year period, and the value of the change in AUMs produced is $180 per year?

Solution: Using Excel RATE function, the break-even discount rate = RATE (20, 180, -1000) = 0.173, or 17.3 percent. Therefore, the break-even discount rate is 17.3%.

610.33 Partial Budgeting: Cost-Effectiveness Approach

A. Cost-effectiveness analysis is an appraisal technique used when benefits cannot be reasonably measured in monetary terms and all alternatives deliver the same benefit stream. The alternative that achieves the stated objectives at the least cost is the most cost-effective alternative.

B. It can be used in two forms:

(1) The constant effect method, which uses least-cost analysis to determine the alternative for meeting a stated level of benefits, including intangible benefits.
(2) The constant-cost method, which calculates the cost per unit of benefit, or the cost-effectiveness ratio. This method requires that it is possible to quantify benefits (but does not necessarily require attaching a monetary price or economic value to benefits).

C. If an analysis is used to determine the most cost-effective means of generating conservation benefits among optional technologies, it is most often in the form of the constant effect method and is called the "least-cost analysis." In such a case, a measure of a project's dollar value is impossible to obtain from cost-effectiveness analysis because the analysis is done without reference to the monetary value of benefits.

Example: Computing Present Value of Total Costs With Lifecycle Cost Analysis
(i) Problem.—Determine the least-cost alternative.
(ii) Situation.—Two alternatives are being considered to provide pressurized water at a given point: either a pump and motor, or a gravity-pressurized pipeline, each with a 20-year life expectancy. The installation cost (capital cost) of the pump and motor is estimated to be $5,000 and of the gravity pipeline, $14,000. The average annual operation and maintenance (O&M) cost for the pump and motor is estimated to be $1,000, and for the gravity pipeline, $300, at today's price level.
(iii) Questions.—When compared over a 20-year life at a 7-percent real discount rate, which is the least-cost alternative? If the real discount rate used is 3 percent, which is the least-cost alternative? What general conclusions can we draw from this example?
(iv) Solutions.—Compute the present value of total costs using lifecycle cost analysis to determine the least-cost alternative.

D. To determine which option is the least-cost, the pump and motor or the gravity-pressurized pipeline, the installation and average annual O&M costs of each must be considered on a common time base using their present values. The installation costs are already in present value form. The present value of O&M costs can be calculated using the Excel PV function. The present value of the total cost can be determined by adding together the present values of the installation costs and the O&M costs. When the present value of the total cost at a given discount rate has been determined for each option, a comparison will reveal which is the least-cost means of providing equal service. It is important to understand that an economic comparison of costs to determine the least-cost option is only valid when each option provides the same level of service or output.

Click here for a copy of Figure 610D-4: Computing Present Value of Total Cost Using Lifecycle Cost Analysis

(1) Conclusion.—As shown in figure 610D-4, when comparing the two options over 20 years at a 7-percent real discount rate, the present value of total costs for the pump and motor option is $15,594, and the present value of total costs for the gravity-pressurized pipeline option is $17,178. Therefore, the pump and motor option is less costly than the gravity-pressurized pipeline option. When the options are evaluated at a 3-percent real discount rate, their relative

costs change. The present value of total costs for the pump and motor option is $19,877 and the present value of total costs for the gravity-pressurized pipeline option is $18,463. The gravity-pressurized pipeline option becomes the least-cost option among the two options.

(2) General Conclusions.—High discount rates tend to push decisionmakers away from higher installation costs in favor of higher operation and maintenance costs. Low discount rates tend to do the opposite, by making one-time installation costs look relatively more favorable than recurring annual operation and maintenance costs. Viewed from another perspective, high discount rates tend to move decisionmakers away from options that require large and relatively irreversible commitments and toward operations with low initial commitment and high flexibility for change. Low discount rates indicate more expected stability in future economic conditions and therefore make large initial commitments more comfortable for decisionmakers. Note that real discount rates—rather than nominal discount rates—are being used in this analysis because it is difficult to project inflation over a 20-year period. Thus, the average annual operation and maintenance costs are estimated at their current value. When costs and benefits are in real terms, discount rates need to be in real terms as well.

610.34 Partial Budgeting: Marginal Analysis Method

A. Marginal analysis is the analysis of the change in one variable when a small change is made in another variable. One of its applications is the marginal physical product. This is the amount by which production changes when a small change is made in one input with all other inputs being held constant. For instance, one could measure how the use of different amounts of fertilizer affects wheat production. Marginal analysis is an important concept underlying many economic analyses. "On (or at) the margin" refers to a small change in the total of some input or in production.

B. This approach is often used to find a conservation alternative to improve a benchmark resource condition. The process sometimes involves first developing a wide range of alternatives and then comparing the differences between the incremental benefits of implementing the various conservation alternatives to the incremental differences among the costs of those alternatives. Additional conservation activities should only be considered for implementation if their incremental benefits exceed incremental costs. In other words, beyond the minimum necessary treatment, any additional costs are to be incurred only if offset by equal or greater additional benefits. Therefore, in formulating a conservation system composed of several separable practices, each practice should be examined to determine whether that practice—in and of itself—provides positive net benefits.

Example:

(i) A farmer is thinking about switching from conventional tillage to a no-till system on 1000 non-irrigated acres where he currently runs a wheat/safflower rotational cropping system. He is curious as to how the change would affect his annual costs for diesel fuel and engine oil during the wheat years in his crop rotation.

(ii) During one year of the farmer's conventional wheat rotation, he runs five passes across the field with his 200 HP tractor, four passes for tillage operations and one pass for planting. By his calculations, it costs him $5.80 in tractor fuel and oil per acre per pass. In addition, he makes one pass per year across his field with his self-propelled boom sprayer, which by his calculations costs $0.11 in fuel and oil expenses per acre. If he switches to no-till using the type of drill he would like to purchase, he will have to upgrade his tractor to a 300 HP model. He calculates that it will cost $11.92 per acre in fuel and oil to run the new tractor pulling the no-till drill. If he switches to no-till, he also expects that to successfully suppress weeds, he will have to increase the number of passes per year with his boom sprayer from one pass to five passes.

Conventional Fuel & Oil Expenses = ($5.80 x 5 passes x 1000 AC) + ($0.11 x 1 pass x 1000 AC) = ($29,000 + $110) = $29,110

No-till Fuel & Oil Expenses = ($11.92 x 1 pass x 1000 AC) + ($0.11 x 5 passes x 1000 AC) = ($11,920 + $550) = $12,470

Marginal Change in Fuel & Oil Costs = -$16,640

(iii) In this example, the marginal difference between conventional tillage and no-till operations in annual fuel and oil costs during the wheat years in the farmer's crop rotation is a decrease of $16,640.

610.35 Partial Budgeting: Economic Thresholds

A. Integrated pest management (IPM) is an approach to pest control that combines biological, cultural, and other alternatives to chemical control with judicious use of pesticides. The objective of IPM is to reduce pest infestation below a level that can cause economic damage while simultaneously minimizing the harmful effects of pest control on human health and environmental resources.

B. A key principle of IPM is that pesticides should only be used when field examination or "scouting" shows that infestations exceed economic thresholds. The economic threshold occurs when the levels of pest population, if left untreated, would result in reductions in revenues that exceed treatment costs.

C. The point at which an input starts to pay for itself is called the economic threshold. Economic

thresholds can assist farmers and ranchers in making decisions about pesticide application. Undesirable weeds and insects can cause major injury to a crop. A small amount of injury may be tolerable if it does not significantly affect crop yields and, consequently, does not significantly affect revenues gained from selling the crop. Nevertheless, if the presence of pests is considered to affect crop yields, decisions about using pesticides must be based on whether the cost of treating with pesticides is less than the value of expected crop yield losses.

D. Economic Threshold Example: Insecticides

(1) The insecticide economic threshold is the point at which expected crop damage from insects is high enough that insecticide control costs equal the value of the expected yield losses due to the insects. The following example demonstrates how the economic threshold method can be used to assess the need to apply insecticide in corn where the European corn borer is the target species.

(2) Example: An average of one borer per plant is estimated to cause a 5-percent yield loss. Scouting the field finds about two worms per plant. Application of an insecticide would provide 75-percent control. Chemical and application costs are $12 per acre. Expected yield is 125 bushels per acre, with an expected market price of $6.50 per bushel.

(i) Potential yield loss per acre = 125 bushels x 10%(2 borers/plant) = 12.5 bushels

(ii) Expected value of loss per acre = 12.5 bushels x $6.50 = $81.25

(iii) Preventable value of loss per acre = 75%x $81.25 = $60.94

(iv) In this example, the net gain per acre from insecticide treatment would be $48.94 ($60.94 - $12). Therefore, it would be advantageous to treat the field. Had the treatment costs exceeded $60.94 per acre, then treating the field would have resulted in greater economic losses than would result from not treating.

(v) According to surveys conducted by the USDA Economic Research Service, scouting and threshold use are widespread in the production of specialty crops such as fruits, vegetables, nuts, and potato.

E. Economic Threshold Example: Herbicides

(1) The herbicide economic threshold is the point at which weed density is high enough that herbicide control costs equal the value of the expected lost yields due to weed density. If a specific herbicide is applied on a field where the threshold is not reached, then excess costs are incurred. For example, if the expected yield loss due to weeds is $12 per acre and herbicide costs are $18 per acre, then this could result in $6 per acre in unnecessary costs.

(2) The following suggests a method that can be used to evaluate the need to apply herbicide (economic threshold) in corn. The following information is required:

(i) Expected crop yield

(ii) Expected crop market price

(iii) Densities of weeds in the field by species and expected yield loss (sources of yield loss information include Extension Service, agricultural research institutes, producer's experience, etc.)

(iv) Cost of herbicide treatment (chemical and application)

(3) Example

A cornfield has an average of 6 giant ragweed, 24 pigweed, and 10 giant foxtail plants per 100 feet of row. Expected yield losses as the result of the weeds are 1.5 percent (interpolated), 2 percent, and 1 percent respectively, for a total of 4.5 percent. If the expected yield is 120 bushels per acre and the expected price is $6.50 per bushel, then the potential yield loss would be $35.10 per acre (4.5% x 120 bushels x $6.50 = $35.10). If herbicide treatment costs were less than $35.10 per acre, then treatment would be justified. If herbicide treatment costs are greater than $35.10 per acre, then additional costs could be avoided if the herbicide were not applied at this time.

610.36 Sensitivity Analysis

A. Evaluating assumptions

(1) A sensitivity analysis is conducted to test the effects of changing any assumptions that were made while evaluating the impacts of implementing a conservation system. Sensitivity analyses can be used to systematically test what happens to the feasibility of a conservation plan if the initial assumptions are altered. It is a means of identifying the vulnerability of the success of a conservation system to uncertain future events and values.

(2) Sensitivity analysis can be done by varying either one assumption or a combination of assumptions to estimate the effects of those changes on the expected outcome. To evaluate a conservation plan, it can be useful to test the effects on a farmer′s earning capacity caused by changes in prices or costs, delays in implementation, changes in yields, or some combination of these.

(3) Sensitivity analyses need not be limited to the purposes of finding out the effects of a change in an assumption on the worth of a project. A sensitivity analysis could be conducted, for example, to determine the effects of a delay in realization of benefits on the cash flow position of a farmer who has borrowed for an irrigation pump.

B. Risk Analysis

(1) Sensitivity analyses may also be conducted in the evaluation of potential risks associated with a conservation project. Risk is defined as the probability or chance that something will or will not occur as planned. For example, what is the chance that yields will reach the prescribed level? What is the likelihood that the system will be more costly than expected? The impact of these occurrences can be tested using sensitivity analysis. They can also be evaluated using a formal procedure called risk analysis.

(2) In circumstances of risk, a decisionmaker can make a decision under the assumption that he or she can enumerate all possible future states and assign probabilities of the occurrences of such states. Applied in conservation decisions, risk analysis can be more narrowly described as an analytical technique in which the estimation of net conservation benefits from conservation alternatives is based on the probabilities of occurrence of all critical events or elements of conservation in all likely future scenarios. Production risks associated with crops also play a part in the evaluation of conditions with conservation.

(3) The decision-tree method has been used as one approach to help decisionmaking under risk. The first step involves depicting actions (e.g., to apply conservation measures or to not apply them) available to a decisionmaker, the second step describes the uncontrollable events that can occur at certain probabilities and the relationship between actions and events, and the third step involves estimation and comparison of potential outcomes for each action-event scenario. Uncontrollable events influencing the outcomes of a landowner's decisions on conservation might include climatic changes (e.g., drought or flood), naturally occurring biological and ecological changes that are not understood and thus are unpredictable (e.g., crop disease outbreaks), and changes in the policies of Government agencies (e.g., increase or decrease of Federal funding for conservation).

(4) Using this decision-tree method, a landowner or planner has to judge how many action and event options to include in the tree. The decision of a landowner regarding a conservation action will finally be based on the estimated final outcome that is derived from multiplying the probabilities assigned to each uncertain event by the expected outcomes associated with a related conservation action, thus calculating a series of expected values for the conservation action (see note below).

Note: Contents of this section are modified from the discussion in the book, "Economics and the Environment" (Chapter 16, "Social Coordination Under Uncertainty," pp. 224-242), by Ian Willis, printed in 1997 by Allen & Unwin.

C. Value Engineering

(1) Value engineering is another way to conduct sensitivity analysis. Value engineering is a process in which the planner, the evaluator, or the decisionmaker starts with an initial conservation system alternative, adds an additional feature or increases the magnitude of a characteristic of the alternative (such as adding additional units of a conservation practice), and then evaluates the result to test for a net increase in the overall value of the conservation project.

(2) Value engineering can provide a means of reconsidering an alternative to make sure it provides the greatest possible net benefits given the purpose and circumstances of the decision.

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Subpart D – Evaluation Techniques

Figure D-1 Enterprise Budget

Utah State University
Extension Economics

Modify Colored Columns

Costs and Returns per acre from growing corn for grain, 2006
Cache County

Receipts	Quantity per acre	Unit	Price/cost per unit	Value/cost per acre	Base Value	Your Value
Corn grain	170.0	bushels	$3.00	$510.00	$510.00	
Residue	-	AUM	$0.00	$0.00	$0.00	
Subtotal				$510.00	$510.00	
Operating costs						
Land preparation						
Plowing (every 3rd year)	1/3	acre	$5.88	$1.96	$1.96	
Discing w/ packer	2	acre	$3.73	$7.47	$7.47	
Land plane	2	acre	$3.34	$6.69	$6.69	
Planting	1	acre	$5.28	$5.28	$5.28	
Seed	0.5	bags	$90.00	$45.00	$45.00	
Cultivations						
first	1	acre	$2.94	$2.94	$2.94	
second	1	acre	$2.94	$2.94	$2.94	
Fertilization						
Nitrogen (34-0-0)	561	pounds	$0.18	$100.14	$100.14	
Phosphate (11-52-0)	163	pounds	$0.18	$29.10	$29.10	
Custom application	1	acre	$7.82	$7.82	$7.82	
Pesticides/herbicides						
Lasso	3.00	quart	$6.50	$19.50	$19.50	
Phorate	6.75	pounds	$2.40	$16.20	$16.20	
2-4-D	2.50	pints	$2.75	$6.87	$6.87	
Custom application	1	acre	$7.82	$7.82	$7.82	
Irrigation (siphon)	5	irrigations				
Labor	1.67	hours	$10.00	$16.67	$16.67	
Water assessment	1	share	$10.00	$10.00	$10.00	
Repairs/maintenance	1	acre	$2.30	$2.30	$2.30	
Pumping	27	acre inch	$0.00	$0.00	$0.00	
Harvesting						
Custom combine	1	acre	$35.00	$35.00	$30.00	
Haul grain (custom)	170.0	bushel	$0.08	$13.60	$9.50	
Interest on operating capital			7.61%	$6.76	$6.76	
Subtotal				$344.05	$344.05	
Ownership costs (excludes cost of land)				$71.77	$71.77	
Farm insurance	1	acre	$2.00	$2.00	$2.00	
Machinery ownership costs	1	acre	$61.52	$61.52	$61.52	
Irrigation equipment costs	1	acre	$8.25	$8.25	$8.25	
Total costs				$415.82	$415.82	
Net returns to owner for unpiad labor, management, equity and risk						
Above operating costs				$165.95	$165.95	
Above total listed costs				$94.18	$94.18	

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Figure D-2 Partial Budget Worksheet Template

Positive Effects		**Negative Effects**	
Additional revenues:	**$________**	**Additional costs:**	**$_______**
Reduced costs:	**$___________**	**Reduced revenues:**	**$_______**
A. Total positive effects:	**$________**	**B. Total negative effects:**	**$_______**
Net effect (A - B):			$_______

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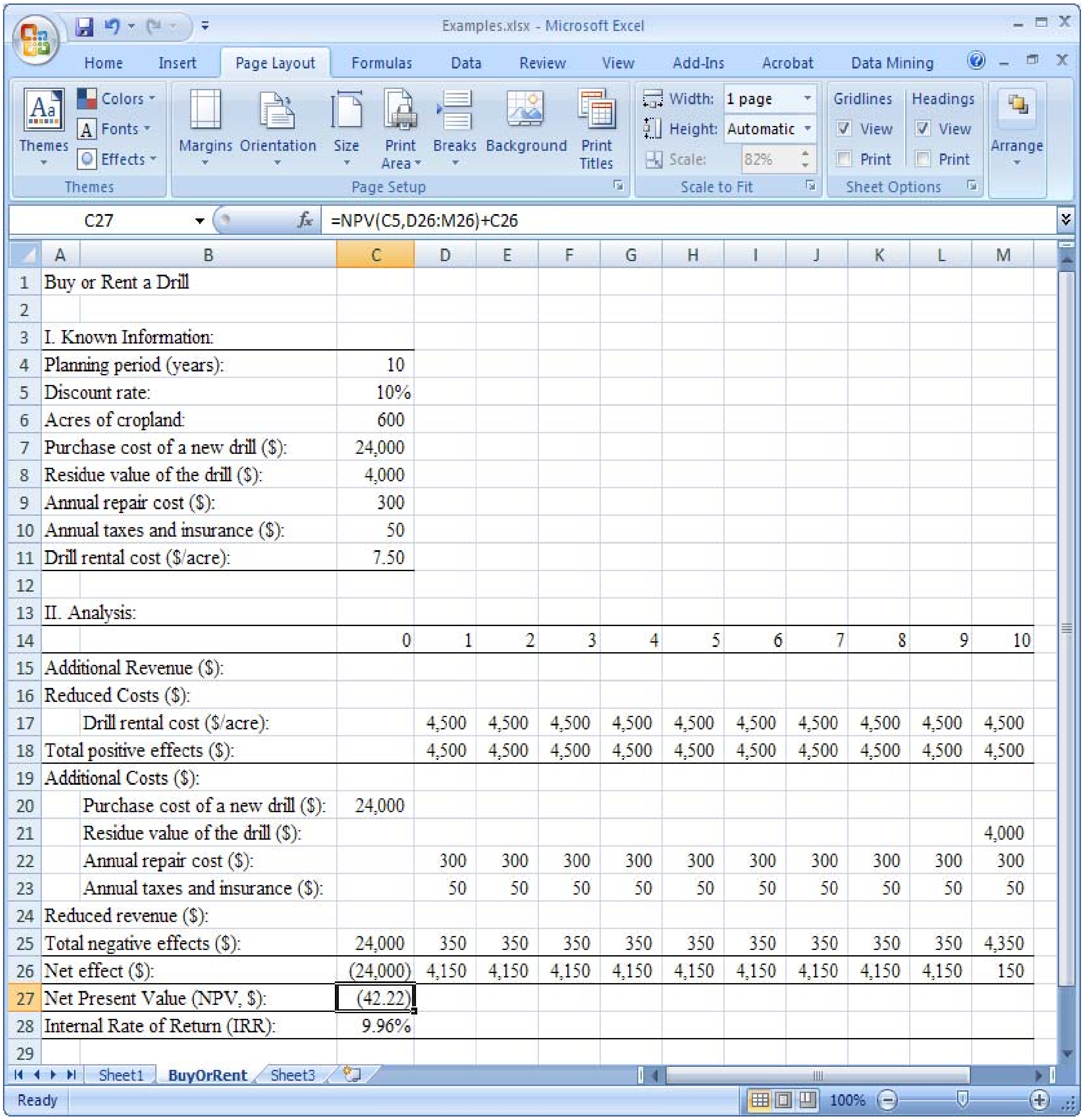
Figure D-3 Buy or Rent Example



	B	C	D	E	F	G	H	I	J	K	L	M
1	Buy or Rent a Drill											
2												
3	I. Known Information:											
4	Planning period (years):	10										
5	Discount rate:	10%										
6	Acres of cropland:	600										
7	Purchase cost of a new drill ($):	24,000										
8	Residue value of the drill ($):	4,000										
9	Annual repair cost ($):	300										
10	Annual taxes and insurance ($):	50										
11	Drill rental cost ($/acre):	7.50										
12												
13	II. Analysis:											
14		0	1	2	3	4	5	6	7	8	9	10
15	Additional Revenue ($):											
16	Reduced Costs ($):											
17	Drill rental cost ($/acre):		4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500
18	Total positive effects ($):		4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500
19	Additional Costs ($):											
20	Purchase cost of a new drill ($):	24,000										
21	Residue value of the drill ($):											4,000
22	Annual repair cost ($):		300	300	300	300	300	300	300	300	300	300
23	Annual taxes and insurance ($):		50	50	50	50	50	50	50	50	50	50
24	Reduced revenue ($):											
25	Total negative effects ($):	24,000	350	350	350	350	350	350	350	350	350	4,350
26	Net effect ($):	(24,000)	4,150	4,150	4,150	4,150	4,150	4,150	4,150	4,150	4,150	150
27	Net Present Value (NPV, $):	(42.22)										
28	Internal Rate of Return (IRR):	9.96%										
29												

