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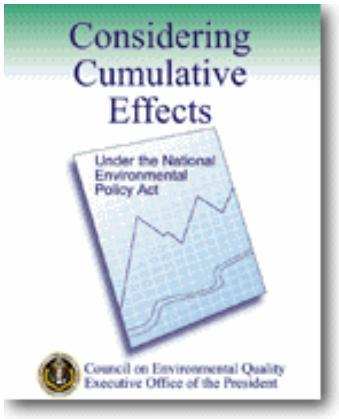
Considering the Cumulative Effects of NRCS Activities

Analyzing incremental environmental impacts of NRCS actions with other past, present and future actions as required by the National Environmental Policy Act (NEPA)

Overview:

Table of Contents	**iii**
Acknowledgements	**iv**
Executive Summary	**v**
Purpose	**1**
Background	**1**
Important Definitions	**2**
How Do Cumulative Effects Occur?	**4**
How are Direct, Indirect, and Cumulative effects different?	**5**
A Forward-Thinking Process	**6**
Reactive Situations	**9**
Cumulative Effects Analysis Methods: Examples	**11**
References	**31**
Appendices	**34**
A. Definitions	
B. Generic Questionnaire	
C. Example: Watershed-scale RMS/Effects Formulation	
D. Practice Effects Diagrams	

Figure 1. One hundred years ago, the area shown was predominantly natural, unmanaged forest. The cumulative effects of converting natural areas to agriculture, urban and managed forests have made a pronounced change to economic systems, hydrology, habitat connectivity, air emissions, and discharges of pollutants to receiving waters. In general, NRCS conservation planning and implementation leads to positive changes but may have unintended, negative effects if not analyzed properly at an appropriate areawide level over a relevant time period.



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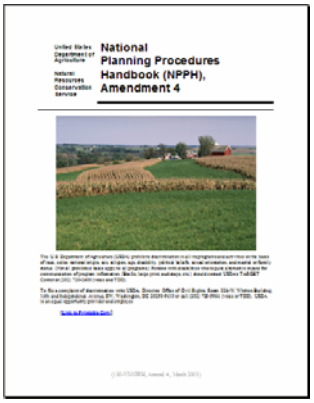

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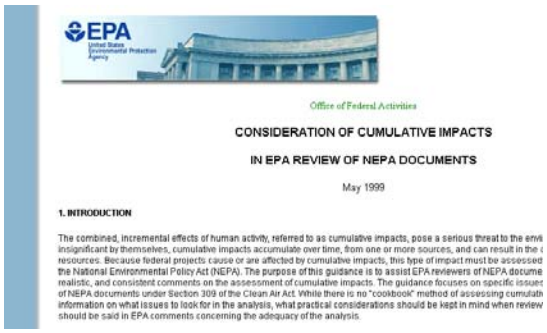

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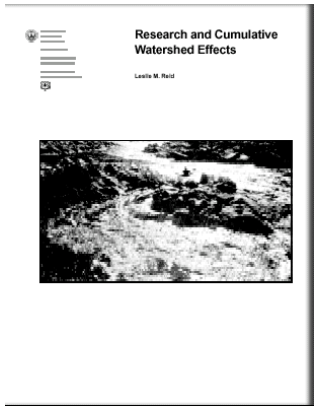
URL: http://es.epa.gov/oeca/ofa/cumula.html



Reid, Leslie M. 1993. **Research and Cumulative Watershed Effects.** General Technical Report PSW-GTR-141. Pacific Southwest Research Station, USDA-Forest Service. Albany, CA

URL: http://www.rsl.psw.fs.fed.us/projects/water/reid_141.pdf

Figure 2. A number of documents are useful in explaining requirements and interpreting cumulative effects analysis under NEPA. Some notable publications including NRCS's National Planning Procedures Handbook are shown above. The title and web site (URL - Uniform Resource Locator address) are noted beneath each document.