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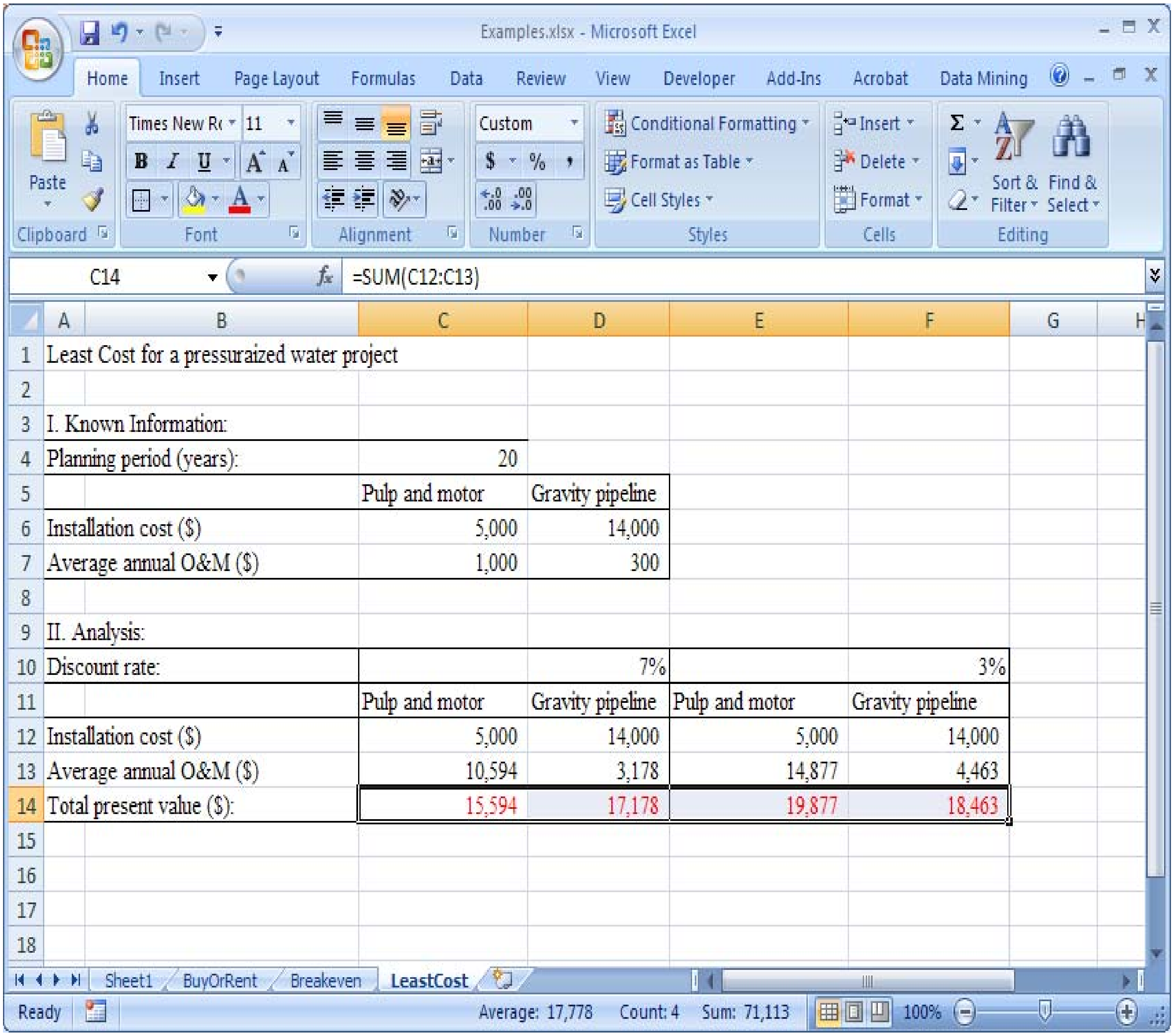
Figure D-4 Computing Present Value of Total Costs Using Life Cycle Cost Analysis



	A/B	C	D	E	F
1	Least Cost for a pressuraized water project				
2					
3	I. Known Information:				
4	Planning period (years):	20			
5		Pulp and motor	Gravity pipeline		
6	Installation cost ($)	5,000	14,000		
7	Average annual O&M ($)	1,000	300		
8					
9	II. Analysis:				
10	Discount rate:		7%		3%
11		Pulp and motor	Gravity pipeline	Pulp and motor	Gravity pipeline
12	Installation cost ($)	5,000	14,000	5,000	14,000
13	Average annual O&M ($)	10,594	3,178	14,877	4,463
14	Total present value ($):	15,594	17,178	19,877	18,463

Subpart E - Analysis of the Adoption of Conservation Practices

610.40 Introduction

A. Land users usually only adopt a system of conservation practices when doing so is in their best interests. Not all economically justified conservation practices, however, are adopted by all land users. Many constraints facing land users affect their decisions about whether to adopt economically-justified conservation practices. Such constraints include both economic and noneconomic factors.

(1) Strategies to promote the adoption of new and unfamiliar conservation practices, such as residue management practices, must take into account several interrelated factors. These include the variety of crops grown, the cost of alternative tillage systems, weather and pest expectations, the land user's management experience, as well as Government policies, risk preference, base knowledge, and the background of regulations.

(2) In essence, a land user's decisions in adopting conservation practices depend on his or her assessment of managerial, economic, and environmental factors affecting his or her business, as well as the economic feasibility of the conservation practices. Understanding land users' concerns regarding conservation practices and why they do, or do not, adopt new conservation practices, is central to collecting and assessing the appropriate information and actions to help them make informed decisions.

B. This chapter analyzes these factors affecting land user adoption of conservation practices and discusses how a planner may design strategies to help land users improve the chances of successfully adopting conservation practices. The discussion begins with the theory of agricultural innovations adoption from the adoption-diffusion (A-D) model. Then a method is proposed in utilizing the A-D model when working with an individual landowner. The framework is useful for developing active listening skills to ascertain what the landowner considers in conservation choices.

610.41 Adoption-Diffusion Model

A. NRCS has utilized the A-D model in promoting conservation to land owners and land managers. The A-D was initially postulated by Ryan and Gross (1943) for describing acceptance of hybrid seed corn varieties in two communities in Iowa. Everett Rogers and Floyd Shoemaker more fully developed the theory of A-D in a 1971 book, "Communication of Innovations – A Cross Cultural Approach."

B. Adoption-diffusion is a way of looking at what influences a producer's decision to adopt an agricultural practice. Influences include information or what is known about the practice. How and when a producer receives information is critical in the adoption process. The size, scale, and type of operation are also relevant to adoption. Other influences include personal characteristics of the producer, characteristics of the community, and characteristics of the practice or innovation.

C. This section will provide a summary of the A-D model and discuss how the A-D model could be used in the field. Items to be covered are the how the model works, information sources, personal and farm-level characteristics that influence decisionmaking, and, finally, obstacles that may affect innovation or technology adoption.

D. The A-D model has three specific terms:

(1) Adoption is the behavior associated with an individual or group's decision on whether or not to accept new ideas, practices, or products.

(2) Diffusion is the process by which the adoption of a new idea, practice, or product spreads throughout a group, community, or society.

(3) Innovation is an idea, practice, or product that is perceived as new by the individual or group.

E. How the A-D Model Works

(1) The A-D model has six stages in the adoption process:

(i) Awareness of the problem.
(ii) Interest in more information.
(iii) Evaluation.—How the technology can be applied to the producer's operation.
(iv) Trial.—Testing the applicability at a specific site.
(v) Adoption.—Full use of the technology.
(vi) Adaptation.—Customization of the practice or technique by the producer. Although the stages are outlined sequentially, the model is dynamic; an individual farmer or rancher may return to any one of the stages at any time during the adoption process.

(2) Throughout the various stages, information is vital to the producer. Information provides knowledge to decide whether or not to adopt a particular practice or system. Because of its key role, producers need timely, accurate, inexpensive, and easily obtainable information. Site-specific information on the agronomic, economic, and environmental costs and benefits aids the producer in the decisionmaking process. The sources of information that a producer uses are also vital to the adoption process.

(3) Producers use different sources of information at the different stages of the adoption process. The key information sources at work in each of the stages of the classic A-D model are listed below. The identified sources are listed in the priority of use. Note that while these key

sources of information remain valid, today additional new sources, such as the Internet and certified crop consultants, play an increasing role in agriculture decisionmaking. Who, what, and when an information source is used will vary by the particular producer group. For example, research in the 1980s found that private industry was the main information source, especially for large producers.

F. Information Sources for Each Stage of Adoption.—The A-D model has specific sources of information that farm operators use during each stage of adoption (Rogers and Shoemaker, 1971). These sources range from mass media and government agencies down to neighbor and personal experience. Below are the stages with the corresponding information source (Figure E-1):

Click here for a copy of Figure 610E-1: Information Sources by Stage of Adoption

A. Personal Characteristics That Influence Innovation Adoption

Along with information and information sources, Rogers and Shoemaker associated certain personal characteristics with the adoption of innovations or agricultural technologies. Each of the following personal characteristics is positively correlated with the willingness of a producer to incorporate newer technology into the farm enterprise:

(i) Above average income
(ii) Greater number of years of formal education
(iii) High number of agency contacts
(iv) High participation rates in agricultural organizations
(v) Greater reliance on mass media
(vi) High awareness of conservation problems
(vii) Willingness to take risks
(viii) Full-time operator
(ix) Desire to pass farm or ranch on to children

B. Farm or Ranch Characteristics

As with personal characteristics, Rogers found a positive correlation between a select set of farm or ranch characteristics and adoption. The characteristics Rogers cited are as follows:

(i) Large-scale farms
(ii) High gross farm sales
(iii) Owner operations

C. Characteristics of the Technology (Practice or System)

Research has found that certain characteristics of the technology or innovation are related to the adoption process. The practice must be—

(i) Economically feasible.
(ii) Observable, simple to use, and divisible into manageable parts.
(iii) Compatible with a farmer's beliefs, ideas, and management style.
(iv) Flexible, easily fitting into the producer's management of the operation.

D. Key Points to Remember When Applying the A-D Model

(1) Timely and accurate information can help accelerate a producer's movement through the stages of adoption.
(2) Field staff should regularly and continually use local information sources to promote conservation technologies.
(3) Outreach strategies and locally led activities will be most effective in "getting conservation on the ground" if the values, personal characteristics, communication networks, and social relationships associated with each adopter category are integrated in local planning activities.
(4) Field staff should seek out and work with early adopters. They are leaders and their opinions and experiences are highly respected. For example, use early adopters to demonstrate conservation technologies to the rest of the community.
(5) Demonstrations, pilot projects, and field tours continue to be viable ways that producers can use to evaluate how a practice or system may work in their operation.
(6) Among small-scale producers, peers, friends, and neighbors serve as trusted leaders and play a significant role in the adoption-diffusion process.
(7) People who might be characterized as belonging to different types of groups in the community tend to respect their "own" leaders (i.e., leaders that are similar to them in status, race, ethnicity, and their farming situation).
(8) For small-scale producers, demonstration and pilot projects must include alternative low-cost technologies.
(9) Technical assistance and "hand-holding" during the trial stage can help a producer acquire the needed management skills in order to have a successful experience with the innovation.
(10) Community support structures, such as environmental education programs and centers, "Conservationist of the Year" programs, active watershed coalition and "Ag Days" help to reinforce and shape the diffusion of a technology.
(11) Based on farm or ranch characteristics and their personal characteristics, low-cost practices and technologies should be made available to small-scale operators.
(12) Whether field staffs are working one-on-one, designing outreach, or setting up locally led

activities, the known obstacles to adoption can serve as a springboard for field staff to increase and to influence the adoption diffusion process.

E. Technical Notes and Resources of the A-D Model

The A-D model is embodied in the Technical Note 1801: Guide for Estimating Participation in Conservation Programs and Projects. The technical note was historically used primarily in Public Law 83-566 programs to estimate the participation rate for land treatment watershed projects. The technical note can be used at the field office level to determine the level of technology acceptance in a particular watershed and how to better work with individuals and groups within a particular watershed to improve conservation adoption.

610.42 Conservation Adoption at the Farm or Operator Level

A. The application of conservation practices, however, is only one of the many decisions a land user has to make in order to manage a farm. When providing conservation assistance to a land user, information on how adoption of alternative conservation systems will affect his or her economic situation should be included in the information presented by the conservation planner.

B. The overall economic environment, particularly the agricultural business environment (interest rates, farm income support programs, conservation program payments, etc.) affects a land user's decisions about whether or not to adopt conservation practices. During times of prosperity, land users usually can afford to invest in long-term conservation strategies and practices. Installation of conservation practices is often a good way to increase future productivity, making conservation an intelligent investment. However, while the installation costs are upfront, benefits from conservation sometimes take time to materialize. Therefore, liquidity, cash flow, or profitability can become an issue for many land users considering conservation investments.

C. In times of economic stress, practices that have high upfront installation costs but whose benefits take time to materialize could be good alternatives from a conservation viewpoint, but may not be affordable to a land user. Under these circumstances, applying part of a conservation system to obtain some benefits may be better than not applying any practices at all. When the land user's economic situation improves, the remaining planned practices could be applied, thus help the land user to reap the full benefits of conservation.

D. In addition, as explained in the A-D model, land users may be unable or unwilling to adopt conservation practices due to other reasons, some of which are not related to financial or economic considerations. For example, it is important for the planner to understand, to the best of his or her abilities, any social constraints that could affect how comfortable the land user will feel about his or her decision to implement a new conservation system. Being prepared to either simply observe or possibly to actively discuss these issues will enable the conservation planner to better help the land user make a choice with which he or she is comfortable. A sound conservation choice is one that reflects the land user's personal circumstances, preferences, and level of comfort with adopting the proposed conservation practices. If local producers generally consider the adoption of a specific, visible conservation practice to be ridiculous or a reason for ostracizing anyone who adopts it, a land user under those circumstances will likely be reluctant to implement that particular practice. In that case, it would be helpful to find an alternative practice if possible. This is just one example of a type of social constraint faced by land users.

E. Because of general climate and physiography, as well as the site-specific conditions of any given land unit, physical limitations can play a large part in what is feasible for a producer to accomplish. If a land user knows that his or her farm or ranch is "hammered," perhaps having been abused by a previous land owner, he or she may be worried that achieving the desired level of resource conditions through implementation of standard conservation practices may present some difficult challenges. Being aware of such challenges can be psychologically daunting.

F. A different type of physical constraint is the physical well-being and abilities of the land user. If the producer is in poor health or has physical limitations due to age or mobility, then one type of conservation system may work well while another would be prohibitively difficult for the land user to operate. It may sometimes be the case that the land user doesn't want to disclose a personal physical limitation to the conservation planner and, instead, will simply decline to adopt a suggested conservation system.

G. Planners need to be sensitive to these and other potential reasons for reluctance to adopt. Conservation planners, who always work within complex constraints faced by land users, can be more effective in the development of successful conservation plans by applying the principles of adoption analysis to better understand land users' individual perspectives.

610.43 Adoption Analysis

A. If land users do not adopt conservation practices, it is because there are obstacles making them unable, unwilling, or both. These reasons are not always easily distinguishable from one another. Land users can be able, yet unwilling; willing, but unable; and, of course, both unable and unwilling. These may sound like minor distinctions, but the difference between a land user being unwilling or being unable is crucial when designing the appropriate conservation adoption strategy. These

obstacles could be due to knowledge, risk preference, economic resources, ownership of the resource base, etc. (figure 610E-2).

Click here for a copy of Figure 610E-2: Obstacles to Adoption of Innovation

B. Reasons for Being Unable to Adopt.—A land user may be willing to adopt a new conservation practice, but unable to do so. Being unable to adopt a new conservation practice implies the existence of one or more obstacles or situations that prevent the land user from adopting the conservation practice even if he or she is willing to do so. Such obstacles or situations might include the following:

(1) Information is Lacking or Scarce.—A land user may be unable to adopt a practice because some of the basic information necessary for a sound economic and agronomic analysis is missing.
(2) The Costs of Obtaining Information Are Too High.—The time, expense, and difficulty of obtaining site-specific information may be too high. Obtaining relevant information is not cost-free to the land user.
(3) The Complexity of the Practice is Too Great.—Available reports of extensive research show that the complexity of a technology is inversely related to the rate and degree of adoption. Conservation practices that are too complex make some land users unable to adopt them.
(4) The Conservation Practice is Too Expensive.—Conservation investment costs (fixed and variable costs) and their impact on net returns are major concerns of land users. An agronomically sound practice with too high of a price tag makes many land users unable to adopt.
(5) The Labor Requirements Are Excessive.—Land, labor, and capital still determine the success of the operations of a farm or ranch. If the labor requirements associated with a new conservation practice are very high relative to the availabilities of labor or capabilities of a farm or ranch, then the farm or ranch manager may be unable to adopt it.
(6) The Planning Horizon is Too Short.—Conservation practices may be rejected by a land user because their current planning horizon is too short, when considering the time associated with recouping initial investments, learning costs, or depreciation of the present equipment line. Many of today's land users may not be farming or ranching in a few years because of retirement or other transitional considerations. Asking them to make a long-term investment in a short planning horizon could result in them being unable to adopt.
(7) The Availability and Accessibility of Supporting Resources Are Limited.—Few land users could adopt innovative conservation practices without significant support. This support can exist in different forms. The lack of any one of these could be the obstacle that prevents a land user from adopting. Examples are:
(i) Local equipment or agrochemical dealers are willing to absorb the risk of investing in products and associated replacement and repair parts not currently being used in their trade areas.
(ii) Other land users using conservation practices are willing to share both successes and failures.
(iii) USDA information and assistance network is capable of answering land user questions.
(iv) Federal, State, and local financial assistance is available when land users need it.
(8) Managerial Skills Are Inadequate.—As in the case with the physical resource bases they manage, diversity among land users is tremendous. A dimension of this diversity is managerial skill. Too often conservation practices are designed for land users with average or above-average management skills. Local assistance networks are also oriented to this group because of the performance and evaluation systems used in USDA. Either of these can create a situation where land users with less than average management skills receive little or no assistance in building these important skills. These land users will then make the decision to reject the conservation practice because they lack the requisite managerial skills or the opportunity to develop them.
(9) Control Over the Adoption Decision is Limited or Nonexistent.—Viewing a land user or operator as an independent decisionmaker who calls all the shots is common. The operator, therefore, becomes the focal point of most efforts to transfer new technologies. In many situations, however, a decision cannot be made without the approval of a partner, source of financial credit, landlord, or some other third party. If these other interests are not convinced of the merits of a new conservation practice, then the land user or operator will be unable to adopt.

B. Reasons for Being Unwilling to Adopt

(1) Land users may be unwilling to adopt a new conservation practice. This implies that they have not been persuaded that the practice will work or is appropriate and beneficial for their farm or ranch operations. Attempts at persuading can be unsuccessful for any of multiple reasons. As in the case of being unable to adopt, many of these situations are created by factors related to insufficient provision of information to the land user; therefore, he or she is making a reasonable decision in rejecting the practice. Until the appropriate information is offered, the unwillingness to adopt will not change.
(2) Reasons Land Users Might Be Unwilling to Adopt
(i) Information Conflicts or is Inconsistent.—Land users may be unwilling to adopt a practice because of inconsistency or even outright conflicts in the information about the practice. Concerned about water quality in a vulnerable area, the land users may hear that a particular

conservation practice always requires more pesticides or that another local land user claims it requires fewer pesticides. They will often remain unwilling to adopt until these divergent messages become more consistent.

(ii) Poor Applicability and Relevance of Information.—To make a sound decision, land users need information that is applicable and relevant to their farms or ranches. Data from a neighboring State or even across the county line may be judged as not meeting local conditions. Until the data of the adapted are made available and relevant to local situations, the land user will remain unwilling to adopt.

(iii) Conflicts Between Current Conservation Goals and the New Technology.—New technologies do not always fit into existing conservation practices and the policy context in which they operate. In these cases, the general expectation is that land users will adapt their operations to meet the adoption requirements of the technology. This can be contrasted with a situation where a flexible technology is designed and introduced so that it can be adapted to fit into a land user's operation. Land users may be unwilling to adopt if they feel that too much adaptation is required.

(iv) Lack of Knowledge on the Part of the Land User or the Promoter of the Conservation Practice.—An individual who has not had the opportunity to learn about a new practice or a planner who lacks sensitivity to the basic needs of a potential adopter can cause the land user to remain unwilling to adopt.

(v) The Practice is Inappropriate for the Physical Setting.—The land users may be expected to adopt a practice that is inappropriate for the physical setting for their farms or ranches. Potential yield losses, inefficient use of inputs, or even negative environmental impacts can result from this situation. Some land users, recognizing this incompatibility, remain unwilling to adopt.

(vi) The Practice Increases Risk of Negative Outcomes.—A conservation practice can increase the probability of a negative outcome in many ways. For example, a relatively wet, versus a dry year can have many implications for pest control, nutrient amount and placement, and the timing of tillage operations. Relying on agrochemicals for pest control can make the land user more dependent on weather patterns and increase the potential costs of rescue operations. The complexity of a practice, importance of the timeliness of operations, and the interdependence of inputs all can increase perceived or real uncertainty and risk. Some land users are simply unwilling to make major decisions under conditions of uncertainty or where risk is significant.

(vii) Belief in Traditional Practices.—Although traditional beliefs and practices in agriculture are often scorned, one should not forget that those traditional land users continue to survive in today's competitive environment while thousands of their innovative or progressive neighbors have gone out of business. Some land users are unwilling to change because those traditional practices may present the least risk in dynamic agricultural markets.

(viii) Conservation (Buyer) Remorse.—After learning more about the practice, the landowner backs out because "it's not what I thought it was" or "the maintenance and repair time was not what I expected."

(ix) Perceived Information Source Bias.—The landowner may not trust a Government or company representative who gives advice requiring the landowner to spend money or time when that advisor does not share in the resulting losses. Government and sales representative salaries do not depend on the success of the conservation practice.

610.44 Strategies for Assisting Conservation Adoption

A. Decision Matrix

(1) A planner may use a decision matrix to analyze a land user's decisionmaking rationale for conservation adoption. Such a decision matrix is an excellent way to organize land users' reasons for adopting or rejecting conservation practices. Each of a landusers' reasons for adopting or rejecting conservation practices can be categorized into one of the four cells in a 2x2 matrix (figure 610E-3). Using the matrix to organize the target group's reasons for adopting or rejecting NRCS's recommendations of conservation practices can assist conservation planners in determining appropriate actions necessary to implementing a successful conservation program or project.

Click here for a copy of Figure 610E-3: Decision Matrix for Conservation Adoption: Reasons for a Landuser's Adoption and Rejection of a New Practice

(2) The matrices in figure 610E-4 summarize various combinations of a land user's reasons for adoption and rejection of new conservation practices (for example, for low initial-cost systems (LICS)). The figure shows, for example, if a land user has never heard of a LICS from NRCS, but has a history of adopting conservation innovations, then that land user would fit into the category of being unable and willing.