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Table of Contents

Acknowledgements iv
Executive Summary v
Purpose 1
Background 1
Important Definitions 2
How Do Cumulative Effects Occur? 4
How are Direct, Indirect and Cumulative Effects Different? 5
A Forward-Thinking Process 6
Reactive Situations 9
Cumulative Effects Analysis Methods: Examples 11
- Questions, Interviews, and Panels 12
- Checklists 15
- Matrices 18
- Network and System Diagrams 21
- Modeling 23
- Trends Analysis 27
- Overlay Mapping and GIS 29

References 31
Appendices 34
- Appendix A - Definitions (full listing) 35
- Appendix B - Generic Questionnaire Checklist 38
- Appendix C - Example: Watershed-Scale RMS/Effects Formulation Process 42
- Appendix D - Practice Effects Network Diagrams 46

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Special Note: Because this guidance document relies heavily on Considering Cumulative Effects (CEQ 1997), recognition is given to the interdisciplinary team of authors and peer review panel listed in that publication.

Executive Summary

The National Environmental Policy Act (NEPA) carries the mandate to analyze the cumulative effects of federal actions (Council on Environmental Quality, 1997). However, the attention given to cumulative effects analysis during the environmental impact assessment process has been largely inadequate. Reasons for this include: 1) a lack of clear delineation of both temporal and spatial boundaries to be incorporated in the analysis; 2) the dilemma of dealing with multiple sources of baseline environmental data; 3) impact study constraints relative to time and money; and 4) limited development of policies and methodologies to address cumulative impacts (Canter and Kamath 1995).

"Evidence is increasing that the most devastating environmental effects may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time." Analyzing cumulative effects is challenging primarily because of the difficulty of defining the geographic and time boundaries associated with impact issues (CEQ 1997). In general, modern natural resources conservation programs are positive in their effect at the site level. However, treatments may inadvertently have undesirable impacts at larger geographic scales as application progresses.

The primary purposes of the guidance document are to enable conservationists to integrate cumulative effects analysis into a *forward-thinking process* as part of NRCS areawide conservation planning activities and, when needed, to properly respond in *reactive situations* when new or unforeseen cumulative effects issues are identified during or after implementation of conservation practices and measures.

The specific aims are:

- *To successfully foresee cumulative effects during areawide planning.*
- *To competently react to impact issues brought to the agency's attention during or after conservation application.*

The overall intent for using the guidance presented herein is to better achieve the agency's mission: "To provide leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and environment." The specific aims are:

1. To successfully foresee cumulative effects during areawide planning and properly modify alternatives (proposed actions) to optimize beneficial impacts and eliminate or mitigate adverse significant impacts.
2. To competently react to impact issues brought to the agency's attention during or after conservation application and carefully analyze cumulative effects and mitigate adverse significant impacts by using adaptive management (which, in turn, helps us improve agency policies, standards and future actions).

To best assist agency planners, definitions of terms and descriptions of useful evaluation tools are included. Definitions improve understanding of concepts underlying the processes, tools and techniques used in cumulative effects analysis. Evaluation tools or methodologies for performing cumulative effects analysis of proposed actions are described through narrative and examples. More extensive examples, where applicable, are reproduced in appendices.

… this report will be most useful for planners and specialists involved with clients, stakeholders and partners working with community-bounded areas or watersheds generally less than 250,000 acres …

Because cumulative effects are best analyzed over large landscape units, this report will be most useful for planners and specialists involved with clients, stakeholders and partners working with community-bounded areas or watersheds. Typically, such units will involve multiple ownerships ranging from a few thousand acres up to 250,000 acres in size.

Purpose

The purpose of the guidance provided in this document is four-fold:

- Provide an understanding of the terminology and concepts associated with cumulative effects analysis under NEPA,
- Outline a *forward-thinking process* to integrate cumulative effects analysis into local NRCS areawide conservation planning,
- Outline how to deal with *reactive situations* when new or unforeseen cumulative effects issues are identified during or after implementation of conservation practices and measures,
- Explain and demonstrate methodology and tools that can be used for conducting a cumulative effects analysis using either process.

The report will be most useful for planners and specialists involved with clients, stakeholders and partners who are: 1) contemplating the use of or developing areawide and watershed plans, or 2) addressing cumulative effects issues during or after the implementation of conservation treatment.