(3) Identifying the category or cell into which an individual land user falls would help a conservation planner tailor a conservation adoption strategy to meet the needs and concerns of that particular land user. Realization of a land user's reasons for adoption or rejection should enable the conservation planner to avoid ignorance of and insensitivity to the land user's needs, and help put more conservation practices on the land.

Click here for a copy of Figure 610E-4: Low Initial-Cost Systems (LICS): Reasons for Landuser's Adoption and Rejection of New Practices

(4) The data in the matrix is based on interactive questions of the land manager that relate to adoption willingness and ability.

(i) Sample questions could include the following:

What is your present operation practice?
Have you heard of LICS?
Do you know of anyone in the county using LICS?

(ii) Upon describing LICS, ask if the land manager is comfortable with operation and maintenance (O&M) requirements of a set of LICS practices. Follow up with a question over the O&M work or costs to determine reasoning for being unable or unwilling.

(5) Sample Conversation:

Example of a farmer who has never worked with NRCS before but has heard about and seen what NRCS has done for other farmers.

Farmer (F) comes into the field office and says, "I want to do terraces."
Conservationist (C) replies, "We can do terraces, but are terraces what you need?"
F: "My neighbor has terraces."
C: "I can understand why you'd like terraces. Tell me, what do you want the terraces to do for you?"
F: "I've got soil falling off the side of the hill."
C: "Terraces can certainly help with that. But, while you're here, we might look at other ways to keep the soil on the side of your hill."
F: "My neighbor's works."
C: "Well, you and I have the opportunity to explore other ways. Perhaps there is another way that better fits your farm and the way you run your farm. Maybe we can think about the equipment you have or want to buy, or the kind of labor you have throughout the year, or maybe we can even find a more cost effective-way to keep the soil on the hill."

(6) This type of conversation allows the farmer to reveal the different types of ability. Maybe the farmer can afford the terrace installation, but does not have the labor for the O&M. His or her neighbor with the terraces has the labor for the O&M but maybe he or she does not. This type of conversation reduces the probability that the resulting contract will have to be modified or cancelled.

(7) This type of conversation reduces the likelihood that the landowner will, in the future, say:

(i) "I didn't realize I'd have to check the terraces after every storm. I just don't have time for that. I've got other things to do after a storm."

(ii) "I didn't realize the terraces would cost me that much! I guess costs have really gone up since my neighbor installed his terraces."

(iii) "I didn't realize that I'd have to spend at least 2 days a year to do maintenance. I'm having a hard time fitting that into my schedule."

(8) You will notice how ability can take different forms: ability to pay the dollar costs, ability to provide the labor for repairs and maintenance when there are other, ongoing tasks on the farm. You will also notice that willingness and ability interact with each other.

B. Observations About Adoption of Conservation Practices

(1) At least three general observations can be made from the lists presented in this section about why land users are unable or unwilling to adopt conservation practices. First, increasing the adoption of conservation practices depends upon whether conservation planners can identify reasons why land users are unable or unwilling to adopt, and then remove these impediments. Being aware of these reasons can expand the conservationist's ability to listen for subtle cues the landowner may give during a conversation. Following up on the subtle cues can lead to more direct information about the barriers.

(2) Second, many of the factors causing land users to be unable or unwilling to adopt conservation are beyond their control. In many cases, it is not so much a land user's failure, but a system's failure. For example, the conservationist might work with State office staff to explore possible modifications to the practice installation that will be more suitable to the particular farm and still meet practice standards.

(3) Third, any one remedial strategy is not sufficient to address all the issues associated with land user's choice against adopting conservation practices. A combination of technical, financial, or educational assistance may be necessary to achieve a desired outcome. The specific type of assistance the land user needs must be delivered in a format compatible with his or her capabilities.

(4) Finally, the promotional strategies that worked for the early adopters are generally not as effective with late adopters. If accelerated rates of adoption for conservation systems are desired, then NRCS personnel must be as willing to accept new ideas and methods as they expect potential adopters to be accepting of new practices. For additional reading, see: "Farmer Adoption of Production Technologies," by Pete Nowak, a professor in the Nelson School for Environmental Studies at the University of Wisconsin-Madison.

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Subpart E – Analysis of the Adoption of Conservation Practices

Figure E-1 Information Sources by Stage of Adoption

Adoption Stage	Information Source
1. Awareness	(1) Mass media (2) Government agencies (3) Friends and neighbors (4) Dealers and salespeople
2. Interest	(1) Mass Media (2) Government agencies (3) Friends and neighbors (4) Dealers and salespeople
3. Evaluation	(1) Friends, neighbors and family (2) Government agencies (3) Mass media
4. Trial	(1) Friends, neighbors and family (2) Government Agencies (3) Mass Media (4) Dealers and salespeople
5. Adoption	(1) Friends, neighbors and family (2) Government agencies (3) Mass media (4) Dealers and salespeople
6. Adaptation	Personal Experience

Figure E-2 Obstacles to Adoption of Innovation

Farmers may not be aware of or understand	• On-site and off-site causes and consequences of erosion and other natural resource problems. • The short and long term benefits of conservation. • The types and sources of available assistance. • The nature of conservation plans, that is, voluntary implementation. • That alternative practices/systems can be custom designed to meet the producer's needs and conditions.
Farmers may not have technical information on	• The economic, agronomic and environmental costs and benefits of alternative practices • Assistance for or knowledge of agency programs.
Community constraints include	• The absence of support from leaders, family, friends and neighbors. • Absence of active community support structures such as districts, salespeople or local USDA offices. • Unequal access to information, financial and technical assistance and support.
Social psychological characteristics include	• Aversion to risk. • Lack of appropriate management skills.
Organizational barriers include	• Conflicting messages from different sources. • Confusion over the roles and responsibilities among the various agencies. • Lack of coordination between and among agencies.
Economic obstacles include	• Lack of cash or credit for producers share of cost. • Limited cash flow while waiting for government reimbursement.
Landlord-tenant relationships	• Short term leases may serve as obstacles to installation and maintenance of practices/systems. • Program sign ups may require long term commitments.

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Subpart E – Analysis of the Adoption of Conservation Practices

Figure E-3 Decision Matrix for Conservation Adoption: Reasons for a Landuser's Adoption and Rejection of a New Practice

Land user is	**Unable**		**Able**	
Willing	Unable but willing	1	Able and willing	2
Unwilling	Unable and unwilling	3	Able but unwilling	4

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Subpart E – Analysis of the Adoption of Conservation Practices

Figure E-4 Low Initial-Cost Systems (LICS): Reasons for Land User's Adoption and Rejection of New Practices

Land user is	**Unable**		**Able**	
Willing	Unable but willing	1	Able and willing	2
	The land user has never heard of a LICS from NRCS, but has a history of adopting conservation innovations.		The land user was assisted by the NRCS field office in planning LICS and a LICS will meet the land user's needs on leased land.	
Unwilling	Unable and unwilling	3	Able but unwilling	4
	No one in the county who can help the land user implement a LICS and, thus far, a LICS seems no better than doing nothing.		A medium-sized, stable operation, the land user has heard of LICS, but has heard conflicting information about the effectiveness of LICS.	

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Subpart F – Introductory Statistics

610.50 Introduction

A. What is Statistics?

(1) Statistics is "The science of the collection, organization, and interpretation of numerical data, especially the analysis of population characteristics by inference from sampling." Measured population characteristics, such as the population mean, are called "parameters." A measured characteristic of a sample, such as the sample mean, is called a "statistic."

(2) The science of statistics deals with—

(i) Designing surveys.

(ii) Collecting and summarizing data.

(iii) Measuring the variations in survey data.

(iv) Measuring the accuracy of estimates.

(v) Testing hypotheses about the population .

(vi) Studying relationships among two or more variables.

(3) Statistics, then, is the science of providing the techniques used to obtain analytical measures, the methods for estimating their reliability, and the drawing of inferences from them.

B. Purpose of This Subpart

The purpose of this subpart is to facilitate the understanding of statistical concepts and techniques, their limitations, the assumptions behind them, and the interpretations that can be made from them. It is a short reference guide for those who apply and use statistical analysis in their work. Users of this subpart are, however, still encouraged to consult experts when there is a need for data collection, analysis, and interpretation.

C. Uses for Statistics in NRCS

NRCS employees are responsible for answering questions and solving problems related to conservation work for land users and resource managers. The keys to meeting these needs are to acquire relevant information and data and to properly interpret the collected information. Hence, statistics—when defined as a tool for data collection, analysis, and interpretation as well as prediction—is useful for NRCS employees in general and particularly for those technical experts who are responsible for the use and analysis of resource information.

D. Data Collection (Sampling)

(1) NRCS personnel are constantly weighing whether or not additional information (obtained at some cost) will yield results that justify the expense of collecting it. Some problems encountered are too minor to justify a large expenditure for detailed data collection. On the other hand, some decisions involve tens of thousands or millions of dollars and years of development. It's only common sense to collect useful information to help make those types of decisions. But where is the line drawn? How far should one go to ensure the accuracy of data collection efforts?

(2) In most situations, it is impossible to collect information from every data source. For example, NRCS may need to find out the extent to which conservation tillage is

currently being applied in the United States. It would be almost impossible to contact and interview every farm operator without committing huge resources. So a sample is taken from the total of all farmers. But, is the sample large enough to reflect the "true" information about all farmers? Conversely, taking a larger sample than necessary could waste funds. Statistical methods can be used to help answer these questions. With the aid of statistics, the sample size that meets specific precision criteria for individual data collection can be determined.

E. Data Analysis

(1) When data are collected from a sample, whether from a primary or secondary source, confidence in the data is always a question. It is possible, through the use of statistical methods, to quantify "confidence" in the reliability of the sample data characterizing the data in a population. In fact, many of the basic statistical measures can be tested for their degree of reliability, a unique characteristic of statistical methods.

(2) Why is the ability to quantify confidence in statistical measurements so important? Imagine assigning two people to independently study a particular problem. To make an intelligent decision, both people separately study the problem, collect and analyze the data presumed to be relevant to studying the problem, and report their results. Unfortunately, their results are very different. Person 1 subjectively decided to take a 10-percent sample from the targeted population. He averaged the data and reported the averaged results, or means. Person 2 used a statistical method such as sampling to determine the most economical sample size out of the total. His averages (means) of sample characteristics were reported as well, but he also included the limits of the statistical confidence that his sample means were representative of the actual mean of the population. Because the second person quantified the limits of confidence in his results, indicating levels of reliability, his report was more trustworthy than the first person's report.

F. Interpretation and Prediction for Decisionmaking

(1) Most NRCS data are eventually interpreted to help make present decisions or to predict future trends of events for future decisions. Hypothesis testing of statistics is a method that can be used to compare an estimate or intelligent guess to actual sampled data. For example, if 33 bushels per acre seems like a low crop yield, a quick sample could be developed from the Agricultural Census data or some other obtainable sources in order to test whether that is actually the case. Using this sample and the techniques of hypothesis testing, a statistical test could be performed to see if the average yield was indeed 33 bushels per acre.

(2) Most NRCS technical specialists are expected to perform predictions for the future when comparing situations of "with" and "without" the application of conservation measures. A statistical analysis technique called regression analysis enables users to predict future trends based on past data. For example, it is possible to estimate future yields based on past yields and inputs in a farm. The relationship between yields and associated inputs is commonly known as a production function, in which the predicted yields are dependent on the expected farm inputs in a mathematical equation or function. This is one of the most powerful tools in statistics, and it is probably the most widely used.

(3) To summarize, statistics gives the user—

(i) A number of ways to sample and analyze data.

(ii) Relatively simple, timesaving means to quantify the reliability of data derived from the sample.

(iii) Techniques to compare estimates and data that represent those of the population.
(iv) A way to predict future trends based on past events.

610.51 Elements of the Sampling Process

A. The process of using statistics sampling to answer questions and make decisions involves a number of steps:

(1) Define the problem
(2) Design the sampling procedure
(3) Collect and analyze the data
(4) Interpret the results

B. Define the Problem

(1) Statistical sampling and analysis is a process that begins with a problem or set of questions. What are the problems or questions you are trying to answer? What types of data do you need to measure or collect to answer those questions? What is the area of interest: a watershed, a set of counties, or an entire State? Answers to these questions will help to clearly define the problem.
(2) The problem must be specified in a way that can be answered through statistical processes. The population and measurements needed to answer the question will be defined at this stage. The population, the set of all elements about which we wish to make an inference, must be clearly defined before the data are collected. For example, if you wish to estimate the average size of farms in a three-county area, the population would be the farms in those three counties. You must decide if farms will be defined in terms of ownership units, management units, or some other method. Once the definition is determined, it must be consistently adhered to throughout the sampling process. Similarly, careful thought and definition must be given to the characteristics measured for each sampling unit.
(3) It may not be necessary to conduct your own survey. Contact experts in your State office for assistance in learning what data are available for your area. There are several national surveys whose data or summary tables may be utilized.
(i) The National Resources Inventory (NRI) is conducted by the NRCS on non-Federal land in the United States. The NRI summary tables may provide the information needed, especially related to land use area and erosion. Your State NRI specialist will be able to assist you with specific summaries.
(ii) The National Agricultural Statistics Service (NASS) Census of Agriculture provides a sample of more than 70 percent of U.S. farms, including resource, production, demographic, and economic information. The other surveys conducted by NASS are useful information about agriculture prices, livestock and crop production, and chemical use.
(iii) The U.S. Census Bureau database provides access to population and demographic data dating back as far as 1790.
(iv) The Forest Inventory and Analysis (FIA) is conducted by the U.S. Forest Service and provides detailed information on forestland.

C. Design the Sampling Procedure

(1) One way to determine the average size of farms in a State would be to find the acreage of each farm in the State and calculate the average. Conducting a census is a full data collection effort using a set of measurements for an entire population. Although a census provides complete information on the set of measurements taken

for a population, it is often not practical because of the time and money needed to conduct such a survey. Statistical analysis enables a researcher to learn a great deal about a population without having to resort to committing the time and money required to gather data for the entire population.

(2) Sampling may be used to collect information on a subset of the population. It is important that the sample be representative of the population. If we drew our sample from a list of corporate farms, we would be missing representation from many small farms. Similarly, if we drew a sample from one area of the State, the sample would not be representative of farms across the entire State. There are a number of methods used to select a representative sample; these methods are called “sample survey designs” or “sampling designs.” One of these, simple random sampling, is discussed in this subpart (see note below). Many other sampling designs exist that allow the selection of a representative sample that may be used to make an inference about the entire population. These designs can be explored further by consulting statistical literature and experts.

(3) The data should be collected in a way that follows the sampling design, should be organized for ease of analysis, and should be checked for recording errors. During this stage, detailed data collection and storage tools (e.g., worksheets or spreadsheets) must be acquired or developed. Statistical methods for analysis of data that are appropriate for the sample design should be determined as well. Ideally, a small pilot test of the entire process will be conducted at this stage to find any flaws in the process before it is fully implemented.

Note: Note that the computing equations for the statistics and example calculations using Excel presented in this subpart are only appropriate for summarizing data collected with a simple random sample.

D. Collect and Analyze the Data

Implement the detailed plans made during the design stage. Careful planning during the design stage will help data collection and analysis to run smoothly. However, data should be checked periodically during collection to discover any problems, such as incorrectly calibrated instruments, early in the process.

E. Interpret the Results

The sampling process began with a problem and a set of questions that needed to be answered. The results of the statistical analysis must be reported in a way that will answer those questions and provide all pertinent details. If the yields of two brands of corn are compared, report not only the brands, but also the number of fields on which the tests were conducted, the geographic range of these fields, etc. In presentation of statistics, always accompany any summary statistic with its appropriate measure of reliability. For example, if you report the average yield of corn, include the standard error of the mean yield, or, alternatively, include a confidence interval showing the level of confidence (e.g., 90 percent, 95 percent, or 99 percent).

610.52 Sampling Techniques

A. Almost everyone in today’s society is affected by sampling in one way or another. Polls are taken for public opinion, manufactured products are sampled for quality control, and in market analysis, consumers are surveyed to discover their wants. A carload of coal or grain is accepted or rejected based on analysis of a few pounds. Physicians make decisions about health based on records obtained from a few hospitals. The use of sampling is widespread,

yet the importance of sampling sometimes goes unnoticed. In NRCS, day-to-day duties are often fulfilled with studies of raw data sets, such as the NRI and soil surveys, that originated as a survey or sample of some kind.

B. A sample is basically a small collection of information from some larger aggregated population. The sample is collected and analyzed to make inferences regarding the relevant characteristics of the total population. One thing that makes this process difficult is the presence of variation. If all farmers on Earth were alike, a sample of one farmer would represent all farmers. Since this is not the case, members of the population are usually different and, therefore, successive samples are usually different. Thus, the major challenge of statistics is to reach appropriate conclusions about the population in spite of sampling variation.

C. The ultimate goal of sampling is to make an inference about the population as a whole without measuring all of the elements belonging to it. There are a wide variety of sampling designs available that will enable us to collect a sample of the population that will be adequately representative. One of these techniques, simple random sampling, is presented in this subpart because it is easy to understand and apply. However, we should be aware that other sampling designs might allow you to collect data on a smaller number of observations and still obtain the same level of information that you would with a larger number of observations using simple random sampling. Work with a statistician to help you design the most efficient sample for your specific situation. A well-designed survey can save both time and money and produce estimates that are reliable.

D. Simple Random Sampling

(1) Simple random sampling is designed in such a way that every element in the population has an equal chance of being sampled. Careful planning ensures that this criterion is met. If certain elements of the population have no chance of entering the sample, we cannot say anything about those elements with any certainty. For example, suppose we want to conduct a study to determine the favorite TV show of residents in a certain city. If we only went to the middle schools and interviewed all the students in these schools, would we get a fair representation of residents in the city? Suppose we want to conduct a study to estimate the proportion of cultivated cropland that used conservation tillage in a given year. If we collected our sample from fields adjacent to roads, can we say anything about tillage in the nonadjacent fields?

(2) It may be necessary to begin with a list of the population. For example, field offices often need to sample tracts of land enrolled in various conservation programs within a county to check for compliance. Simple random sampling may be used to draw a sample from a list of signup sheets. Then a random number generator, such as the one in Excel, may be used to select a sample from that list. In this way, each enrolled tract in the county would have an equal chance of entering the sample. Often a population cannot be enumerated by a list. The following example describes simple random sampling of a geographic area.

E. Earthworms: An Example of Simple Random Sampling

(1) Suppose you want to estimate the average number of earthworms per square foot in the top 6-inch soil layer of a 10-foot by 20-foot garden. You set up a grid of lines at 1-foot intervals to get a total of 200 square foot plots. Sketch the layout on a piece of paper and number the plots from 1 to 200.

(2) Use the Excel random number generator to select a set of 10 plots to be sampled. Type the following command in a cell: =RANDBETWEEN (1,200). Copy and paste

this command into the nine cells below the first. If any of the values are repeated, you may use the command to select a new value to replace the redundant value. This is called sampling with replacement.

(3) Once you have the set of 10 random numbers, mark these on the paper sample grid. Find the corresponding locations in the garden and mark them. Record the number of earthworms in the top 6 inches of soil for the selected plots. In the random sample of 10 square-foot plots (6 inches deep) within a garden, the number of earthworms counted in each plot was: 2, 5, 6, 6, 7, 9, 10, 11, 12, and 15. We will use this example in calculating some of the statistics later in this subpart.

F. Sample Size

(1) Before using the random number table or Excel to select a sample, one must decide how large a sample will be needed. Too small a sample may lead to inaccurate observations about the population. Observing one farmer's conservation tillage methods does not tell much about the other 699 farmers in the area. Yet, it is not necessary to survey all 700 farmers either. This would require undue expense and time.

(2) How to determine a sample size? The sample size is a function of confidence constant t, the variance of sample mean, V, and the acceptable error, e, from the true mean as follows:

n= size of the sample = tV/e2

(3) Step 1: Specify the level of confidence required in the sample mean.
(i) t = confidence constant: the level of confidence required in the sample mean
(ii) t = 1σ provides 67-percent confidence level
(iii) t = 2σ = 4 for 95-percent confidence
(iv) t = 3σ = 6.76 for 99-percent confidence level

(4) Step 2: Specify the acceptable error, e, from the true mean of the population, or the variance of the sample mean, V.
(i) e = acceptable error from the true mean
(ii) V = variance = (R/t)2
(iii) R = the range of data expected

(5) For example, if there is a need to estimate the average use of conservation tillage of farmers in Cook and Haynes counties, plus or minus 50 acres, with 95 percent confidence, t would equal 4 and e would equal 50. The choice of values for t and e depends on the degree of precision wanted for the sample.

(6) The variance of the sample V is calculated from the sample data. So, how can an estimate of V be used to calculate sample size if no data have been collected yet? The best way to obtain V is to take a presample, calculate that variance, and use it in finding the sample size. But presampling is normally costly and time consuming. Thus, the following example was developed to show how to find a rough estimate of V without presampling.

(7) In the conservation tillage example, the population consists of 700 farms that are each 600 acres in size. The main variable of interest is the acreage that is conservation tilled. It's quite obvious that this amount could range from 0 to 600, because a farmer could either conservation till all or none of his or her acres or some number in between. Using the V formula with R= 600-0=600, V= (600/4)2 = 22,500:

With a value for V, sample size n can be calculated with a confidence constant of 4 (95-percent confidence), and an acceptable error of 50, as follows:

n = = tV/e2 = (4)(22,500)/(50)2 = 36

(9) To demand a 99-percent degree of confidence, and to require estimates to be within 40 acres of the true mean, would necessitate a sample of 95 farmers rather than 36:

n = (6.76) (22,500)/(40)2 = 95

(10) Generally, as the estimated variance and required degree of confidence increase and the acceptable error decreases, sample size must increase.

610.53 Basic Statistical Concepts

A. Bias, Accuracy, and Precision

(1) The terms “bias,” “accuracy,” and “precision” are commonly used—and often misused—when discussing sampling estimates. Bias is a systematic distortion that may be caused by a poorly constructed sampling design or a flaw in measurement. Suppose we want to estimate the average pH of soil in a field. An average value calculated from soil pH data obtained using an improperly calibrated hand-held pH meter would be biased.

(2) Accuracy is a measure of success in estimating the true value of a quantity. We rarely know what the true value of a quantity is. Sound statistical practices and careful measurements will help us get closer to the truth.