The outcome for using the guidance presented herein is to better achieve the agency's mission "to provide leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and environment." The specific aims are:

1. For conservation activity in the planning stage, to successfully understand and foresee cumulative effects and properly modify alternatives (proposed actions) to optimize beneficial impacts and eliminate or mitigate adverse significant impacts.
2. For conservation activity during or after the implementation stage, to thoroughly understand issues brought to the agency's attention and carefully analyze cumulative effects and mitigate adverse significant impacts by using adaptive management. (Adaptive management is a process that adjusts decisions and subsequent conservation treatment based on the results of monitoring or evaluation. This process helps us improve agency policies, standards and future actions.)

Background

"Evidence is increasing that the most devastating environmental effects may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time." Analyzing cumulative effects is more challenging, primarily because of the difficulty of defining the geographic and time boundaries (CEQ 1997). In general, modern natural resources conservation programs are significantly positive in their effect at the site level. However, treatments may inadvertently have undesirable impacts at larger geographic scales as application progresses. For example:

- Croplands are retired to a point that reduce traditional agribusiness transactions and community viability, and unintentionally allows invasion by undesirable animal and weed species which spread to active cropland,
- Episodic streambank armoring that eventually reaches a point in a stream system where aquatic and terrestrial habitats are degraded with concurrent losses in fish and wildlife populations,
- Building additional retention ponds or basins and further changing flooding patterns which have already altered migratory bird habitat,
- Reliance on modern but costly structural practices can change cash flow and borrowing behavior which, in turn, causes hardship on a community's limited-resource producers.

NEPA and CEQ regulations require federal agencies to study the direct, indirect and cumulative effects of their proposed actions. The objective of cumulative effects analysis is to make sure proposed actions account for the full range of consequences. Analysis will involve assumptions and uncertainties but must be conducted with the best techniques and data available. The need for better techniques and data can be identified, but are not justification for avoiding or delaying cumulative effects analysis. Over time, where substantial uncertainties exist, proposed actions and their implementation can be modified as new methodology and data come on-line.

Important Definitions for Understanding How Cumulative Effects Analysis Integrates with the Planning Process

Definitions of terms provide the working vocabulary required to understand processes, tools and techniques in analyzing cumulative effects. Some important definitions are included here. Appendix A contains a full listing.

Affected Environment - The affected environment in a NEPA analysis that addresses cumulative effects includes all potentially affected resources (soil, water, air, plants, animals), ecosystems, and human communities.

Areawide Conservation Planning - The 3-phase, 9-step iterative process used by NRCS to help clients plan and apply conservation treatments for a watershed or other geographical area (referred to as the planning area) defined by the clients and stakeholders. ***See figure 3, column A.*** The areawide conservation plan addresses all identified resource problems including cumulative effects issues, contains alternatives that meet the minimum quality criteria for each resource, and addresses applicable laws and regulations.

Baseline Conditions - Conditions of resources, ecosystems and human communities used as the bases or levels of comparison for analyzing effects of proposed actions. These may be established or estimated from current day conditions with consideration of historical circumstances.

Benchmark Conditions - The status or quality of one or more current planning area situations, circumstances, or settings projected over a future specified time period. Status and quality are usually measured and defined by using one or more relevant indicators and target values. The projection of benchmark condition accounts for reasonably foreseeable future actions as well as past and present actions but does not include the effects of alternatives (proposed actions) being contemplated by the planning group. The benchmark condition is used as a point of reference to: 1) compare against projected resource conditions anticipated for an alternative, and 2) measure change in resource conditions resulting from applied conservation.

Bounding - The process of establishing spatial and temporal boundaries to encompass additional effects on the resources, ecosystems, and human communities of concern during a cumulative effects analysis.

Conservation Practice - A specific treatment, such as a structural or vegetative measure, or management technique, commonly used to meet specific needs in planning and implementing conservation, for which standards and specifications have been developed.

Cumulative Effects - The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other action.

Cumulative Effects Analysis - An 11-step procedure with an objective to account for the full range of consequences from proposed actions. ***See figure 3, column B.*** The process will involve assumptions and uncertainties but must be conducted with the best techniques and data available.

Indicator - The description or measurement of a resource concern that, when observed periodically, indicates or demonstrates trends. Directly linked to indicators are target values which identify a specific quantitative or qualitative estimate for the desired state of the resource concern.

Resource Management System (RMS) - A prescribed combination of conservation practices and management identified by land or water uses that, when implemented, prevents resource degradation and permits sustained use by meeting quality criteria established in the Field Office Technical Guide (FOTG) for the treatment of soil, water, air, plant, and animal resources.

Scoping - The early, up-front and open process to determine the extent of significant resource problems and issues be addressed in the planning process.

Thresholds - The status or quality of a condition tied to a spatial and temporal scale where effects from a proposed action are anticipated to have a conspicuous or evident beneficial or adverse impact on a resource, ecosystem or human community.

Target Value - Identifies a specific value to be used in conjunction with an indicator.

NRCS Areawide Conservation Planning Process Column A		NEPA-CEQ Cumulative Effects Analysis Steps Column B
Phase I - Collection and Analysis: 1. Identify Problems and Opportunities 2. Determine Objectives	*Iterative Processes*	**Scoping:** 1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals. 2. Establish the geographic scope for the analysis. 3. Establish the time frame for the analysis. 4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
3. Inventory Resources		**Describing the Affected Environment:** 5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses. 6. Characterize the stresses affecting these resources, ecosystems, human communities and their relation to regulatory thresholds.
4. Analyze Resource Data		**Determining the Environmental Consequences:** 7. Define a baseline condition for the resources, ecosystems, and human communities. 8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
Phase II - Decision Support: 5. Formulate Alternatives 6. Evaluate Alternatives		9. Determine the magnitude and significance of cumulative effects. 10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
7. Make Decisions		--
Phase III - Application and Evaluation: 8. Implement the Plan		--
9. Evaluate the Plan		11. Monitor the cumulative effects of the selected alternative and adapt management.

Figure 3. A listing and comparison of the NRCS planning process and CEQ cumulative effects analysis steps.

Column A - The 9-step iterative process used by NRCS to help clients plan and apply conservation treatments for a watershed or other geographical area defined by clients. Typically, conservation treatments to address particular resource concerns at the site level are known before large-area planning is initiated. These treatments are known as resource management systems (RMS's). Areawide planning establishes the participation level or extent of RMS's (proposed actions) to be applied throughout the landscape and sets forth a strategy on where RMS's need to be applied first for best effect. (NRCS 2000)

Column B - An 11-step iterative procedure developed by CEQ that guides users to study the full range of consequences from proposed actions. The procedure should not be viewed as formal CEQ guidance nor is it intended to be legally binding. (CEQ 1997)

How Do Cumulative Effects Occur?

There is a broad range of potential cumulative effects, and there are several mechanisms through which they can occur. It is important to understand these mechanisms because they help planners think broadly about ecological interactions (Canadian Environmental Assessment Agency, 1999).

- Physical-chemical transport. This occurs when a physical or chemical element moves away from the action undertaken, then interacts with another action. An example of this is: 1) the application of an herbicide or pesticide on a field, 2) the transport of the chemical via surface water into the soil profile, and 3) infiltration of the chemical into the groundwater as a result of irrigation.

- Nibbling loss. The gradual disturbance and loss of land and habitat. An example of this is the breaking out of native grasslands for crop production. Many small breakout actions, over time, may significantly affect wildlife species that are dependent on the grasslands for their life cycle requirements.

- Spatial crowding. Cumulative effects can occur when too much is happening within too small an area. Actions may be different and small, but with overlap and synergism. A threshold may be exceeded and the environment may not be able to recover to pre-disturbance conditions. This can occur quickly or gradually over a long period of time before the effects become apparent. For example, prescribed burning of certain crop residues to reduce disease in a small geographic area may have little impact. But airborne pollutants from the burn may act synergistically with emissions from automobiles and wood-burning stoves in the same geographic area to create a significant cumulative effect.

- Temporal crowding and trailing. Cumulative effects can occur when too much is happening in too brief a period of time (temporal crowding) or may last for many years beyond the life of the action that caused them (temporal trailing). An example of *temporal crowding* might be applying nutrients to pasture or crops too frequently so that appropriate plant uptake is unlikely. A threshold may be exceeded whereby the crop is injured or excess nutrients are carried by surface water to receiving streams. An example of *temporal trailing* is the construction of a floodwater retarding structure in a watershed where, over time, it is likely to accumulate toxic-laden sediments.