(3) Precision is the spread of the sample data about their average value. In our example, a field containing both areas of highly acidic soil and areas of alkaline soil would likely produce a wide range of pH values. The precision of the pH readings from this field would be lower than that of a field with more uniform pH readings. In summary, a seriously biased estimate of soil pH may be precise, but it cannot be accurate.

B. Types of Data

(1) Data are recorded for characteristics of interest for each sampling unit that is included in the sample. A characteristic that varies from one sampling unit to another is referred to as a variable. The type of data that are recorded for these variables will affect the type of analysis that may be conducted on the data. The types of data are ratio scale, interval scale, ordinal scale, and nominal scale.

(2) **Ratio scale** data have a constant unit interval and zero is a point on the scale used to measure these data. Examples of this type of data are number of acres, bushels per acre, height, and weight. Let’s consider the number of acres in terms of the definition above. Each acre is the same size, and it is physically possible to have zero acres.

(3) **Interval scale** data have constant unit intervals, but not a true zero. Celsius or Fahrenheit temperature scales are an example of interval scales. Each Celsius or Fahrenheit degree is a constant interval unit, but zero is arbitrary. The Kelvin temperature scale on the other hand has a constant interval unit and a physically meaningful zero. The Kelvin temperature scale is a ratio scale.

(4) **Ordinal scale** data do not have a constant interval but may be used in relative comparisons. Some examples of these ordered data are height recorded as high, medium, or low; a preference rating on a scale of 1 to 10, where 1 is least preferred and 10 is most preferred; and brightness recorded as bright, brighter, or brightest.

(5) **Nominal scale** data are classified by name only with no relative order for comparison. Examples of nominal scale data include brand of seed corn, questionnaire responses of yes or no, and eye color (e.g., blue, green, and brown).

(6) **Conservation Tillage Sample Data Set**.—This data set contains hypothetical data from 25 farms, each 600 acres in size, from two counties. It contains data on observation number (OBS), acres conservation tilled (ACRES), age of operator (AGE), years of formal education (EDUC), county (CO), and "uses conservation tillage" (CONSTL). This data set is shown below as it would appear in an Excel spreadsheet and will be used in many subsequent examples in this subpart.

Table F-1 Conservation Tillage Sample Data Set

	A	B	C	D	E
1	OBS	ACRES	AGE	EDUC	COUNTY
2	1	190	50	14	Cook
3	2	135	59	14	Haynes
4	3	275	39	16	Haynes
5	4	185	49	14	Haynes
6	5	340	39	12	Cook
7	6	575	32	16	Haynes
8	7	210	51	14	Cook
9	8	95	55	8	Haynes
10	9	55	67	8	Cook
11	10	210	28	12	Haynes
12	11	280	35	14	Haynes
13	12	0	68	8	Cook
14	13	120	55	12	Haynes
15	14	80	59	12	Cook
16	15	600	30	18	Cook
17	16	415	29	18	Haynes
18	17	0	62	8	Haynes
19	18	395	27	16	Haynes
20	19	480	31	16	Cook
21	20	180	52	12	Cook
22	21	60	63	6	Haynes
23	22	0	61	12	Haynes
24	23	108	61	12	Haynes
25	24	225	46	12	Cook
26	25	295	37	16	Cook

C. Plot the Data

Plotting the data allows the analyst to get a mental picture of the characteristics of the data set and is an important tool to be used before, during, and after analysis. These plots will assist with visualizing the value around which most of the data are concentrated, the spread of the data, and any values that are much larger or smaller than the majority of the observations. Relationships between two variables may become evident through viewing of scatter plots. Several types of plots commonly used for this purpose are line plots, stem-and-leaf plots, histograms (bar charts), box plots, and scatter plots. Histograms and scatter plots can be created using Excel.

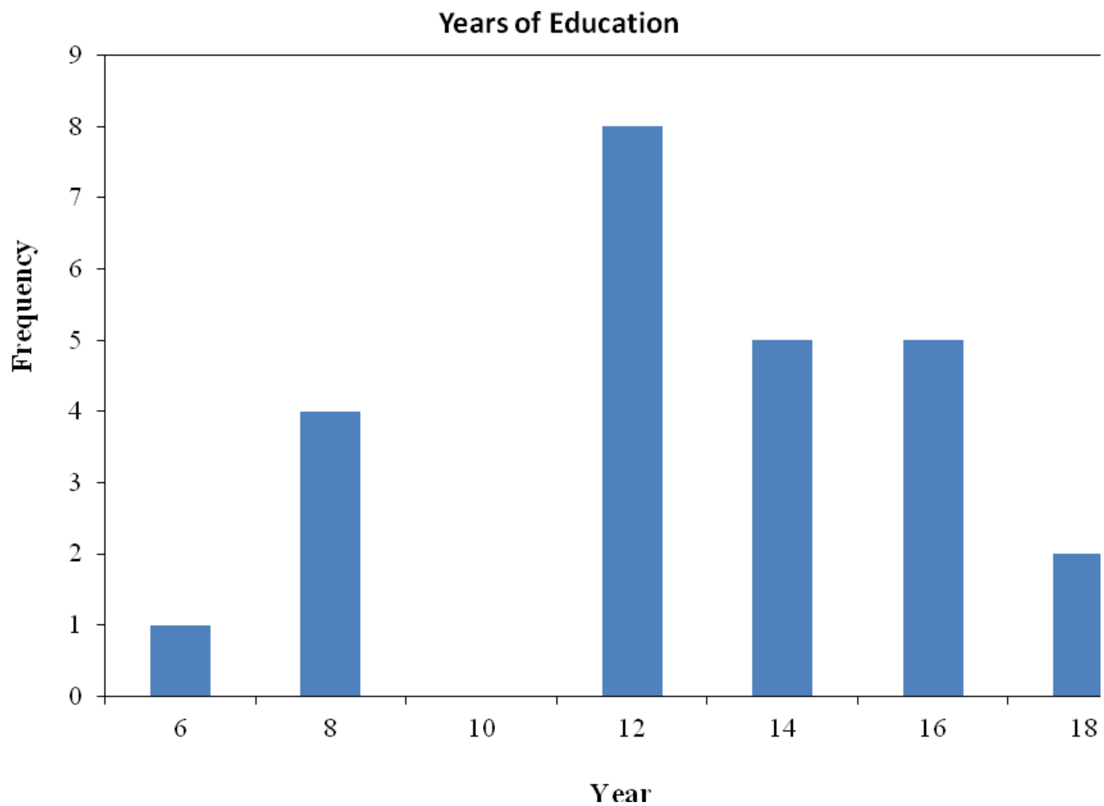
D. Histogram

(1) A histogram displays the frequency of values for observations in a dataset. It provides a picture of the distribution of data. Preparing a histogram enables us to

easily see the minimum, maximum, and most common values in a data set. We may be able to use a histogram to predict what the calculated value of the average will be.

(2) Figure 610F-1 is a histogram displaying the number of years of education for farmers included in the Conservation Tillage example. Two farmers had 18 years of education and one had 6 years. The range of data is 12 (18-6). Most farmers in this example (eight in number) had 12 years of education. From this histogram we can guess that the average farmer in this example has at least 1 year of post-high-school education.

Figure F-2 Histogram of Years of Education for Farmers in the Conservation Tillage Example



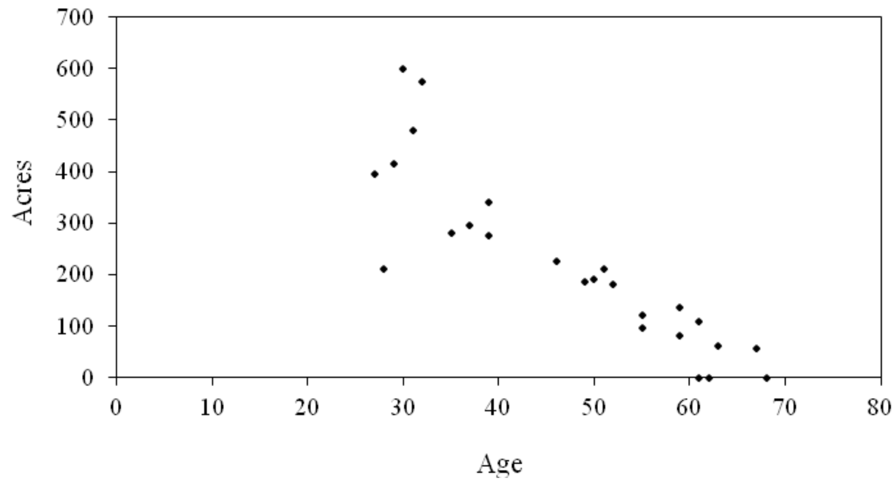
(3) To construct this chart in Excel, you need to use the histogram tool in the Excel Analysis ToolPak. If you don't see the "Data Analysis" button in the "Analysis" group on the "Data" tab, you must load the Analysis ToolPak add-in (see note below). Set up a column containing the range of education (6 to 18) with 2-year increments in cells F1-F7 (you may choose 1-year increments or some other equally spaced values). These are the bin values. Select "Histogram" from the choices in "Data Analysis" drop-down list. Provide the Input Range (C1:C26), Bin Range (F1:F7), and Output Range (H1). Check the boxes next to "Labels and Chart Output" and hit "OK."

Note: The data analysis tools are CCE-approved as part of Excel and Access. In case your office has not had the Excel Data Analysis Tools loaded as part of the CCE Office installation, you should follow the "Excel Help" instructions for loading it. All NRCS technical specialists should have it available.

E. Scatter Plots

(1) Scatter plots provide a picture of the relationship between two variables. Figure 610F-2 is based on the conservation tillage example. The plot of acres versus age exhibits an inverse relationship between the number of acres in conservation tillage and the age of the farmers. In this example it appears that older farmers tend to use conservation tillage on fewer acres than do younger farmers.

Figure F-3 Scatter Plot Of Acres Of Conservation Tillage Versus Age Of Farmers In The Conservation Tillage Example



(2) The scatter plot is constructed using the “Scatter” button in the “Charts” group on the “Insert” tab in Excel. To construct this chart in Excel, highlight all data for acres and age in cells B1-C26, press the “Scatter” button and select the type of scatter plot with no lines.

610.54 Basic Statistics and Computation for Simple Random Sampling

A. Introduction.—This section presents a number of basic statistics describing the central tendency and variability that are derived from simple random sampling from the targeted population. Sampling designs determine the methods appropriate for computing these statistics. Other sampling designs require the use of alternative computing equations and possibly other statistical software to correctly process the data. For example, NRI data are collected using a stratified cluster sample. Calculating the means and standard errors for these data using the techniques presented in this section will lead to erroneous results. Work with your local NRI specialist to correctly summarize NRI data. Similarly, if you obtain data from other sources, always ask what sampling design was used to collect the data and how to correctly summarize it. The equations presented in the subsequent sections are common to sampling literature including Cochran (1977) and Schaeffer et al. (1996).

B. Mean, Median, and Mode

(1) The three measures of typical central tendency values are arithmetic mean, median, and mode. Arithmetic mean is probably the most well-known and often used statistic. It is referred to as the sample mean when it is derived from a sample. The mean is merely the arithmetic average of all the values from a sample and is intended to represent the “typical” value of the drawn population. Its advantages are ease of

computation, common usage, and use in algebraic manipulation. But the major disadvantage of this method is that arithmetic mean is unduly affected by extreme values and may, in fact, be far from representative of the data in the population. It is important, then, to be able to diagnose the variability of the data as well as the mean. Samples from data populations such as real estate values or annual incomes often contain extreme values. The sample mean is calculated as:

$$\overline{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{x_1 + x_2 + x_3 + \ldots + x_n}{n} \tag{F-1}$$

(2) In the random sample of 10 square-foot plots (6 inches deep) within a garden, the number of earthworms counted in each plot was: 2, 5, 6, 6, 7, 9, 10, 11, 12, and 15. The average number of earthworms per square foot in the top 6-inch layer of soil for the garden, $\overline{x}$, is 8.3. In Excel, place the 10 sample values in cells in a column (e.g., B2:B11) as in the figure below.

Figure F-4 A Random Sample Of Earthworms

	A	B
1	Plot	Number of Earthworms
2	1	2
3	2	5
4	3	6
5	4	6
6	5	7
7	6	9
8	7	10
9	8	11
10	9	12
11	10	15
12		

(3) Type the following command in cell B12: =AVERAGE (B2:B11). Alternatively, you may use the Data Analysis button in the "Analysis" group on the "Data" tab. Select "Descriptive Statistics" from the choice list. Enter the input range (e.g., B2:B11), output range (e.g., C1), check the boxes next to "Columns," "Labels in First Row," and "Summary Statistics," and hit "OK." The set of descriptive statistics calculated for the 10 selected numbers include mean, standard error, median, mode, standard deviation, sample variance, kurtosis, skewness, range, minimum, maximum, sum, and count, as shown in the figure below.

Figure F-5 Example of Random Sampling in EXCEL

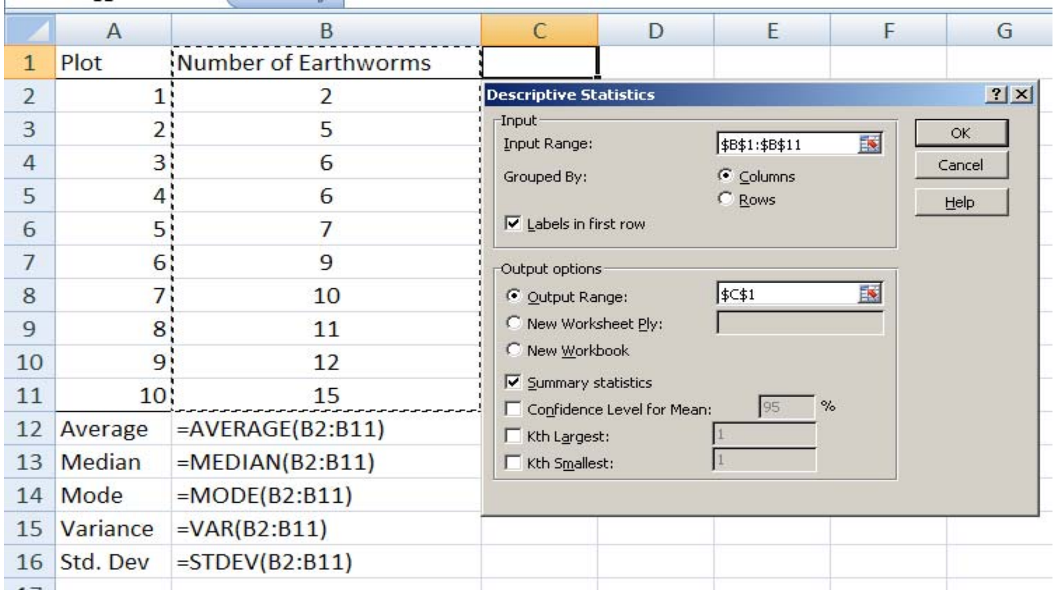


Figure F-6 Statistical Summary of a Random Sample

	A	B	C	D
1	Plot	Number of Earthworms	*Number of Earthworms*	
2	1	2		
3	2	5	Mean	8.3
4	3	6	Standard Error	1.21
5	4	6	Median	8
6	5	7	Mode	6
7	6	9	Standard Deviation	3.83
8	7	10	Sample Variance	14.68
9	8	11	Kurtosis	-0.27
10	9	12	Skewness	0.16
11	10	15	Range	13
12	Average	8.3	Minimum	2
13	Median	8	Maximum	15
14	Mode	6	Sum	83
15	Variance	14.68	Count	10.00
16	Std. Dev	3.83		

(4) The median value provides a second measure of central tendency. The median value of a data set is the midpoint or middle value of the dataset when it is ordered by size of those values. If the dataset has an even number of observations, the median value will be the average of the two middle values.

(5) In the example above, the number of earthworms counted in each plot was 12, 15, 9, 6, 7, 6, 10, 11, 2, and 5. To determine the median value of a set of numbers, the data must first be ordered by size as 2, 5, 6, 6, 7, 9, 10, 11, 12, and 15. This sample has an even number of observations. The median value, 8, is the average value of the middle two observations, 7 and 9. To calculate the median of the 10 values in Excel, type the following in cell B13: =MEDIAN(B2:B11).

(6) There are times when it may be better to use the median than the mean when reporting “typical” values. As a simple example, suppose the annual incomes (in thousands of dollars) for a random sample of 10 individuals working for a company are 23, 23, 24, 25, 32, 33, 33, 35, 36, and 150. The mean annual income of these 10 individuals is 41.4 thousand dollars and the median annual income is 32.5 thousand dollars. Which of these two measures might better represent the typical annual income of employees in that company? Why?

(7) Mode is the most frequent value observed in a dataset. In the earthworm count example, the mode is 6. To calculate the mode of the 10 values in Excel, type the following in cell B14: =MODE (B2:B11). The Excel formulas for mean, median, and mode are displayed in the above figures as well.

C. Sample Variance and Standard Deviation

(1) Perhaps the most widely used measure of data variability is standard deviation. Standard deviation characterizes dispersion about a mean and gives an indication as to whether most of the data falls close to the mean or is spread out. Variation about mean is often spoken of in terms of variance rather than standard deviation. Variance is simply the square of the standard deviation.

(2) An advantage of these measures of dispersion is that they can be used to formulate confidence limits and hypothesis tests (to be discussed later). The major disadvantage becomes apparent when comparing two sets of data because the formula for a standard deviation dictates that the standard deviation measurement of a data set with relatively larger values will be higher than that of one with relatively smaller values. Consider the following examples: The mean of data set A is 15 and the mean of data set B is 1,000. The standard deviation is 9.78 for data set A and 20.09 for set B. It would be inaccurate to conclude that data set B is more variable than data set A. Therefore, a method of measurement is needed for comparing the variability of data sets with widely differing means.

(3) The standard deviation and variance of a data set indicate to what degree the data in general varies from the mean. The higher these measures are, the more dispersion exists in the data. These two measures are unit specific. That is, if the mean of a variable is in acres, the standard deviation is a function of the size of the mean. Therefore, it is meaningless to compare standard deviations between two different variables, say conservation tillage acres and farmers' age, as the magnitudes of the means are so different. It may be useful in some cases, such as when comparing the standard deviation of conservation-tilled acres in one sample to the standard deviation of conservation-tilled acres in some other sample. This is acceptable and would aid in choosing between two sets of data to study.

(4) The sample variance represents the variability in individual sample observations. The sample variance, s^2, is used in calculating the estimated variance for the estimated population mean and total, the corresponding confidence intervals, and in calculating the sample size needed to estimate population means and totals. The sample variance for a simple random sample is calculated as (Cochran 1977, Schaeffer et al., 1996):

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1} = \frac{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2}{n-1} . \qquad \text{(F-2)}$$

(5) The standard deviation for a simple random sample is the square root of the sample variance.

(6) The sample variance and standard deviation may be calculated in Excel, as shown above. In cell B15 type =VAR (B2:B11) to calculate the sample variance or =STDEV (B2:B11) to calculate the standard deviation. The sample variance for this example is 14.68 and the standard deviation is 3.83 earthworms per square foot of soil (6 inches deep).

D. Coefficient of Variation

(1) It may be useful in some cases to compare the variability of two different sets of data, such as comparing the total number of conservation-tilled acres in one sample to that of another sample. In this case, we would like to use a measure of relative variation—the coefficient of variation (CV)—to compare the variations of variables across different data sets. CV is a measure of relative variation in each set of data and is calculated by dividing the standard deviation by the mean, then multiplying 100. Using the example cited previously, the mean of data set A is 15 and the mean of data set B is 1,000. The standard deviation is 9.78 for data set A and 20.09 for data set B; therefore, the CV of data sets A and B are 65.17 and 2.01 respectively. Thus, with the magnitude of the mean accounted for, data set A shows more variability than data set B, even though the standard deviation of A is less than that of B.

(2) A second advantage of using the CV is that one is able to compare the variability of data sets that are in different units. The CV is independent of the unit of measurement. It is proper to compare the CV for wheat yields to the CV for soil loss.

(3) Overall, if one were interested in analyzing the variability of more than one set of data through comparisons, it would be more meaningful to use the coefficient of variation than the standard deviation.

E. Standard Error of the Mean

(1) The standard error, which can be thought of as the standard deviation of sample means, is a measure used extensively in the development of confidence intervals.

(2) The standard error of the mean is a measure that indicates the variability in sample means, much as the standard deviation indicates variability in individual sample observations. In the earthworm example, a simple random sample was taken from a population. If the random sample were to be repeated, the mean would probably not be 8.3. In fact, numerous samples from the same population would yield different means.

(3) It would be possible to estimate the variability of sample means by actually taking repeated samples and using the standard deviation formula. But the calculation of the standard error of the mean makes it possible to gain the same information by using the one initial sample. The standard error of the mean is calculated by dividing the standard deviation by the square root of the sample size. The standard deviation in the earthworm example is calculated as 3.83 earthworms per square foot of soil (6 inches deep). Dividing this result by the square root of 10 (the sample size) gives a standard error of 1.21 earthworms per square foot of soil (6 inches deep). Recall that the standard error is one of the statistics reported in the descriptive statistics found in the data analysis tools of Excel.

(4) Standard Error = $s_d = \sqrt{s/n}$ (F-3)

F. Correlation Coefficient

(1) The correlation coefficient is a statistic that measures a specific type of relationship between two variables. There are several different ways to measure the correlation between two variables. A commonly used correlation coefficient is Pearson's correlation coefficient. Pearson's correlation coefficient between two variables is defined as the covariance of the two variables divided by the product of their standard deviations. A sample-based Pearson's correlation coefficient for variables x and y is:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

(F-4)

(2) The correlation coefficient ranges numerically between 1 and -1.

(3) In many instances, a sample with more than one variable (characteristic) may be taken. For example, if a sample is taken of farmers who use conservation tillage, data on the farmers' ages and the farmers' education levels might be collected. By looking at the relationship between data on farmers' ages and data on their education, a positive correlation coefficient close to one would suggest that older age is positively associated with higher education. A negative correlation coefficient close to -1 would indicate that older age is negatively associated with education. And finally, a correlation coefficient close to zero would indicate that the data do not support concluding that there is any significant correlation between a farmer's age and his or her education.

(4) Correlation should not be thought of as cause and effect, but merely as directional association. For example, economists have found a positive correlation between education and income. In general, people with more education have higher income than do people with less education. But this correlation does not give us any statistical evidence to show that higher education causes higher incomes. In fact, causation may even run the other direction as people with higher income may buy more education just as they buy more automobiles and more vacations. Thus, higher income may cause higher education! Do not fall into the trap of extending correlation to causation. Causation will be discussed in the section on the use of regression analysis.

(5) Let's go through an example of calculating the correlation coefficient using data in the conservation tillage example. A scatter plot (figure 610F-2) displayed the negative relationship between these two variables. From that plot we know that the correlation coefficient between age and acres of conservation tillage will be negative. To calculate the correlation coefficient between age and acres, select the "Correlation Wizard" from the drop-down list of the "Data Analysis" button in the "Analysis" group on the "Data" tab, type B1:C26 in the "Input Range" box of the Correlation Wizard, check "Columns," "Labels in First Row," and "Output Range," type A28 or any other empty cell in the "Output Range" box, and click "OK." The resulting correlation coefficient between the two variables is -0.88.

610.55 Confidence Limits (Reliability of a Sample)

A. A point estimate from a sample, such as the sample mean, is usually not very meaningful by itself. It is almost certain to be less than exact and it gives absolutely no indication of how much uncertainty is associated with the estimate. Any sample is subject to sampling error due to variability in the population. This variation can be found by comparing results of multiple samples from the same population. For example, five different samples of age from the 700 farmers in Cook and Haynes counties would yield five different sample means. These different sample means reflect the variation that is inherent in the population of 700 farmers. Generally, only one sample is taken so the mean of the sample should be accompanied by some interval to ensure that the true population means lies within the interval.

B. The statistical method for indicating reliability of a sample mean involves the use of confidence limits. Confidence limits for the mean of a sample express the confidence that the true population mean falls within a given interval. They are expressed in percentage probability terms, with a higher probability indicating a higher level of confidence that the true mean falls within the given interval. For example, the upper and lower confidence limits (40 versus 48) for the mean of a sample of age from the population of 700 farmers could be expressed as, the mean age of the population = 44 with 90-percent confidence. (Another way to say this is: If simple random samples were drawn for all possible samples of size n, 90 percent of the time the associated confidence intervals would contain the true mean. Note that the confidence intervals would differ with different samples.)

C. This statement suggests that we are 90-percent certain that the true population mean is between 40 and 48. Conversely, the interval will not contain the population mean in 1 out of 10 samples. The most common percentages of confidence used in this method are 90 percent, 95 percent, and 99 percent. Since 90-percent confidence is the same as 10-percent error and 95-percent confidence is the same as 5-percent error, etc., the most common probabilities of error are 10 percent, 5 percent, and 1 percent respectively. An interval of reliability can be calculated for the mean of a sample in the following manner:

(1) Confidence limit = mean +/- (t)*standard error of the mean.
(2) Confidence limit = the estimate +/- the bound on the error of estimation,
where, the bound on the error of estimation = (t)*standard error of the mean

D. The t-value is a confidence coefficient that is based on degrees of freedom and the percent confidence chosen. In general, the degrees of freedom for a sample equal the number of observations in the sample minus 1. A matrix of “t” values is given in table 610F-2. Using the age of farmers as example, sample size is 25, so degrees of freedom is 24, if 95-percent confidence is chosen as the level of reliability.

E. The upper and lower bounds on the confidence intervals are calculated as the estimate +/- the bound on the error of estimation. Examples of calculating confidence limits for the estimates of the population mean, total, and proportion are included in the sections 610.57, 610.58, and 610.59, respectively.

F. In table 610F-2, with degrees of freedom, and probability of error (or percent of confidence) required, “t” can be obtained from moving down the .05 probability of error (95-percent confidence) column. The “t” value for 20 degrees of freedom is 2.09 and the “t” for 30 degrees of freedom is 2.04. To find the “t” for 24 degrees of freedom, interpolate and find 2.07 as t-value. Given the mean age as 47.4 and the standard error as 2.71, the confidence limits could be derived as follows:

(1) Confidence limits = 47.4 +/- (2.07) (2.71) = 47.4 +/- 5.6
(2) Confidence limits = 41.8 and 53.0

G. Thus, one can be 95-percent sure that the average age of the 700 farmers falls between 41.8 and 53, given the mean of the 25 farmer sample.

Table F-2 t-Table

Freedom	**50 (50%)**	**.10 (90%)**	**.05(95%)**	**0.1 (99%)**
1	1.000	6.34	12.71	63.66
2	.816	2.92	4.30	9.92
3.	.765	2.35	3.18	5.84
4.	.741	2.13	2.78	4.60
5	.727	2.02	2.57	4.03
6	.718	1.94	2.45	3.71
7	.711	1.90	2.36	3.50
8	.706	1.86	2.31	3.36
9	.703	1.83	2.26	3.25
10	.700	1.81	2.23	3.17
11	.697	1.80	2.20	3.11
12	.695	1.78	2.18	3.06
13	.694	1.77	2.16	3.01
14	.692	1.76	2.14	2.98
15	.691	1.75	2.13	2.95
20	.687	1.72	2.09	2,84
30	.683	1.70	2.04	2.75
40	.681	1.68	2.04	2.71
50	.679	1.68	2.02	2.68
75	.678	1.67	2.00	2.65
100	.677	1.66	1.98	2.63

125	.676	1.66	1.98	2.62
150	.676	1.65	1.98	2.61
200	.675	1.65	1.97	2.60
300	.675	1.65	1.97	2.59
400	.6.75	1.65	1.97	2.59
500	.674	1.65	1.96	2.59
1000	.674	1.65	1.96	2.58
1000+	.674	1.64	1.96	2.58

H. Another example: Determine the 90-percent confidence limits for the mean of the education level of the farmers in the conservation tillage. Given the mean of the 25-farmer sample as 12.8 years of education with a standard error of .65, then the t-value from the t-table is 1.71 (under the .10 (90-percent) column of the t-table, that is interpolated between 1.72 and 1.70. Substitute these values into the equation to derive the confidence limits, as follows:

(1) Confidence limits = 12.8 +/- (1.71) (.65) = 12.8 +/- 1.1
(2) Confidence limits = 11.7 and 13.9.

I. Thus, one can be 90-percent sure that the average education level of the 700 farmers falls between the near-high-school-graduate level and the 2-year college level, given the mean of the 25-farmer sample.

610.56 Hypothesis Testing

A. Introduction

(1) A hypothesis can be defined as a tentative theory or supposition. Everyone hypothesizes from time to time when observations are made. For example, the following statements could be taken as hypotheses:
(i) The average height of American adult males is 5 feet, 9 inches.
(ii) The soybean yield in watershed X is 35 bushels per acre.
(iii) The average row crop farmer in the Midwest conservation tills half his cropland.
(2) These three hypotheses are statistical hypotheses because they are statements about a statistical population; specifically, they are statements about certain variables (characteristics such as height, yield, and percent of conservation tillage) in a statistical population.
(3) It is often desirable to test if such hypotheses are valid. To do this, an appropriate sample is taken, and the hypothesis is rejected or not rejected based on the results of statistical tests.

B. Testing the Mean

(1) The average 600-acre farmer in Cook and Haynes counties is 55 years old, has an eighth grade education, and conservation tills 200 of his acres. These are three separate hypotheses about the same 700-farmer population. How would one go on testing whether these estimates are accurate? One option would be to interview all 700 farmers. Although very thorough, this method involves extensive time and money—too extensive for the resources of most Government agencies. Instead, one could use the following process:
(i) Interview an appropriate-sized random sample of the 700 farmers.
(ii) Gather information about age, education, and degree of conservation tillage used.
(iii) Calculate the sample mean for each of the three variables.
(iv) Use hypothesis testing methods to compare the sampled means to the three hypotheses made above.

(2) Assuming steps i, ii, and iii have already been completed (using hypothetical data) and the results of these steps helped calculate the sample means, step iv involves the use and comparison of two "t" statistics: the "t-value" shown in the t-table (just as was done for confidence intervals,) and the "calculated t," which is calculated using information from the sample.

(3) As was done to calculate confidence intervals, the percent confidence (e.g., 90 percent, 95 percent, or 99 percent) required of the test must be determined. Using this value, plus the degrees of freedom, the proper t-value can be found in the t-table. In this case, the sample size is 25, so the degrees of freedom are one less than that, or 24. If a 90-percent confidence is required in the hypothesis test, the next step is to interpolate between 20 and 30 degrees of freedom in the t-table, under the .10 (90-percent) column. The proper t-value is equal to 1.71.

(4) The equation used to find the calculated t is the absolute difference between sample mean and hypothesized population mean divided by the standard error of the sample mean.

Calculated t = |sample mean – hypothesized mean| / standard error of the sample mean

(5) Given the sample mean and the standard error of the sample mean, the calculated t-value for the farmers' age is derived by subtracting the hypothesized mean (55) from the sample mean (47), which gives -8. The absolute value |-8|=8 is then divided by the standard error of the mean, 2.71, to yield a calculated t-value of 3.86:

The calculated t-value for the farmers' age = |47-55| / 2.71 = 3.86

(6) The comparison rule for t-value from the t-table and the calculated t is as follows:
(i) If the calculated t exceeds t –value from table 610F-1, reject the hypothesis.
(ii) If not, do not reject the hypothesis.

(7) The age hypothesis stated that the 700 farmers' average age is 55. The calculated t (3.86) is greater than the t-value from the t-table (1.71), so this hypothesis is rejected. (The sample tends to show the average age is less than 55.) The test is to reject with 90-percent confidence, thus a 10-percent margin of error is acceptable.

(8) To test the second hypothesis that the farmers' average education level is an eighth grade education, the same steps are followed using data from the education information in the sample. If the 90-percent level of confidence is satisfactory, the t-value in the t-table would be the same as in the same example (t=1.71). The calculated t in this example would be:

The calculated t for education = |12.8 – 8| / 0.65 = 7.38

(9) In the equation, 12.8 is the given sample mean, 8 is the hypothesized mean, and 0.65 is the given standard error of the mean. The calculated t (7.38) is larger than the t-value in the t-table (1.71), so the hypothesis that the average farmer in the population of 700 has an eighth grade education is rejected. (The sample would tend to show they have higher than an eighth grade education on average.)

(10) The third test is on the hypothesis that the average farmer conservation tills 200 of his 600-acre farm. Assuming a 90-percent confidence level again, the t-value in the t-table is 1.71. The calculated t is .59 using the given data from the sample under the conservation till variable as below:

The calculated t for conservation tilled acres = |220 – 200| / ÷ 34.16 = 0.59.

(11) The calculated t (0.59) does not exceed the t-value in the t-table (1.71), so the hypothesis that the average farmer conservation tills 200 acres is not rejected. To summarize, statistical procedures were used to test three different hypotheses regarding 700 farmers in Cook and Haynes counties. The procedures involve comparison of a value (calculated t), which is derived using the combined results of the sample and the hypothesis to a t-value (in the t-table), and a confidence constant, which takes into consideration the sample size and an acceptable level of precision.

(12) The failure to reject a hypothesis reveals that the sample mean itself is no more accurate than the hypothesized value (although the methods used to obtain the sample mean may be more defensible). The rejection of a hypothesis shows that the sample mean is statistically more accurate than the hypothesized mean; confidence in this decision, however, is only as high as the level of confidence used to obtain the t-value in the t-table.

(13) If we have two different hypotheses about the true mean we need to test them to find out which has the greater probability of being true. When we test a null hypothesis, H0, against an alternative hypothesis, H1, based on sample observations, two types of error may occur:

Decisions/Facts	H0 is true	H0 is false
Fail to reject H0	correct decision: true negative	Type II error: false negative
Reject H0	Type I error: false positive	correct decision: true positive

(14) The probability of making type I error is called α and the probability of making type II error is called β. Though we cannot eliminate the errors completely, we may control the probabilities of making these errors by collecting an appropriate number of samples and by setting appropriate critical regions (of two normal distribution curves) (Chu, 1968).

C. Test for Difference Between Two Means – Comparing Two Groups of Data

(1) One of the most-often used statistical hypothesis tests is the test for difference between two means. The differences being investigated are those between two means, and the hypothesis being tested states that the two means are equal. Uses for this test could include comparing the rate of weight gain of hogs on two different rations, comparing math scores of male verses female students, or testing to see if the 300 farmers in Cook County vary from the 400 in Haynes County in terms of age, education, and the use of conservation tillage. The actual hypothesis would state that

there are no differences in average scores between male and female students; and that there are no differences between average age, education, or use of conservation tillage between farmers in the two counties, respectively.

(2) To test each of the three hypotheses, that there is no difference between average use of conservation tillage, age, and education between farmers sampled in Cook and Hynes counties, a "calculated t" and a t-value from the t-table are compared to determine whether each of the three hypothesis is rejected or not, just as was done for the "Testing the Mean" procedure. However, the calculated t formula for the test for difference between two means is much more complicated than the one for testing the mean (see appendix of formulas). The decision rule for the test for difference between two means is: If the calculated t is larger than the t-value from the t-table, reject the hypothesis (this is the identical rule used in testing the mean).

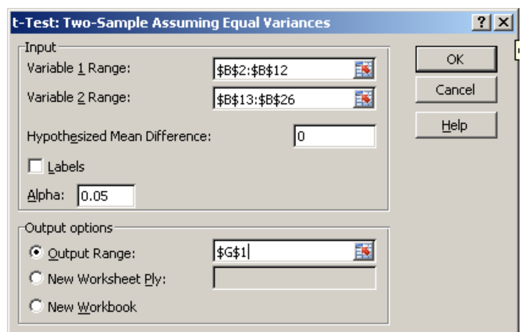
(3) The Excel Data Analysis ToolPak has one t-Test for paired samples and two t-Test for unpaired samples. One t-Test for unpaired samples assumes that the two samples from populations with equal variances and the other do not. With the equal variance assumption, the t-Test uses the pooled variance of the two samples in the t-Test formula; without the equal variance assumption, the t-Test uses the average of the two sample variances in the t-Test formula. The data about the farmers of Cook and Hynes counties are unpaired samples.

(4) To test the hypothesis that the average use of conservation tillage is the same in Cook and Haynes counties using the Excel t-Test function, you need to first sort the data set by county, and then click the "Data Analysis" button in the "Analysis" group on the "Data" tab. The next step is to choose the "t-Test: Two-Sample Assuming Equal Variances" option from the list of data analysis tools. As showing in figure 610F-6.x, in the t-Test dialog window, you need to specify the locations of inputs and output, and set the hypothesized mean difference as 0. Assuming 95-percent confidence is required in the test, you need to set the Alpha value to 0.05, then click "OK."

(5) The test output shows that the calculated t is 0.54, with 23 degrees of freedom in this example. With 95-percent confidence, the t-value is 2.07. The calculated t is not larger than the t-value derived from the t-table, so the hypothesis is not rejected. Using the sample of 11 farmers from Cook County and 14 farmers from Haynes County, plus the test of difference, it can be concluded that the population of 300 farmers in Cook County conservation till, on average, the same proportion of their farms as do the 400 farmers in Haynes County. A t-Test with unequal variances assumption can be performance in similar fashion with little difference in results in this case.

Figure F-6 t-Test for Two Unpaired Samples

	A	B	C	D	E	F	G	H	I
1	OBS	ACRES	AGE	EDUC	COUNTY		t-Test: Two-Sample Assuming Equal Variances		
2	1	190	50	14	Cook				
3	5	340	39	12	Cook			Variable 1	Variable 2
4	7	210	51	14	Cook		Mean	241.3636364	203.7857143
5	9	55	67	8	Cook		Variance	32485.45455	28210.64286
6	12	0	68	8	Cook		Observations	11	14
7	14	80	59	12	Cook		Pooled Variance	30069.25663	
8	15	600	30	18	Cook		Hypothesized Mean Difference	0	
9	19	480	31	16	Cook		df	23	
10	20	180	52	12	Cook		t Stat	0.537850742	
11	24	225	46	12	Cook		P(T<=t) one-tail	0.297923373	
12	25	295	37	16	Cook		t Critical one-tail	1.713871517	
13	2	135	59	14	Haynes		P(T<=t) two-tail	0.595846747	
14	3	275	39	16	Haynes		t Critical two-tail	2.068657599	
15	4	185	49	14	Haynes				
16	6	575	32	16	Haynes				
17	8	95	55	8	Haynes		t-Test: Two-Sample Assuming Unequal Variances		
18	10	210	28	12	Haynes				
19	11	280	35	14	Haynes			Variable 1	Variable 2
20	13	120	55	12	Haynes		Mean	241.3636364	203.7857143
21	16	415	29	18	Haynes		Variance	32485.45455	28210.64286
22	17	0	62	8	Haynes		Observations	11	14
23	18	395	27	16	Haynes		Hypothesized Mean Difference	0	
24	21	60	63	6	Haynes		df	21	
25	22	0	61	12	Haynes		t Stat	0.533126423	
26	23	108	61	12	Haynes		P(T<=t) one-tail	0.299771703	
27							t Critical one-tail	1.720742871	
28							P(T<=t) two-tail	0.599543407	
29							t Critical two-tail	2.079613837	
30									



(6) The hypothesis, which states that the average age of the 300 farmers in Cook County does not differ from the average age of the 400 farmers in Haynes County, can be tested as well using the same Excel tool. Assuming equal variances, the calculated t is 0.25. If a 95-percent confidence was assumed, the critical t value would be 2.07. Since the calculated t is not larger than the t-value from the t-table, the original hypothesis about the average age of the farmers is not rejected. Using the same procedures, it would also be concluded that the average education level between counties does not differ statistically for the total populations, since the calculated t (0.14) is less than the critical t value (2.07).

(7) The test for difference between two means is a useful technique in statistics. Many comparisons of large populations can be made using this test along with sampling techniques. The test is straight forward using the Excel Data Analysis ToolPak.

610.57 Estimating the Population Mean

A. Formulas

(1) Agronomists may want to test a new variety of seeds to determine the average number of days between planting and germination or between germination and maturity. A feed company may want to test the average weight gain for chicks fed a new ration during their first 3 weeks. A farmer may want to know the average amount of protein per ton of silage harvested on the farm. The estimators in this section provide a method for estimating the population mean from data collected as a simple random sample of the population. For a simple random sample of size n from a population of size N, estimates of population means, estimated variance of the means, and bound of the error of the estimation can be computed with the following equations:

(2) Estimator of the Population Mean

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n} \qquad \text{(F-5)}$$

(3) Estimated Variance of the Population Mean

$$\hat{V}(\bar{y}) = \frac{s^2}{n}\left(\frac{N-n}{N}\right), \qquad \text{(F-6)}$$

Where s^2 is the sample variance defined in equation F-2 as $s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}$ and the quantity $\left(\frac{N-n}{N}\right)$ is the finite population correction factor (FPC). The FPC decreases the size of the variance, thus making the estimate more precise. As a rule of thumb, if the FPC is greater than 0.95 (or equivalently if n is one-twentieth of N or smaller, the FPC can be ignored.

(4) Bound on the Error of Estimation

$$B = t\sqrt{\hat{V}(\bar{y})} = t\sqrt{\frac{s^2}{n}\left(\frac{N-n}{N}\right)}, \qquad \text{(F-7)}$$

Where t = the Student's t value. Table 610F-2 of t-values is includes earlier in this subpart.

(5) Sample Size Required

The sample size required to estimate the true mean with a bound on the error of estimation B is:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2} \qquad \text{(F-8)}$$

Where $D = \frac{B^2}{4}$,

B is defined in equation F-7, and σ^2 is the population variance. We seldom know the population variance. If we conduct a pilot test survey, we can use s^2, the sample variance from that sample to estimate σ^2. Alternatively, we can use the following approximation to represent the standard deviation:

$$\sigma \approx \frac{range}{4} \qquad \text{(F-9)}$$

where the range is the difference between the lowest and highest values.

B. Examples

(1) We will use the same earthworm example used earlier to demonstrate how we can use Excel to calculate an estimate of the population mean and the estimated variance of the mean. In the random sample of 10 square-foot plots (6 inches deep) within a garden, the number of earthworms counted in each plot was 2, 5, 6, 6, 7, 9, 10, 11, 12, and 15. The sample size, n, is 10 and the population size, N, is 200.

(2) Use the "Data Analysis" button in the "Analysis" group on the "Data" tab. Select "Descriptive Statistics" from the choice list, following the same procedure as before, but check the box next to "Confidence Level for Mean" as well (Note the box to the right of "Confidence Level for the Mean" has 95 percent by default.), and hit "OK" (figure 610F-7). The set of descriptive statistics calculated for the 10 selected numbers include mean, standard error, median, mode, standard deviation, sample variance, kurtosis, skewness, range, minimum, maximum, sum, count, and confidence level, as shown in figure 610F-8.