Figure 4. Landscapes exhibiting cumulative effects mechanisms. *Above:* Residential development sprawls around a reservoir originally built for flood control. *Right:* Vegetative buffers installed on agricultural lands to reverse a trend of accumulating sediment and nutrients in streams.

How are Direct, Indirect, and Cumulative Effects Different?

The purpose of effects analysis during an environmental assessment (EA) is to determine if there are any significant direct, indirect, or cumulative effects. Significant effects trigger the need to prepare an environmental impact statement (EIS). See figure 5. In an EIS, the purpose of effects analysis is to identify and analyze significant adverse effects, disclose them to the decision-makers and the public, and mitigate them to the extent possible.

An important concept in preparing EA's and EIS's or completing any environmental evaluation is that there are key differences in *emphases* between identifying and analyzing direct, indirect and cumulative effects. A direct effect is what happens at a site soon after an action (or, in the case of a proposed action, what is anticipated to happen). An indirect effect occurs later on or off-site and is triggered by the action itself or its direct effects. A cumulative effect is the impact on the environment resulting from the incremental consequences of the action when added to other past, present, and reasonably foreseeable future actions regardless of who takes such other action. Typically, a cumulative effect necessitates looking at a longer time period and larger landscape unit to perform a competent analysis.

Some notable emphases include:

Direct and Indirect Effects	Cumulative Effects
Analysis of the effect bounded by the site-level "footprint" and "trail" of the action	Analysis of the effect and connected actions/effects bounded by an ecosystem or landscape
Chain of causation usually linear and straightforward	Chain of causation connective, complex and additive
Effects happen relatively quickly with some lag time for indirect effects	Effects may take decades
Trends of individual effects and causation more detectable	Trends of interacting effects and causation less detectable
Evidence of causation and accuracy of the analysis usually clear and certain	Evidence of causation and accuracy of the analysis usually intricate and less certain

Observance of these differences during effects analysis will help planners identify and distinguish direct, indirect and cumulative effects.