Figure F-7 Estimation of Population Mean Using EXCEL

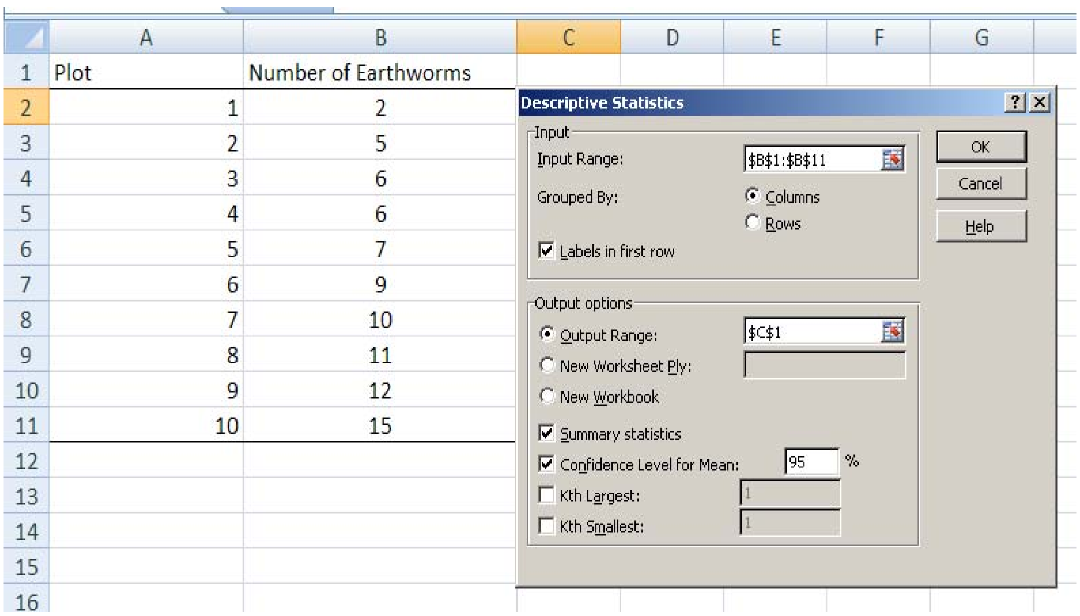


Figure F-8 Results of Estimation of Population Mean Using EXCEL

	A	B	C	D
1	Plot	Number of Earthworms	*Number of Earthworms*	
2	1	2		
3	2	5	Mean	8.3
4	3	6	Standard Error	1.21
5	4	6	Median	8
6	5	7	Mode	6
7	6	9	Standard Deviation	3.83
8	7	10	Sample Variance	14.68
9	8	11	Kurtosis	-0.27
10	9	12	Skewness	0.16
11	10	15	Range	13
12	Population Size (N):	200	Minimum	2
13	Sample Size (n):	10	Maximum	15
14	Estimated Variance of the Mean:		Sum	83
15	with fpc:	1.39	Count	10
16	w/o fpc:	1.47	Confidence Level(95.0%)	2.74
17	Estimated Std. Error of the Mean:		Confidence Level with fpc:	2.67
18	with fpc:	1.18	Upper Bound:	11.04
19	w/o fpc:	1.21	Lower Bound:	5.56

(3) Estimated Population Mean and Variance

As in figure 610F-8, the average number of earthworms per square foot in the top 6-inch layer of soil for the garden, $\bar{y}$ (equation F-5) is 8.3 worms per square foot (cell D3). A little math is required to obtain the estimated variance of the mean (equation F-6). The sample variance, s^2 , is reported in cell D8 as 14.68 (rounded to two decimal places). The FPC in our example is (200-10)/200 = .95. To calculate the estimated variance of the mean that includes the FPC, type the following in cell B15: =(D8/10)*(200-10)/200. The value, rounded to two decimal places, is 1.39. Because the FPC is .95, by the rule of thumb given above we could have calculated the estimated variance of the mean without including the FPC by typing the following in cell B16: =Var(B2:B11). The resulting value, rounded to two decimal places, is 1.47. Notice that the estimated variance is larger when it is calculated without the FPC. We want our estimates to be precise (have smaller variance). If we take the square root of the estimated variance calculated without the FPC, 1.47, the result is the standard error, 1.21, reported in cell D4. The units of the standard error in this case are earthworms per square foot in the top 6-inch layer of soil for the garden, the same as that of the mean.

(4) Confidence Limits

(i) Next we will calculate the confidence limits (also called certainty limits) of our estimate of the mean number of earthworms per square foot of garden soil (6-inch depth). As shown in cell D16, the confidence limits are 2.74 for the 10 worm sample at 95-percent confidence level (you can get the same result using equation F-7). A 95-percent confidence level is the default in Excel. This is a commonly reported level of confidence that can be changed by typing in 90 or 99 in the "Confidence Level" box in the Descriptive Statistics Wizard. Cell D16 contains the 95-percent bound on the error of estimation (equation F-7) without inclusion of the FPC. The FPC may easily be included by multiplying the value

in D16, 2.74, by the square root of the FPC. Type =D16*((200-10)/200)^0.5) in D17.

(ii) We stated earlier that an FPC with a value of 95 percent or greater can be ignored. In this case, the application of FPC changes the bound of the error of estimation to 2.67 earthworms per square foot of garden soil (6-inch depth). The bound on the error of estimation, 2.74, is subtracted and added to the estimated population mean, 8.3, to get the lower and upper confidence limits of 5.56 and 11.04, respectively. This means that we are 95-percent certain that the true number of earthworms per square foot of garden soil (6 inches deep) is between 5 and 11 earthworms.

(5) Sample Size

(i) Suppose we wish to estimate the average tract size of land currently enrolled in a specific conservation program for a 10-county area. Paper records for the 800 tracts in the 10-county area currently enrolled in the program are filed by tract number. Because the records are not available electronically, we want to draw a simple random sample of the records to estimate the average tract size. We know that the sizes of the enrolled tracts range in size from 20 to 600 acres. How many of the 800 records would we have to sample (with a simple random sample design) to estimate the average size of the enrolled tracts with a bound of error of estimation B=20 acres? The range of enrolled tract sizes is 600-20 = 580 acres.

(ii) The standard deviation can be estimated as: $\sigma = \frac{\text{range}}{4} = \frac{580}{4} = 145$

(iii) The population variance, σ^2, is estimated by squaring 145 to get 21,025.

$$D = \frac{B^2}{4} = \frac{20^2}{4} = 100$$

(iv) Putting all the information into equation F-8 we get:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2} = \frac{800(21025)}{799(100) + 21025} = 166.7$$

(v) We should take a simple random sample of 167 records to estimate the average size of the enrolled tracts to be within 20 acres of the error of estimation.

610.58 Estimating the Population Total

A. Formulas

(1) Sometimes we may be more interested in estimating the population total than the population mean. A woodlot owner may want to estimate the total volume of wood that is ready for harvest by selecting a random sample of plots in the woodlot and taking measurements on all the trees within the selected plots. A ginseng farmer may take a random sample of 2-foot sections of rows to estimate the total weight of the upcoming harvest. Estimators in this section incorporate the population size to arrive at an estimate of the total. For a simple random sample of size n from a population of size N, estimates of population totals, estimated variance, and bound on the error of estimation may be computed with the following:

(i) Estimator of the Population Total

$$\hat{T} = N\bar{x} = \frac{N\sum_{i=1}^{n} x_i}{n} \qquad \text{(F-10)}$$

(ii) Estimated Variance of the Population Total

$$\hat{V}(\hat{T}) = \hat{V}(N\bar{x}) = N^2 \frac{s^2}{n}\left(\frac{N-n}{N}\right), \qquad \text{(F-11)}$$

Where $s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$ is the sample variance, and the quantity $\left(\frac{N-n}{N}\right)$ is the FPC. The FPC decreases the size of the variance, thus making the estimate more precise. As a rule of thumb, if the FPC is greater than .95 (or equivalently if n is one-twentieth of N or smaller), the FPC can be ignored.

(iii) Bound on the Error of Estimation

$$B = t\sqrt{\hat{V}(N\bar{x})} = t\sqrt{N^2\left(\frac{s^2}{n}\right)\left(\frac{N-n}{N}\right)}, \qquad \text{(F-12)}$$

where t = the Student's t value. The t-values are available in table 610F-2. Excel can also be used to calculate the bound on the error of estimation without accessing the tables.

(2) Sample Size Required

(i) The sample size required to estimate the true population total with a bound on the error of estimation B is exactly the same as that given in equation F-8 to estimate the true population mean with a bound on the error of estimation B:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2}, \qquad \text{(F-13)}$$

where $D = \frac{B^2}{4}$, B is defined in equation F-12, and σ^2 is the population variance.

(ii) We seldom know the population variance. If we conduct a pilot test survey, we can use s^2, the sample variance from that sample, to estimate σ^2. Alternatively, we can use the following approximation to represent the standard deviation:

$$\sigma \approx \frac{\text{range}}{4}$$

(3) Examples

The examples in this section will build on those presented in the previous section. We will again use the earthworm example to demonstrate how we can use Excel to calculate an estimate of the population mean and the estimated variance of the mean. Using the earthworm data in figure 610F-9, the sample size, n, is 10 and the population size, N, is 200. We use the Descriptive Statistics Wizard in Excel to get the set of descriptive statistics for the data as described in the last example and shown in the figure below.

Figure F-9 Example For Estimating Population Mean Using EXCEL

	A	B	C	D
1	Plot	Number of Earthworms	*Number of Earthworms*	
2	1	2		
3	2	5	Mean	8.3
4	3	6	Standard Error	1.21
5	4	6	Median	8
6	5	7	Mode	6
7	6	9	Standard Deviation	3.83
8	7	10	Sample Variance	14.68
9	8	11	Kurtosis	-0.27
10	9	12	Skewness	0.16
11	10	15	Range	13
12	Population Size (N):	200	Minimum	2
13	Sample Size (n):	10	Maximum	15
14	Estimated Polulation Variance:		Sum	83
15	with fpc:	55775.56	Count	10
16	w/o fpc:	58711.11	Confidence Level(95.0%)	2.74
17	Estimated Population Std. Error:		Population Total:	1660
18	with fpc:	236.17	Population Total Bound:	
19	w/o fpc:	242.30	with fpc:	534.25
20			w/o fpc:	548.13

(4) Estimated Population Total and Variance

(i) As in figure 610F-9, the average number of earthworms per square foot in the top 6-inch layer of soil for the garden $\overline{x}$, (equation F-5) is 8.3 worms per square foot (cell D3). In this example we are interested in estimating the population total (i.e., the total number of worms in the top 6 inches of soil in the example garden). Using equation F-9, we multiply the estimated mean 8.3 worms per square foot (cell D3) by N=200 square feet in the garden to get 1,660 worms in the top 6 inches of garden soil.

(ii) A little math is again required to obtain the estimated variance of the population total (equation F-10). The sample variance s^2, is reported in cell D8 as 14.68 (rounded to two decimal places). The FPC in our example is (200-10)/200 = .95. To calculate the estimated variance of the total that includes the FPC, type the following in cell B15: = (200^2)*(D8/10)*(200-10)/200. The value, rounded to two decimal places, is 55,775.56. Because the FPC is .95, by the rule of thumb given above we could have calculated the estimated variance of the mean without including the FPC by typing the following in cell B16: (200^2)*(D8/10). The resulting value, rounded to two decimal places, is 58,711.11. Notice that the estimated variance is larger when it is calculated without the FPC. We want our estimates to be precise (have smaller variance). If we take the square root of the estimated variance calculated without the FPC, 58,711.11, the result is the standard error, 242.30. The units of the standard error in this case are earthworms in the top 6-inch layer of soil for the garden, the same as that of the total.

(5) Confidence Limits

(i) Next we will calculate the confidence limits (also called certainty limits) of our estimate of the total number of earthworms in the garden soil (6-inch depth). As shown in cell D16, the confidence limits are 2.74 for the 10-worm sample at 95-percent confidence level (you can get the same result using equation F-7). In this example we are interested in computing the error of estimation for the total (equation F-12). To get this estimate without the inclusion of the FPC, we

multiply the values in D20 by N=200 to get 548.13 worms in the top 6 inches of garden soil. The FPC may easily be included by multiplying the value in D16, 2.74, by both N and the square root of the FPC (equation F-12). Type =200*D16*((200-10)/200)^0.5 in D19.

(ii) The result is 534.25 earthworms per square foot of garden soil (6-inch depth). The bound on the error of estimation, 534, is subtracted and added to the estimated population total, 1660, to get the lower and upper confidence limits of 1126 and 2194, respectively. We are 95-percent certain that the total number of earthworms in the garden soil (6 inches deep) is between 1,126 and 2,194 earthworms.

(6) Sample Size

(i) The equation used to estimate the sample size needed to estimate the total with a bound on the error of estimation (equation F-13) is the same as that used to estimate the sample size needed to estimate the means with a bound on the error of estimation (equation F-8).

(ii) In the example in section 610.56, we wanted to estimate the average tract size of land currently enrolled in a specific conservation program for a 10-county area. Paper records for the 800 tracts in the 10-county area currently enrolled in the program are filed by tract number. Because the records are not available electronically, we wanted to draw a simple random sample of the records to estimate the average tract size. We knew that the sizes of the enrolled tracts range in size from 20 to 600 acres and wanted to determine the size of the sample required to estimate the average size of the enrolled tracts with a bound on error of estimation B=20 acres.

(iii) In this section instead of estimating the sample size needed to estimate the average tract size that has a bound on error of estimation B=20 acres, suppose we would like to determine the sample size required to estimate the total number of acres enrolled in the conservation program to have a bound on the error of estimation B=100. All the calculations would be the same as that of section 610.56, except that we would substitute B=100 for B=20 in the example.

$$\sigma = \frac{\text{range}}{4} = \frac{580}{4} = 145$$

- The population variance, σ^2, is estimated by squaring 145 to get 21,025.

$$D = \frac{B^2}{4} = \frac{100^2}{4} = 2500$$

- Putting all the information into equation F-8 we get:

$$n = \frac{N\sigma^2}{(N-1)D + \sigma^2} = \frac{800(21025)}{799(2500) + 21025} = 8.3$$

- We should take a simple random sample of nine records to estimate the total acreage of the enrolled tracts to be within a bound of error of estimation of 100 acres. If we wanted to estimate the total acreage of enrolled tracts to within 20 acres of error, we would have used B=20 and would have needed a sample size of 167 as in section 610.56.

610.59 Estimating the Population Proportion

A. Formulas

(1) Sections 610.56 and 610.57 required ratio scale or interval scale data for completing the desired calculations. This section will present methods of estimating the

population proportion and the estimated variance of the population proportion for nominal scale data (e.g., proportion of the population that is 18 years of age or older, the proportion of voters who support a particular candidate, or the proportion of tracts registered for a particular conservation program that are in compliance.) We will consider only the case of two classes. The data are often coded as 1 if the element sampled has the characteristic of interest or 0 if it does not. Using the descriptive statistics in the data analysis tools of Excel to estimate variance and confidence intervals for this data will produce erroneous results.

(2) For a simple random sample of size n from a population of size N, estimates of population proportion, estimated variance of the proportion, and bound of the error of the estimation can be computed with the following equations based on Cochran (1977) and Schaeffer et al. (1996):

(3) Estimator of the Population Proportion

$$\hat{p} = \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \text{(F-14)}$$

(4) Estimated Variance of the Population Proportion

$$\hat{V}(\hat{p}) = \frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right) \qquad \text{(F-15)}$$

where $\hat{q} = 1 - \hat{p}$ and the quantity $\left(\frac{N-n}{N}\right)$ is the FPC. The FPC decreases the size of the variance, thus making the estimate more precise. As a rule of thumb, if the FPC is greater than 0.95 (or equivalently if n is one-twentieth of N or smaller, the FPC can be ignored.

(5) Bound on the Error of Estimation

$$B = t\sqrt{\hat{V}(\hat{p})} = t\sqrt{\frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right)}, \qquad \text{(F-16)}$$

where t = the Student's t value with n-1 degrees of freedom. See table 610F-2 for a table of t-values. Excel cannot be used to directly calculate the bound on the error of estimation for nominal data. We can approximate a 95-percent bound of error by substituting t=2 in equation F-16.

(6) Sample Size Required

The sample size required to estimate the true mean with a bound on the error of estimation B is:

- $$n = \frac{Npq}{(N-1)D + pq} \qquad \text{(F-17)}$$

where $D = \frac{B^2}{4}$, B is defined in Equation F-7, and q = 1 - p. We seldom know p, but can sometimes estimate it from past surveys. If we have no prior information, we can use p = 0.5 as a conservative estimate.

B. Examples

(1) Estimated Population Proportion and Variance

(i) Suppose we want to determine the proportion of tracts enrolled in a conservation

program within a region that are in compliance of the agreement. A simple random sample of size n=80 is drawn from a total N=2000. The 80 tracts were checked and 72 were found to be in compliance. An estimate of the proportion of the 80 tracts that are in compliance is 72/80 = 0.9. We estimate that 90 percent of the enrolled tracts are in compliance.

(ii) The estimated variance of the population proportion estimate may be calculated using equation F-15.

- $$\hat{V}(\hat{p}) = \frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right) = \frac{(.9)(.1)}{79}\frac{(2000-80)}{2000} = .00109$$
- The standard error of the estimated proportion is the square root of the estimated variance, 0.033.

(2) Confidence Limits

The bound of the error of estimation is calculated with equation F-16. Notice that this is equivalent to multiplying the standard error of the estimated proportion by 2.

- $$B = t\sqrt{\frac{\hat{p}\hat{q}}{n-1}\left(\frac{N-n}{N}\right)} = 2\sqrt{\frac{(.9)(.1)}{79}\frac{2000-80}{2000}} = 0.066$$
- The bound, 0.066 is subtracted and added to the estimated proportion, .90, to get the lower and upper confidence limits (0.834 and 0.966), respectively. We are 95-percent certain that the true proportion of tracts that are in compliance is between 83.4 percent and 96.6 percent.

(3) Sample Size

(i) Suppose we want to determine the proportion of a potato field that is infested with potato beetles. The field is 100 feet in length and is planted with 25 rows of potatoes. We will examine the underside of leaves on plants in 2-foot sections of the rows to determine the presence or absence of one or more clusters of eggs. We decide to take a simple random sample of the 1,225 2-foot sections of rows in the field. How many 2-foot sections do we need to sample to estimate within 3 percent of the error of estimation the proportion of the field that is infested with potato beetles?

- In this example, N=1,225 and B=0.03.
- $$D = \frac{B^2}{4}\frac{0.03^2}{4} = 0.000225$$
- Since we do not know the proportion, p, we will use p=0.5 in equation F-17.
- $$n = \frac{Npq}{(N-1)D + pq} = \frac{(1225)(.5)(.5)}{(1224)(0.000225) + (.5)(.5)} = 582.9$$

(ii) A simple random sample of 583 2-foot sections of field would be needed to estimate the infested proportion of the field to within 3 percent of the error of estimation. If instead we wanted to estimate the infested proportion to within 5 percent, a simple random sample of 302 2-foot sections would be required.

610.60 Linear Regression Analysis and Prediction

A. Introduction

(1) In the previous discussion, except for the correlation coefficients, all of the problems considered involved only one variable of a population at one time. Confidence limits were constructed around the mean of one variable. Hypothesis tests were developed for a single variable. The observations in different samples were compared, but generally this comparison was based on only one measurement or variable per

comparison. Statistical inference analysis will be based on two or more variables of a sample. For example, more adequate judgments about farmers' use of conservation tillage can be made if characteristics that may affect this use, such as their age or education level, can be studied simultaneously.

(2) Linear regression analysis is concerned with the relationships between two or more variables. More specifically, it enables a user to determine to what degree one variable is affected by the others. In the conservation tillage example, farmers' use of conservation tillage may depend to some degree on their age and their education level. Linear regression analysis can be employed to mathematically and statistically describe the relationship between the farmers' ages and education levels to their use of conservation tillage.

(3) The major component of linear regression analysis is the linear regression model. This model may vary from application to application, but it can be expressed, in general, as:

(i) $Y = Bo + B1X1 + B2\ X2 + \ldots + Bn\ Xn$ (F-18)

(ii) Where:

- Y = Variable to be explained, called the dependent variable, e.g., use of conservation tillage (data from a sample)
- Bo =Intercept (to be solved)
- Xi=Variable or variables used to explain Y, called independent variables, e.g., age, education (data from a sample)
- Bi=Unknown parameters (to be solved)
- i = 1, 2, -----, N, Number of independent variables

(4) The term, linear regression model or function, stems directly from the use of the linear model, where the dependent variable has a linear relationship with any of the independent variables. If the regression function has only one independent variable and if it is plotted on a graph, the relationship will be expressed in a straight line. If there is more than one independent variable, the relationship between the dependent variable and any of two independent variables will be expressed in a flat plane.

B. Simple Linear Regression

(1) Assuming Y, a dependent variable and an independent variable X, have a linear relationship, their simple linear regression model would be represented as:

(i) $Y = Bo + B1\ X1$ (F-19)

(ii) Where:

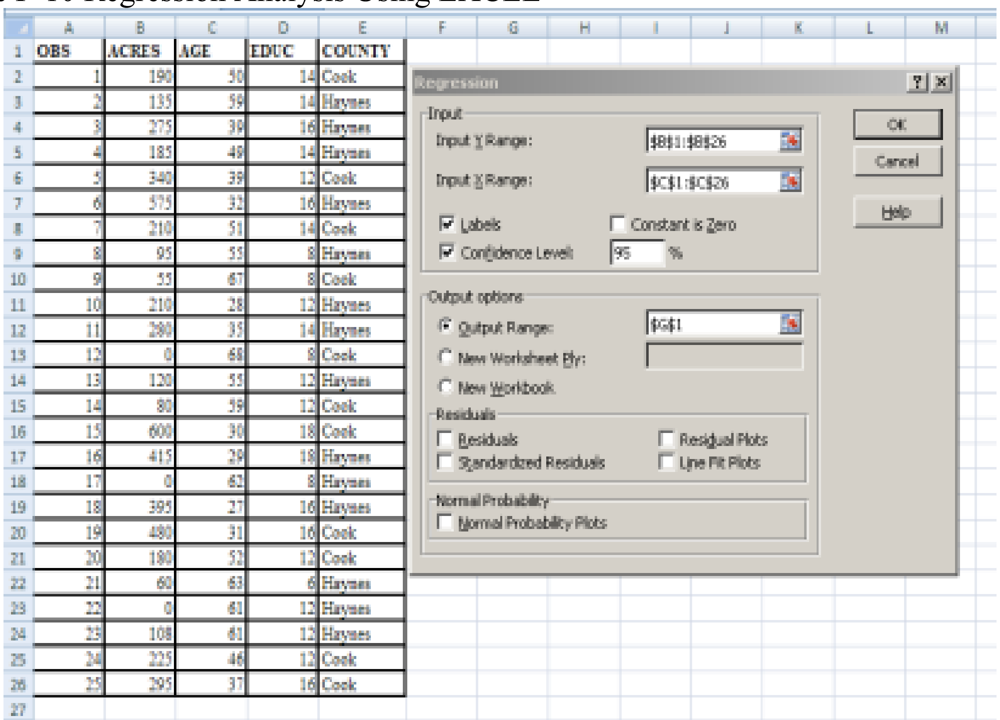
- Y = Dependent variable (from the sample)
- Bo =Intercept (to be solved)
- B1=Unknown parameters (to be solved)
- X1=Independent variable (from the sample)

(2) Assume the interest is in whether or not the age of the farmers sampled in Cook and Haynes counties affects their use of conservation tillage. Also, if there is some effect on usage, how much is it affected? Finally, can the use of conservation tillage by similar farmers be predicted based on this information?

(3) Use sample data on the age of the farmers and their use of conservation tillage sampled in Cook and Haynes counties. The regression analysis can be conducted in Excel by using the Regression Wizard in Excel (in the "Data Analysis" button in the "Analysis" group on the "Data" tab), as shown in figure 610F-10. The regression analysis in Excel has the following procedure. First, select the "Regression Wizard"; second, type in B1:B26 as "Input Range" for Y variable and C1:C26 as "Input

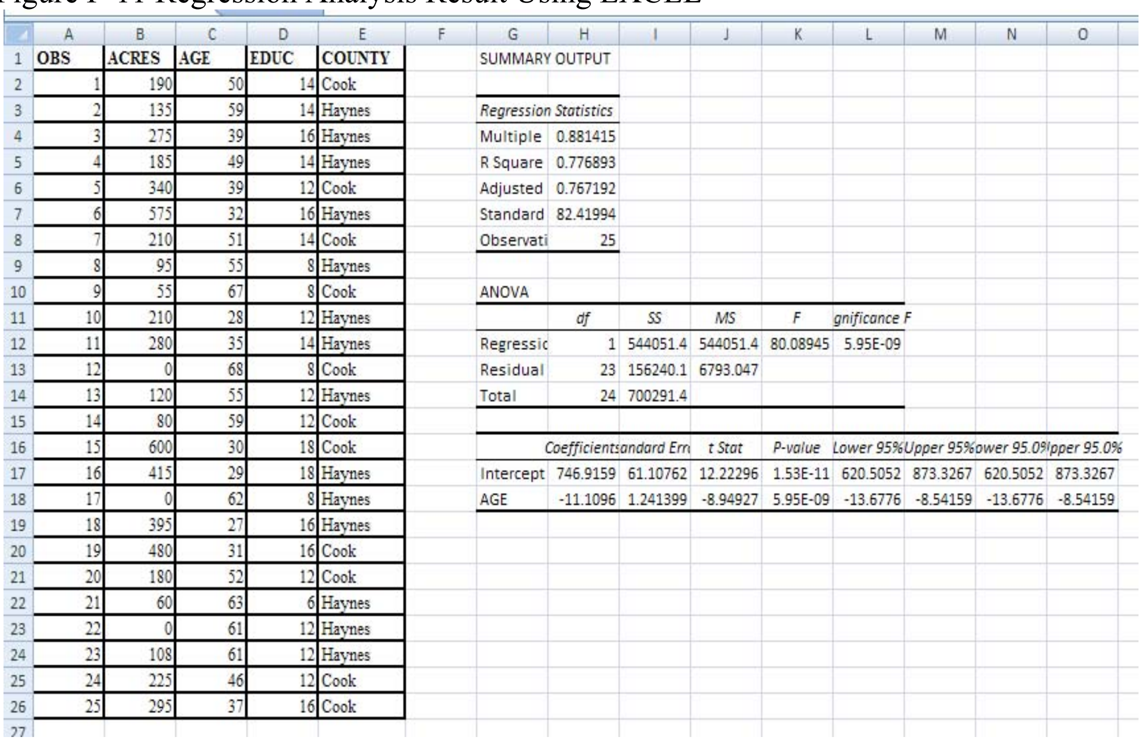
Range" for X variable, check the boxes next to "Labels," "Confidence Level," and "Output Range," type in G1 as the starting point for outputs. Finally, click "OK."

Figure F-10 Regression Analysis Using EXCEL



OBS	ACRES	AGE	EDUC	COUNTY
1	190	50	14	Cook
2	135	59	14	Haynes
3	275	39	16	Haynes
4	185	49	14	Haynes
5	340	39	12	Cook
6	575	32	16	Haynes
7	210	51	14	Cook
8	95	55	8	Haynes
9	55	67	8	Cook
10	210	28	12	Haynes
11	280	35	14	Haynes
12	0	68	8	Cook
13	120	55	12	Haynes
14	80	59	12	Cook
15	600	30	18	Cook
16	415	29	18	Haynes
17	0	62	8	Haynes
18	395	27	16	Haynes
19	480	31	16	Cook
20	180	52	12	Cook
21	60	63	6	Haynes
22	0	61	12	Haynes
23	108	61	12	Haynes
24	225	46	12	Cook
25	295	37	16	Cook

Figure F-11 Regression Analysis Result Using EXCEL



OBS	ACRES	AGE	EDUC	COUNTY
1	190	50	14	Cook
2	135	59	14	Haynes
3	275	39	16	Haynes
4	185	49	14	Haynes
5	340	39	12	Cook
6	575	32	16	Haynes
7	210	51	14	Cook
8	95	55	8	Haynes
9	55	67	8	Cook
10	210	28	12	Haynes
11	280	35	14	Haynes
12	0	68	8	Cook
13	120	55	12	Haynes
14	80	59	12	Cook
15	600	30	18	Cook
16	415	29	18	Haynes
17	0	62	8	Haynes
18	395	27	16	Haynes
19	480	31	16	Cook
20	180	52	12	Cook
21	60	63	6	Haynes
22	0	61	12	Haynes
23	108	61	12	Haynes
24	225	46	12	Cook
25	295	37	16	Cook

SUMMARY OUTPUT

Regression Statistics	
Multiple	0.881415
R Square	0.776893
Adjusted	0.767192
Standard	82.41994
Observati	25

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressic	1	544051.4	544051.4	80.08945	5.95E-09
Residual	23	156240.1	6793.047		
Total	24	700291.4			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	746.9159	61.10762	12.22296	1.53E-11	620.5052	873.3267	620.5052	873.3267
AGE	-11.1096	1.241399	-8.94927	5.95E-09	-13.6776	-8.54159	-13.6776	-8.54159

(4) As shown in the regression output in figure 610F-11, the simple regression function between farmers' use of conservation tillage and their age could be expressed as follows:

Use of conservation tillage = 746.92 – 11.11 (farmers' age)

- The negative B1 implies that the older farmers in the sample conservation till less than the younger farmers. That is, observing the youngest to the oldest members of the sample, there is a downward trend in the use of conservation tillage. It is very important, however, to test the significance of both B0 and B1 to determine the degree of confidence in the results. The "Test of Significance" operates much like the test for difference between two means and testing the mean. The calculated t and degrees of freedom could be derived from the available information for testing the hypothesis that B0 = 0 and B1 = 0. If the hypothesis that B0 = 0 is not rejected, then the model becomes:
- Use of conservation tillage = – 11.11 (farmers' age)
- If the hypothesis that B1 = 0 is not rejected, the equation falls apart and it must be assumed that the age of a farmer has no effect on his use of conservation tillage.

(5) For this example, assuming 95-percent confidence with 23 degrees of freedom (minus 2 degrees of freedom, due to two parameters in the regression model) and using table 610F-2, the interpolated t-value equals 2.08. The absolute values for the calculated t's of both B0 and B1 (12.22 and -8.95, as shown in the regression output figure above) are greater than 2.81, so both hypotheses that the parameters are equal to zero are rejected. The equation is tested and remains as:

Use of conservation tillage = 746.92 – 11.11 (farmers' age)

(6) Thus, the relationship described previously between age and use of conservation tillage also stands. This equation means that given the age of a farmer with similar characteristics as those sampled, the equation can predict the amount of conservation tillage he is practicing. Thus, a 48-year-old farmer could be expected to conservation till 214 acres (214 = 746.92 – 11.11 (48). A 24-year-old farmer could be expected to conservation till 480 acres (480=746.92 – 11.11 (24)).

(7) For a second example, assume there is interest in whether or not the education level of farmers affects their use of conservation tillage. The regression analysis can be conducted in Excel using the Regression Wizard, with the change of the "Input Range" for x to D1:D26, and the result is presented in the figure below.

Figure F-12 Another Example of Regression Analysis Using EXCEL

OBS	ACRES	AGE	EDUC	COUNTY
1	190	50	14	Cook
2	135	59	14	Haynes
3	275	39	16	Haynes
4	185	49	14	Haynes
5	340	39	12	Cook
6	575	32	16	Haynes
7	210	51	14	Cook
8	95	55	8	Haynes
9	55	67	8	Cook
10	210	28	12	Haynes
11	280	35	14	Haynes
12	0	68	8	Cook
13	120	55	12	Haynes
14	80	59	12	Cook
15	600	30	18	Cook
16	415	29	18	Haynes
17	0	62	8	Haynes
18	395	27	16	Haynes
19	480	31	16	Cook
20	180	52	12	Cook
21	60	63	6	Haynes
22	0	61	12	Haynes
23	108	61	12	Haynes
24	225	46	12	Cook
25	295	37	16	Cook

SUMMARY OUTPUT

Regression Statistics	
Multiple	0.80688
R Square	0.651056
Adjusted	0.635884
Standard	103.075
Observati	25

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressic	1	455928.8	455928.8	42.91312	1.1E-06
Residual	23	244362.6	10624.46		
Total	24	700291.4			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-319.86	84.99785	-3.76315	0.001011	-495.691	-144.029	-495.691	-144.029
EDUC	42.20156	6.44219	6.55081	1.1E-06	28.87488	55.52825	28.87488	55.52825

(8) The regression analysis results in the following equation:

Use of conservation tillage = -319.86 + 42.20 farmers' education

- The absolute values of calculated t's for B0 and B1 (3.76 and -6.55) are both larger than the t-value from the t-table (2.08). Thus, the hypotheses that B0 = 0 and B1 = 0 are rejected, thus the original equation remains. The above equation implies that a farmer with similar characteristics as those sampled with a high school education would be predicted to conservation till 187 acres (187 = -319.86 + 42.20 (12)).
- The R-squared shown in the regression output is the estimated coefficient of determination. This figure indicates the fraction of total variation in the dependent variable that can be explained by changes in the independent variable. In the two examples, both age and education were separately found to be significant (using the test of significance) in explaining the variation of acres conservation tilled. Because the regression equation with age as the independent variable has an R-squared of 0.78, vs. 0.65 for the regression equation using education as independent variable, it did a better job of explaining the dependent variable (use of conservation tillage). Thus, the regression equation with age as the independent variable is more useful in prediction of the use of conservation tillage. (Studying the R-squared formula in the appendix of formulas will aid understanding the implications of the actual measures.)

C. Multiple Linear Regression

(1) The regression model for multiple linear regression is represented as:
   (i) Y = Bo + B1X1 + B2 X2 +…+ Bn Xn (F-20)
   (ii) Where:
   - Y = Dependent variable (from the sample)
   - Bo =Intercept (to be solved)
   - B1, B2, B3, – Bn = Unknown parameters (to be solved)
   - X1, X2, X3, – Xn =Independent variables (from the sample)

(2) Using the conservation tillage example, the effects of both age and education on conservation tillage use could be found by substituting these variables into the regression model as: Use of conservation tillage = Bo + B1 (farmers' age) + B2 (farmers' education)

(3) The multiple regression analysis can also be conducted using the Excel Regression Wizard. The only difference from the regression analyses above is to type in C1:D26 as "Input Range" for x. The result of the regression analysis is shown in the figure below.

Figure F-13 Multiple Regression Analysis Using EXCEL

OBS	ACRES	AGE	EDUC	COUNTY
1	190	50	14	Cook
2	135	59	14	Haynes
3	275	39	16	Haynes
4	185	49	14	Haynes
5	340	39	12	Cook
6	575	32	16	Haynes
7	210	51	14	Cook
8	95	55	8	Haynes
9	55	67	8	Cook
10	210	28	12	Haynes
11	280	35	14	Haynes
12	0	68	8	Cook
13	120	55	12	Haynes
14	80	59	12	Cook
15	600	30	18	Cook
16	415	29	18	Haynes
17	0	62	8	Haynes
18	395	27	16	Haynes
19	480	31	16	Cook
20	180	52	12	Cook
21	60	63	6	Haynes
22	0	61	12	Haynes
23	108	61	12	Haynes
24	225	46	12	Cook
25	295	37	16	Cook

SUMMARY OUTPUT

Regression Statistics	
Multiple	0.901942
R Square	0.813499
Adjusted	0.796544
Standard	77.04932
Observati	25

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressic	2	569686.3	284843.2	47.98088	9.5E-09
Residual	22	130605.1	5936.597		
Total	24	700291.4			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	400.2317	176.344	2.269607	0.033381	34.51655	765.9468	34.51655	765.9468
AGE	-8.10914	1.85248	-4.37745	0.00024	-11.9509	-4.26733	-11.9509	-4.26733
EDUC	15.97356	7.686956	2.078009	0.049583	0.031791	31.91533	0.031791	31.91533

(4) From the regression analysis output, the relationship between conservation tillage and independent variables Age and Education can be expressed as follows: Use of conservation tillage = 400.23 – 8.11 (farmers' age) + 15.97 (farmers' education)

(5) Before this model is used for prediction, it is imperative to test the significance of each of the parameters (B's). From the regression output, the absolute values of the t values for all B's are 2.27, 4.38, and 2.08, respectively, all of which either equal or exceed the critical value of t at a 95-percent confidence level (2.08). Thus, the tests reject the hypotheses that the parameters are equal to zero and accept the model as originally specified.

(6) This model can be used to predict the use of conservation tillage by a farmer with characteristics similar to those in Cook or Haynes counties. For example, a 48-year-old farmer with a high school education would conservation till 202 acres according to this model, (400.23 – 8.12(48) + 15.97(12)). A 24-year-old farmer with a 4-year college education is predicted to conservation till 461 acres (400.23 – 8.12 (24) + 15.97 (16)). The predictive computation of a multiple linear regression model is much like that of a simple linear regression model, except that more than one independent variable is used.

(7) As shown below, it is obvious that the choice of independent variables is important to predicting the number of acres that are conservation tilled. For example, the predictions of conservation tillage for a 48-year-old farmer with a high school education can be different based which of the above regression equations are used:

Model	Prediction
Conservation tillage acres = Bo + B1 (AGE)	214 Acres
Conservation tillage acres = Bo + B1 (EDUC)	187 Acres
Conservation tillage acres = Bo + B1 (AGE) + B2 (EDUC)	202 Acres

(8) The test of significance will help to eliminate from consideration independent variables that do not add to the prediction; but how does one choose which independent variables to initially include in the model? The person who can safely say which independent variables should be included in the model is someone who is knowledgeable about the application of conservation tillage, or, in other words, someone who is familiar with the dependent variables. In this example, an expert in conservation tillage would be very helpful in selecting the major variables that affect a farmer's decision to conservation till. In this example, only two variables—age and education—are considered. It is possible that a farmer's financial situation or dominant soil type could be as important. Then, the financial and soil data of the sample would need to be gathered for the regression analysis and the formulation of a predictive model.

(9) To summarize, the basic steps to follow in studying the relationships between two or more variables in linear regression analysis are as follows:

(i) Consult an expert in the area being analyzed so that the major variables involved can be included for data collection in the sample, and thus used for the model.

(ii) Use correct sampling techniques to collect the relevant data on each variable.

(iii) Construct a linear regression model in the general form:

- Y = Bo + B1X1 + B2 X2 +…+ Bn Xn

(iv) If only one independent variable is used, the model is a simple linear regression. If more than one independent variable is included, the model is called a multiple regression model.

(v) Use a regression analysis software, such as the Regression Wizard in Excel, to estimate the parameters (B's) their associated t stats, and R-Square of the model.

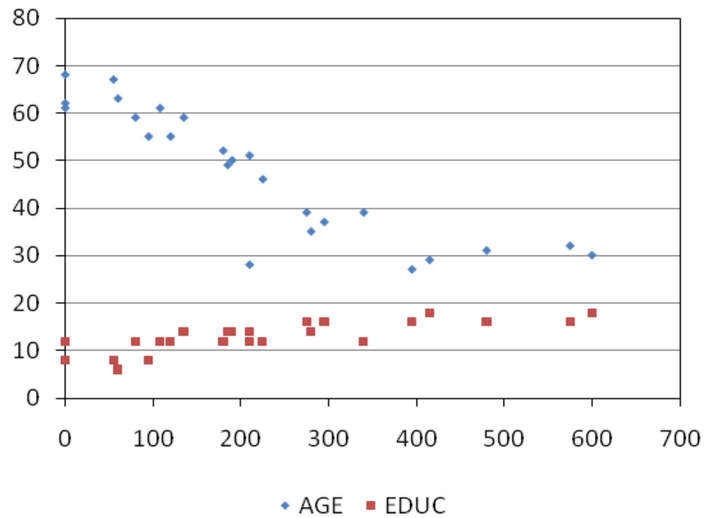
(vi) Use the test of significance (with the chosen level of confidence) to test the reliability of each parameter and, thus, its desirability as an independent variable in the equation. If the hypothesis that Bi = 0 is not rejected, then the independent "i" variable should be dropped from the equation and the remaining model should be retested.

(vii) If the model is to be used for prediction, make sure that it is applied to

populations with characteristics similar to those sampled. For example, using the model developed from a sample in Cook and Haynes counties to predict conservation tillage in Mexico would be inappropriate because the characteristics of farmers in the United States and Mexico are so different. When using a regression model for prediction, keep in mind the similarity of characteristics of the population from which the sample, and thus the model, were derived.

(10) Graphs are useful in the selection of independent variables that affect and help explain the variation of the dependent variable. Creating a graph similar to that shown below, for example, displaying the acres conservation tilled against the farmers' ages and education levels, could reveal the relationships between use of conservation acreage and farmers' ages and farmers' education levels.

Figure F-14 Relationship Between the Use of Conservation Acreage and Farmers' Ages and Farmers' Education Levels



610.61 Basic Statistical Formulas

Mean: $$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where:

x_i = the observed value of the i^{th} unit in the sample

n = number of units in the sample

Variance: $$s^2 = \frac{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}{n(n-1)}$$

where:

x_i = the observed value of the i^{th} unit in the sample

n = number of units in the sample

Standard Deviation: $$s = \sqrt{s^2}$$

where:

s^2 = Variance

Coefficient of Variation: $$CV = \frac{s}{\bar{x}} \cdot 100$$

where:

s = Standard Deviation

$\bar{x}$ = Mean

Standard Error of the Mean: $$s_{\bar{x}} = \sqrt{\frac{s^2}{n}\left(1 - \frac{n}{N}\right)}$$

where:

s^2 = Variance of the sample

n = Sample size

N = Population size

$1 - \frac{n}{N}$ = finite population correction

Correlation Coefficient: $$r = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\left[n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2\right]\left[n\sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y_i\right)^2\right]}$$

where:

x_i = the observed value of the i^{th} unit in the X sample

y_i = the observed value of the i^{th} unit in the Y sample

Sample Size: $n = \frac{t^2 V}{E^2}$

where:

t = t-value from Student's t distribution, Table 2

V = variance of the sample

E=acceptable error from the mean value

Sample Variance Estimate: $V = \left(R/4\right)^2$

where:

R = expected range of data

CONFIDENCE INTERVALS

Confidence Limits: $\overline{x} \pm (t)(S_{\overline{x}})$

where:

$\overline{x}$ = mean

t = t-value, Table 2

$S_{\overline{x}}$ = standard error of the mean

HYPOTHESIS TESTING

Calculated *t*: $t = \frac{\overline{x} - \mu}{S_{\overline{x}}}$

(Test of the Mean)

where:

$\overline{x}$ = sample mean

μ = hypothesized mean

$S_{\overline{x}}$ = standard error of the mean

Calculated t: $$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{PV\left(n_1 + n_2\right)}{n_1 n_2}}}$$

(Test of the Difference)

where:

$\bar{X}_1 =$ sample mean of sample 1

$\bar{X}_2 =$ sample mean of sample 2

$n_1 =$ size of sample 1

$n_2 =$ size of sample 2

$$PV = \frac{SS_1 + SS_2}{n_1 + n_2 - 2}$$

where:

$SS_1 =$ sum of squares from sample 1

$$SS_1 = \sum_{i=1}^{n_1} X_{1i}^2 - \frac{\left(\sum_{i=1}^{n_1} X_{1i}\right)^2}{n_1}$$

$SS_2 =$ sum of squares from sample 2

$$SS_2 = \sum_{i=1}^{n_2} X_{2i}^2 - \frac{\left(\sum_{i=1}^{n_2} X_{2i}\right)^2}{n_2}$$

SIMPLE REGRESSION ANALYSIS

Slope Parameter $\left(\beta_1\right)$: $\hat{\beta}_1 = \sum_{i=1}^{n} x_{1i} y_i / \sum_{i=1}^{n} x_{1i}^2$

where:

$x_{1i} = X_{1i} - \bar{X}_1$

$y_i = Y_i - \bar{Y}$

Intercept $\left(\beta_0\right)$: $\hat{\beta}_0 = \bar{Y} - \hat{\beta}_1 \bar{X}_1$

where:

$\hat{\beta}_1 =$ slope parameter estimate

Coefficient of Determination: $$r = \frac{\left(\sum_{i=1}^{n} x_i y_i\right)^2}{\sum_{i=1}^{n} x_i^2 \sum_{i=1}^{n} y_i^2}$$

where:

$x_i = X_i - \overline{X}$

$y_i = Y_i - \overline{Y}$

Test $\beta_k = \beta_0$: $$t = \frac{\hat{\beta}_k - \beta_0}{SE\left(\hat{\beta}_k\right)}$$

where:

$\hat{\beta}_k =$ regression parameter estimate

$\beta_0 =$ hypothesized value

$SE\left(\hat{\beta}_k\right) =$ estimated standard error of $\hat{\beta}_k$

Chi-Square Test: $$\chi^2 = \sum_{i=1}^{n} \frac{\left(o_i - e_i\right)^2}{e_i^2}$$

where:

$o_i =$ observed value in cell i

$e_i =$ expected value in cell i

Testing $\sigma^2 = \sigma_0^2$: $$\chi^2 = \frac{(n-1)s^2}{\sigma_0^2}$$

where:

$n =$ sample size

$s^2 =$ sample estimate of σ^2

Testing $\sigma_1^2 = \sigma_2^2$: $$F = \frac{s_1^2}{s_2^2}$$

where:

$s_1^2 =$ sample estimate of σ_1^2

$s_2^2 =$ sample estimate of σ_2^2

610.62 Statistical Glossary

A. Calculated t.—A confidence coefficient calculated from sample measures including the sample mean and standard error of the sample mean. The table t, or Student's distribution, permits the evaluation of deviations expressed in terms of standard errors for samples of various sizes, or simply to test for the significance of the difference between two means. A given standard error is divided into a difference or deviation (between two means), to obtain t as a basis for a test of significance.

B. Coefficient of Variation (CV).—A relative measure of variation used to compare the variability of data sets that are in different units. CV is derived by dividing standard error with the sample mean.

C. Confidence Limits.—An interval estimate of a population measure (e.g., confidence limits can express the true population mean as an interval estimate with a certain probability).

D. Correlation.—A qualitative correspondence between two sets of data either in a positive (move in the same direction) or negative (move in the opposite direction) manner.

E. Correlation Coefficient.—A calculated coefficient ranging from -1 to 1 that measures the directional association between two sets of data.

F. Data.—Compiled information that can be used for analysis or computation.

G. Dependent Variable.—The variable in a linear regression model that is explained by one or more independent variables and appears on the left side of the equation.