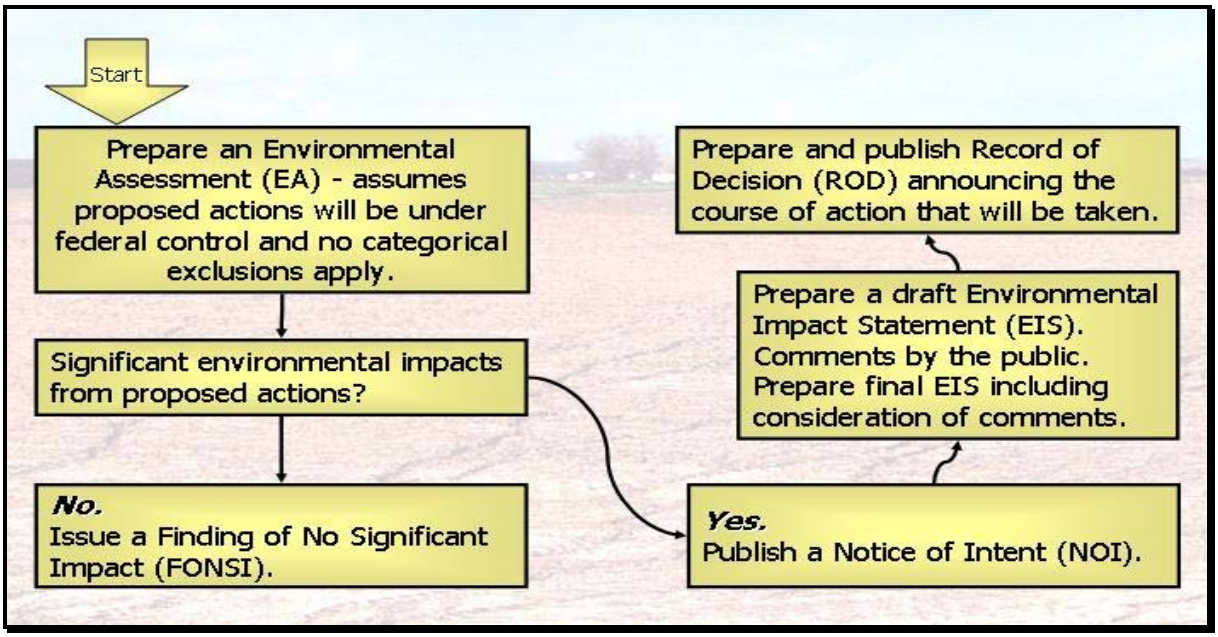


Figure 5. The flow of NEPA activities is the same for all situations. However, the cumulative effects analysis part of an EA or EIS is usually more complex.

A Forward-Thinking Process

Some authorities contend that all environmental effects are cumulative because every impact that occurs in a natural system is in addition to something that has occurred, is occurring, or will occur. The tendency when conducting environmental impact analysis is to focus primarily on the direct impacts of specific projects. However, NEPA carries the mandate to analyze the cumulative effects of proposed alternatives, as well as the direct and indirect effects (CEQ 1997).

In general, conservation treatments applied on an operating unit or a small group of operating units may not cause conspicuous cumulative effects. However, as participation levels in conservation programs increase over time in a large area, cumulative effects may become quite noticeable and measurable. Planning and analysis at the areawide level (i.e., watersheds or other large areas usually with multiple ownerships) is crucial to studying incremental impacts of conservation treatments that individually may not be detectable at the site-scale. A principal goal would be to use a forward-thinking process to assess whether anticipated effects from planned or accumulating conservation activity will exceed established thresholds.

The areawide level … of analysis and planning is crucial to properly studying incremental impacts of conservation treatments that individually may not be detectable at the site-scale.

NRCS's planning process can easily accommodate the 11-step CEA procedure (figure 3). As a *forward-thinking process*, the NRCS Areawide Planning Process can be used to: 1) properly anticipate the direct, indirect, and cumulative effects of proposed actions, 2) help judge the significance of impacts, and 3) modify, eliminate or add alternatives to optimize beneficial effects and mitigate adverse effects. There is no need to follow a second separate process to address the 11 CEA steps. A single process is all that is necessary.

When CEA becomes an integral and concurrent part of the areawide planning process, the stage is set to understand the full impacts of the proposed action. If such a process is not employed, *reactive situations* become more frequent, triggered by individuals or groups who legitimately challenge conservation effects based on missing or poorly understood cause-and-effect relationships. Inattention or failure to thoroughly understand the contribution of NRCS activities to cumulative effects can be costly and in direct conflict with the agency's mission "to provide leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and environment."

Getting Started

Analyzing cumulative effects is challenging because of its predictive nature as well as a tendency to focus only on NRCS actions. A certain level of variability or risk and uncertainty will be experienced regardless of methods used for prediction. The planning process must be conducted with the best scientific tools, techniques and data available to minimize uncertainty.

Considerations for each of the 9 planning steps to account for cumulative effects are listed in table 1. Information for each step is primarily derived from the National Planning Procedures Handbook (NRCS 2003), Considering Cumulative Effects (CEQ 1997) and a variety of plans under development or already existing that have purposefully included cumulative effects analysis. For descriptions and examples of methodologies, refer to the ***Evaluation Methods and Tools*** section.

As a forward-thinking process, the NRCS Areawide Planning Process can be used to: 1) properly anticipate effects of proposed actions, 2) help judge the significance of impacts, and 3) modify, eliminate or add alternatives to optimize beneficial effects and mitigate adverse effects.

Table 1. Overview of cumulative effects analysis elements and tools used during the NRCS planning process.