H. F-Test.—The technique of the analysis of variance requires the comparison of two variances and a test for the significance of the difference between the calculated variances.

I Hypothesis.—An assumption subject to verification or proof.

J. Hypothesis Testing.—Using statistical procedures to reject or not reject an initial hypothesis.

K. Independent Variable.—The variable or variables in a linear regression model that explain the dependent variable and appear on the right side of the equation.

L. Intercept.—The constant (or B0 in the equation of the text) parameter in a linear regression model that would appear as the intercept of a line on a two-dimensional graph.

M. Linear Regression Analysis.—The estimation of parameters in a relationship between two or more variables in a linear fashion.

N. Mean.—An arithmetic average, usually used to describe the average value of a particular sample.

O. Multiple Linear Regression.—Estimation of parameters in a relationship between one dependent and two or more independent.

P. Population.—The whole; the entire set of items or individuals from which a sample is drawn.

Q. Predictive Model.—The equation with estimated parameters that results from the regression analysis procedure that can be used to estimate or predict a new value for a dependent variable using values of known independent variables.

R. Presampling.—A mini sample used to roughly estimate the variance of a variable in a given population so that sample size can be calculated and applied to the principal sample when it takes place.

S. Random Sample.—A sample chosen so that each value of a variable in the population has an equal and independent chance of being collected.

T. Regression Parameters.—Known as beta coefficients (B's) in linear regression and solved by using the regression analysis procedure.

U. Sample.—A portion of the whole regarded as representative of the whole; a collection of data used to represent the population.

V. Simple Linear Regression.—Estimation of a relationship between two variables (one dependent and one independent).

W. Standard Deviation.—Dispersion of values about the mean, indicating the variation in a data set.

X. Standard Error of the Mean.—A measure that indicates the variability of sample means much like the standard deviation indicates variability in individual sample observations.

Y. Statistics.—The science that deals with techniques used to obtain analytical measures, the methods for estimating their reliability and the drawing of inferences from them.

Z. T (t-Value) or Table T.—A confidence constant usually found in a "t" table and originally developed from a probability distribution called "students t;" t is used in many statistical calculations and analysis including sample size, confidence limits, hypothesis testing, and regression analysis.

AA. Table of Random Numbers.—Table with a large quantity of single digits of number arranged in a random fashion; used to facilitate the selection of a random sample.

BB. Test for Difference Between Two Means.—A test that checks for differences in two populations by statistically comparing sample means.

CC. Test of the Mean.—A test that uses the mean from a sample and probability theory to not reject or reject a hypothesis about the sample.

DD. Test of Significance.—A test of the desirability of each independent variable in regression analysis based on the hypothesis that the beta parameters (B's) equal zero.

EE. Variable.—A characteristic of a population that can be chosen for study.

FF. Variance.—The square of the standard deviation used to measure data variability.

Part 610 – Natural Resource Economics Handbook

Subpart G – General Glossary

610.70 Terms and Definitions

Term	**Definition**
Amortization	Converting capital to periodic payments by determining the size of payment per time period needed to pay off a debt over a given time at a given interest rate. $\frac{r(1+r)^n}{(1+r)^n - 1}$ where: r = interest rate and n = number of periods
Annuity	A series of payments made over time. An annuity may be a benefit or a cost.
Benchmark	The resource setting from which options are evaluated. A benchmark is commonly thought of as representing the resource setting before conservation treatment.
Benefit-cost analysis	An economic analysis of an investment or policy alternative in which estimated total costs are compared with estimated total benefits.
Breakeven	The point where the proceeds from total output of an alternative plan equal the costs of all inputs associated with that alternative.
Capital	One of four traditional factors of production used to produce goods and services. Capital is generally defined to include machinery, livestock, buildings, cash, or some combination of these that can be used to purchase or trade for other resources. Capital does not include management, land, and labor contributed toward the production of goods and services.
Capital investment	Monetary expenditures necessary for initial installation of a practice or system.
Commodities	Undifferentiated good in which one producer's product is indistinguishable from another.
Competitive enterprise	A business entity which increases its own production in order to capture a greater share of the market, thus causing other competing entities to decrease their production.
Compounding	The process through which interest that is earned for one period is immediately added to the principal, thus resulting in a larger principal on which interest is computed for the following period. $(1+r)^n$ where: r = interest rate, n = number of periods

Cost effectiveness analysis	An appraisal technique especially useful where benefits cannot be reasonably measured in monetary terms. On a present value basis, the least expensive alternative combination of tangible costs that will realize essentially the same benefits should be identified. The combination is often referred to as least cost or cost effectiveness. Once it is determined that the least expensive alternative has been identified and its costs valued, then the subjective question "is it worth it?" can be more readily addressed.
Crop budget	A systematic listing of resources used, their cost for specified yield levels, and the value of the output by individual crops or enterprises.
Demand	The quantity of a good (or service) that consumers will purchase at a given price.
Soil deposition	Soil movement (erosion) from one location to another resulting in the covering of fertile soil sediment, which results in a less productive soil.
Depreciation	A decrease in the value of property through wear, deterioration, or obsolescence.
Discount rate (see also interest rate)	The time value of money, expressed as a percentage. Interest rate is a comparable term, but interest only related to monetary transactions. Discount rate is the more general term for all economic analysis.
Discounting	The process of finding a present value, given a future value.
Economic analysis	An analysis done using economic values. In general, economic analysis omits payments, such as credit transactions, and values all items at their value-in-use or their opportunity cost to the society.
Effectiveness	The extent to which an alternative plan alleviates the specified problems and achieves the specified opportunities.
Efficiency	The extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specific opportunities, consistent with protecting the Nation's environment. Considered a measuring stick for evaluating choices based on the ratio of output to input.
Evaluation period	The period beginning at the end of the installation. Based on the expected useful economic life.
Financial analysis	Analysis done to determine effects of a particular action or plan on the liquidity, cash flow, or profitability of a business or enterprise.
Fixed costs	Expenditures an enterprise would incur even if no output were produced.
Interest	The earning power of money or the price for the use of money.
Interest rate	The cost of using borrowed capital or the value placed on using owned capital, determined by demand, time, and risk.

Internal rate of return	The interest rate money will earn as the total investment is repaid by its revenues.
Management	A decisionmaking process of determining how land, labor, and capital will be combined into an enterprise or organization for the purpose of obtaining one's objective.
Marginal analysis	Determining the level of production where marginal costs are equal to marginal benefits and net benefits are maximized.
Marginal benefit	The additional benefit of producing one more unit of output.
Marginal cost	The additional cost of producing one more unit of output.
Conservation objective	A stated resource conservation goal related to improving general natural resource conditions or resolving one or more specific resource concerns. For a land user, a conservation objective typically comprises what he or she wants to accomplish or what he or she wants to see change as a result of implementing a conservation system. Also usually includes elements of both resolving resource concerns and improving farm or ranch operations. For NRCS, a stated conservation objective usually includes making progress toward agency goals for specific natural resource conditions.
Offsite benefits and costs	Offsite benefits are those benefits realized (and offsite costs are those costs that are incurred) outside of the immediate project area.
Onsite benefits and costs	Onsite benefits are those benefits realized (and onsite costs are those costs that are incurred) on the physical land unit where a conservation system is implemented.
Opportunity costs	The earning capabilities of assets for use in alternative investments having similar risks and timeframes.
Partial budgeting	In contrast with whole-farm or whole-enterprise budgeting, partial budgeting evaluates only the relevant changes that occur in returns and production costs in response to the implementation of a conservation system.
Period of analysis	The specified time period over which the costs and benefits of a given proposed project are analyzed. Generally, includes both the installation period and the expected operations period. Should not exceed the shorter of the planning horizons, such as the repayment period or the physical life of the alternative. If the selected planning horizon is shorter than the physical life of the alternative, however, the benefits that accrue beyond the period analyzed must still be carefully analyzed.
Perpetuity	An indefinite period of time, a period of time that exceeds all legally relevant timeframes, or an annuity that is payable forever.

Planning horizon	The period of time for which a business owner, farmer, or rancher formulates goals for the operation or business; the time period within which a specific conservation practice or system of practices is planned for installation and implementation; or the time period over which a general conservation plan developed by an NRCS planner is intended to be implemented and operated.
Present value	Current value of a cost or benefit (or a stream of costs or benefits) that will occur in the future, calculated by means of discounting.
Price	The exchange value for commodities generally determined through the market system.
Price index	A series of data that are used to reflect changes in prices relative to prices in some base period.
Principal	The amount of an initial investment or the initial investment plus accrued interest.
Private costs or benefits	Those costs or benefits that are accruing to identified individuals but not to the public sectors.
Production costs	Expenditures, both fixed and variable, for all items required for specified levels of crop or livestock production.
Projections	Best estimates of future development, based upon historical trends, analysis of current relationships, and an evaluation of foreseeable conditions.
Public costs or benefits	Those costs or benefits that are accrued to groups of people and remain inseparable to individuals.
Rent	The amount paid to use an asset belonging to another. Interest is the rental payment for using someone else's money.
Simple interest	Money earned on the principal only and not on accumulated interest.
Social costs	Adverse conditions, either monetary or nonmonetary, that accrue to people outside of those with an immediate, private interest in an activity or transaction. Contrast with private costs. Often used in reference to society as a whole.
Supply	The quantity of a good or service a firm is willing to produce to sell at a given price.
Travel cost method	Method of estimating the economic value to society of a destination or activity at a specific location by using travel expenditures as a proxy for the market value of the destination or activity. Most often used to place a monetary value on nonmarket recreational assets or activities.
Unit cost	Monetary value or price per unit (e.g., cost per cubic yard of concrete or cost

	per acre of owning an 18-foot self-propelled combine).
Variable costs	Costs of production that increase as the quantity of output increases.
Water resource project	A water-related conservation project that includes at least one structural practice as a means of resolving one or more water resources conservation issues. It may also include land treatment practices. All economic analysis of water resource projects for which federal funds will be expended must be completed in accordance with the guidelines contained in Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G).
Base period (year)	A specified year serving as the basis for comparison to establish an index of prices or other time-related variables. For example, if the year 1991 were selected as the base year for a farm commodity price index, the index value for that year would be 100. All other years' farm commodity price levels could then be compared with 1991's prices, and index values could be calculated to convey the degree to which prices have varied over time in comparison with prices in that base year.
With condition	The anticipated situation projected to occur in the future if the proposed conservation measures are installed. Sometimes referred to as the "future with project."
Without condition	The anticipated situation projected to occur in the future if the proposed conservation measures are not installed. Sometimes referred to as the "future without project."
Out-of-pocket cash costs	Direct cash expenditures for the purchase of items such as farm supplies, hired labor, and services.
Contingent valuation method	Method of estimating the economic value (cost) to society of an environmental good (bad) by interviewing stakeholders and asking them either how much they would pay to retain (eliminate) an existing environmental good (bad), or how much they would have to be compensated in order to give up (tolerate) an existing environmental good (bad). Contingent valuation is also used to evaluate the value (cost) to society of prospective environmental goods (bads). The two types of contingent valuation survey method are the "willingness to pay" method and the "compensation required" method (also known as the "willingness-to-accept" method).
Cropping sequence	The pattern in which crops are grown over time in the evaluation area or the crop rotation system being employed by a farmer.
Custom rate	The usual fee for farm services rendered, generally for machine hire.
Diminishing returns	A condition where each successive unit of input adds less to total output than the previous unit.

Factors of production	Resources, either human (labor) or nonhuman (land or capital), used for producing goods or services that in turn satisfy wants. The three factors of production commonly identified are land, labor, and capital. Within this context, land is often used as a label for all natural resources.
Fair market value	The price at which an informed owner of an asset would sell that asset to an informed and willing buyer.
Family labor	Nonhired labor inputs from an individual or from their household.
Future with project	The future conditions that will exist, actual or estimated, for each alternative and the approved plan of action. Also known as the "with condition."
Future without project	The future conditions, actual or estimated, most likely to exist in the absence of the proposed plan or project. Also known as the "without condition."
Gross returns	Total production in units multiplied by the price per unit.
Installation period	The number of years required to install the measures of the planned alternative.
Least-cost alternative	The lowest expenditure for installing, operating, and maintaining a system or systems of conservation measures to achieve a specified objective.
Net returns	The residual value of production after total costs of production are subtracted from the gross returns.
Operating cost	Expenditures for machine operation that generally include lubrication, repairs, and fuel (not applicable to all machines).
Operation, maintenance, and replacement	Actual expenditures and donated services to ensure proper functioning of the facility or measure throughout its intended life, or capital outlay required to maintain the benefit stream and planned mitigation measures.
Ownership costs	Costs unrelated to rate of annual use, such as expenditures for depreciation, taxes, interest on investment, insurance, and housing.
Price base	A level of prices, usually associated with a "base" year, used as the basis for establishing a price index.
Production risks	The risk that the crops will fail or livestock will die.
Salvage value	The monetary value of an investment at the end of its economic life, usually the trade-in value as new equipment is purchased.
Short-term	A time period during which at least one production cost is fixed.
Long-term	A time period during which all production costs are variable.

Sinking fund	A planned accumulation of money or financial capital in an interest-bearing account over a period of years. The intent of a sinking fund is to ensure that adequate funds are available to replace a piece of capital equipment once it has reached the end of its useful life and has been depreciated down to zero.
Technological advancement	Gains in production efficiencies or conservation opportunities through new innovations.
“T” chart	A "T" chart describes the resource setting, resource concerns, and conservation system and lists the "benefits" (good or positive results) and "costs" (bad or negative results) of a proposed conservation action.
Adoption analysis	The formal process of evaluating factors that impede the adoption of conservation practices or systems.
Adoption of conservation practices	The acceptance and implementation of conservation practices or systems.
Alternate conservation systems (ACSs)	A conservation system for treating sheet, rill, wind, and ephemeral gully erosion on highly erodible land that is documented in the Field Office Technical Guide (FOTG) and which achieves a substantial reduction in soil loss rates. This term applies only to conservation plans and conservation systems developed to carry out the provisions of the Food Security Act of 1985, as amended by the Food, Agriculture, Conservation and Trade Act of 1990 and the Federal Agricultural Improvement and Reform Act of 1996.
Alternatives	Sets of practices and activities with individual and societal objectives from which a land user can choose in order to address benchmark natural resource conditions and treat them to achieve the expected future condition.
Annual percentage rate (APR)	A loan interest rate that includes various fees in its calculation. Exactly what is included in its calculation varies among financial institution.
Basic conservation systems (BCSs)	An erosion control system for treating sheet, rill, wind, and ephemeral gully erosion on highly erodible land. A BCS may be a component of a resource management system (RMS). The BCS must achieve soil loss tolerance requirements for the principal soil it is designed to protect and be documented in the FOTG. This term applies only to conservation plans and conservation systems developed to carry out the provisions of the Food Security Act of 1985, as amended by the Food, Agriculture, Conservation, and Trade Act of 1990, and the Federal Agricultural Improvement and Reform Act of 1996.
Conservation benefits	Changes in natural resource or other variables that are deemed positive or desirable effects of the conservation planning and implementation process.
Conservation costs	Expenditures and other costs incurred in order to implement a conservation practice or system.
Conservation	Decisionmaking by land users about conserving natural resources.

decisionmaking	
Conservation effects for decisionmaking (CED)	A formalized process used to assist land users in making conservation decisions by providing a method for organizing and evaluating information on benchmark conditions, resource concerns, conservation system effects, and other factors related to adoption of conservation practices.
Conservation effects or impacts	Positive or negative changes resulting from the implementation of a conservation practice or system. Determined by comparing the benchmark condition with the expected future condition with the conservation treatment.
Conservation management system (CMS)	A system of conservation practices that is expected to bring all resource concerns on the treated land unit up to an acceptable condition. Also known as a resource management system (RMS).
Conservation planning	A formal, nine-step NRCS process through which resource data are collected and analyzed, conservation alternatives are developed and evaluated, and a conservation alternative is selected, implemented, and evaluated after implementation for effectiveness.
Financial assistance programs contract	A legal agreement between a land user and NRCS in which the land user commits to implementing a project consisting of one or more conservation practices, and in which NRCS commits to paying some of the implementation costs of that project.
Conservation practice standards (CPS)	A conservation practice standard contains information on why and where a conservation practice is applied, and it sets forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purposes.
Conservation practice	Any work completed or structure installed in order to improve the condition of one or more natural resource assets. See NRCS resource concerns.
Conservation system	A group of practices that collectively treat one or more natural resource concerns.
Conservation treatments	The implementation of one or more conservation practices in order to improve natural resource conditions.
Consumer Price Index (CPI)	A measure of inflation for consumer goods, such as food and clothes, generated by the Department of Labor's Bureau of Labor Statistics.
Discounted cash flow analysis	A tool commonly used in investment analysis to evaluate projects with benefits and costs occurring at different time.
Economic thresholds	An economic threshold occurs when a resource concern, if left untreated, would result in reductions in revenues that exceed treatment costs.
Engineering News Record (ENR) index	A construction costs index generated by Engineering News Record, an engineering industry publication for professionals in the engineering and

construction industries.

Externality	An externality exists when some or all of the benefits of a private action are enjoyed by (or costs paid by) someone who was not directly a party to the market transaction generating those benefits (or costs).
Future value	The expected value of an asset at a set time in the future based on a specific interest rate or rate of return.
GDP	Gross Domestic Product. The market value of all goods and services produced within a specific geographic region (usually a nation) during a defined period of time.
GDP deflator	Measures the ratio of nominal (or current-price) GDP to the real (or chain volume) measure of GDP. Produced by the Bureau of Economic Analysis.
Hedonic pricing method	Placing a value on a nonmarket natural resource asset by identifying a change in the price or value of some other asset that is affected by a change in resource conditions.
Inflation	An increase in the general price level of an economy.
Land-user values	Refers to the viewpoints and preferences of the cooperating land user within the CED process. Each individual's preferences will affect the value they place on an impact as well as determining whether that impact is viewed as a positive or negative difference in conditions.
Market benefits and costs	Benefits and costs consisting of goods, services, and assets bought and sold in a public market and for which market-based prices and values can be readily identified. Examples include labor, purchased input goods, increased farm yields, etc.
Net present value (NPV)	A net present value is the summation of all positive and negative present values for an investment project. The NPV of in a project is also called the net worth of the project.
Nonmarket benefits and costs	Benefits and costs consisting of goods, services, and assets not traded in any public market and for which market-based prices and values cannot be readily identified. Examples include clean air, enjoyment of beautiful landscapes, increased health of wildlife, reduced personal satisfaction, etc.
Nonrenewable resources	Natural resources that are essentially finite in quantity and, within a human time scale, are not renewed by natural processes. Examples include fossil fuels and minerals.
Nominal discount rate	A discount rate that has not been adjusted to take inflation into consideration.
Nominal value	Any value or price that has not been adjusted to take inflation into consideration.

NPV criterion	The net present value criterion states that an investment project is feasible if its NPV is positive. For two or more exclusive investment projects, the one with the highest NPV is the best choice.
NRCS resource concerns	Title 450, General Manual, Part 401, states in part, "NRCS provides technical assistance to decision-makers to protect, maintain, and improve soil, water, air, plant, and animal resources and related human considerations." These resource categories have traditionally been referred to within NRCS as the SWAPA+H resource concerns: soil, water, air, plant, animal, and human. In 2010, energy was added as an additional official resource concern of interest to NRCS, expanding the list to SWAPAE+H.
Resource management system (RMS)	A system of conservation practices that is expected to bring all resource concerns on the treated land unit up to an acceptable condition. Also known as a conservation management system (CMS).
Offsite costs	Costs of conservation that are incurred outside of a project's immediate area.
Onsite costs	Costs of conservation implementation that are directly associated with the land unit where conservation practices are to be applied.
Opportunity cost method	Valuation of a project's nonmarket costs based on what the benefits of the project would have to be in order to offset its impacts.
Perpetual resources	Natural resources whose availability is not affected by human use. Examples include solar radiation, tidal forces, and wind energy.
Prices Received by Farmers Index (PPRI)	An index calculated monthly by the National Agricultural Statistics Service (NASS). Can be used to convert conservation benefits between real and nominal values.
Producer Price Index (PPI)	Measures inflation for the producer goods such as machinery. Generated by the Department of Labor Bureau of Labor Statistics.
Producer Prices Paid by Farmers Index (PPPI)	Calculated monthly by NASS. Can be used to convert conservation costs between nominal and real values.
Public investment	Real or financial investment activities conducted within the public (Government) sector of the economy.
Private investment	Real or financial investment activities conducted within the private (nongovernmental) sector of the economy.
Real discount rate	A discount rate that has been adjusted to take inflation into consideration.
Real or constant value	Any financial or market value that has been adjusted to take inflation into consideration.
Renewable resources	Natural resources that reproduce or are replenished by natural processes. Examples include plants and animals.

Replacement cost method	Valuation estimate based on much it would cost to use alternative means to either provide the benefit or mitigate the cost being evaluated.
Resource conservation	In the agricultural sector, it refers to efforts to protect, maintain, and improve soil, water, air, plant, and animal resources and related human considerations to ensure a quality resource base for long-term productivity of the land and a quality environment for human living standards.
Risk analysis	Within a conservation context, risk analysis is an analytical technique in which the estimation of net conservation benefits from conservation alternatives is based on the probabilities of occurrence of all critical events or elements of conservation in all likely future scenarios.
Sensitivity analysis	Analysis conducted to test the effects of changing any assumptions that were made while evaluating the impacts of implementing a conservation system. Serves as a means of identifying the vulnerability of the success of a conservation system to uncertain future events and values.
Temporal distribution of benefits and costs	The pattern in which the benefits and costs of a conservation project are expected to be realized over time.
Time value of money	The time value of money means that cash flows at different points of time differ in value and thus are not directly comparable.
Unable to adopt	Being unable to adopt a new conservation practice implies the existence of one or more obstacles or situations that prevent the land user from adopting the conservation practice even if he or she is willing to do so.
Unwilling to adopt	Occurs when a land user has not been persuaded that a practice will work or is appropriate and beneficial for their farm or ranch operations.
Useful life of a conservation practice	The time period over which a conservation practice can be expected to continue to function, to fulfill its intended purpose, and continue to provide conservation benefits.
Value engineering	Value engineering is a process in which the planner, the evaluator, or the decisionmaker starts with an initial conservation system alternative, adds an additional feature or increases the magnitude of a characteristic of the alternative (such as adding additional units of a conservation practice), and then evaluates the result to test for a net increase in the overall value of the conservation project.

Subpart H - General References

610.80 References

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