NRCS Areawide Conservation Planning Process	Key Elements and Activities	Evaluation Methods and Tools
1. Identify Problems and Opportunities	Recruit local and regional organizations and specialists aware of cumulative effects issues as stakeholders and planning team members. This is important regardless of the individual, group or agency implementing action(s). Incorporate and reach agreement on the initial identification of significant cumulative effects issues and boundary(ies) of the planning area (geographic scope) related to the general application of land use/setting Resource Management Systems (RMS's)[1]. See appendix C for a watershed-scale RMS-Effects formulation process example. Identify other influencing actions that have occurred, are occurring, or are likely to occur in the foreseeable future. Based on the list of problems and opportunities, prepare an explanation of why there is a "need for action."	• Questionnaires, interviews, panels • Checklists • Overlay maps and GIS
2. Determine Objectives	Objectives are largely a translation of *problem statements* to *objective statements*. Development of statements may further narrow the scope of proposed actions. The "purpose for action" can be formulated by documenting the objectives and associated desired future conditions. The "purpose for action" should also explain how the anticipated use of applicable RMS's would meet the "need for action."	
3. Inventory Resources 4. Analyze Resource Data	The inventory and analysis strategy is based on those problems or issues related to objectives. Use the question "What are the origins of the problem/issue?" repeatedly to develop a chain or network of possible causes for each issue. Each "chain" or "network" of answers should help planners identify the types of inventories needed. The degrees of detail for the inventories should be sufficient to address these critical questions: • How and at what rate have resources conditions tied to scoped issues changed? (e.g., total SOIL-erosion and WATER-quality-sediment in the urban transition zone have increased 5 percent annually over the last 5 years) • What stress factors are likely tied to the changes and are they anticipated to increase or diminish? (e.g., sprawl-type development is causing erosion and sediment and is expected to double in 10 years) • How have relevant regulatory controls affected stress factors? (e.g., the local Urban Growth Plan was established to regulate the rate of development but it is routinely revised to allow more and faster expansion) *Indicators* of resource conditions, stress factors and regulatory controls are selected at this time and use conventional and understandable units of measure. They are focal points of the inventories. As indicator data are compared to applicable *thresholds* or *target values* for each problem or issue, document: 1) the time frames used, 2) the benchmark conditions (baselines), and 3) key cause-and-effect relationships. Note that the collection of indicator data begins the monitoring process described in step 9 below.	• Checklists • Network and system diagrams • Overlay maps and GIS • Trend analyses • Questionnaires, interviews, panels

Table 1. Continued.

NRCS Areawide Conservation Planning Process	Key Elements and Activities	Evaluation Methods and Tools
5. Formulate Alternatives 6. Evaluate Alternatives	Proposed actions[1] are reexamined, a range of alternatives are formulated (e.g., 3-5 scenarios of major practice/measure combinations including the no-action alternative), and estimates of participation rates and extent of future application are determined. To begin the evaluation, ask the question "What happens when an alternative is applied?" The answers will generate a list of effects (usually direct effects) that typically lead to off-site or later effects (indirect effects). Many of the effects will be intended and some will be unintended. As the network of direct and indirect effects accumulate based on anticipated participation rates for the alternative, are other effects generated (cumulative effects)? How do all effects react with other past, present and reasonably foreseeable future actions? Will key indicators reach target values or thresholds of acceptability? Are unintentional direct, indirect and cumulative effects tolerable? These questions and evaluation are pursued equally for each alternative. The qualitative and quantitative evaluations estimate the context and intensity of cumulative effects of the proposed actions and can be used to modify alternatives to optimize beneficial effects and eliminate or mitigate adverse effects. Planning step 6 concludes with a set of evaluated alternatives[2].	• Network and system diagrams • Models • Questionnaires, interviews, panels • Tables and matrices • Overlay maps and GIS • Trend Analyses
7. Make Decisions	Alternatives are carefully examined and a particular course of action is selected by decision-makers. Decisions are typically representational, i.e., individual landowners and public decision-makers still need to make decisions at the site level that conform with areawide decisions. Decisions that are appreciably different than any of the evaluated alternatives will force a reiteration back to at least step 6.	• Questionnaires, interviews, panels
8. Implement the Plan	The implementation strategy and application of decisions within the planning area are completed in conformance with the EA or EIS.	
9. Evaluate the Plan	Monitoring actually begins when indicator data in step 3 is collected to determine baseline conditions. It continues concurrently with plan implementation to validate benchmark or baseline conditions and assumptions and, over time, to determine if actions were applied properly and if they achieved desired conditions (*thresholds* or *target values*) as described in the EA or EIS. Monitoring results are used to adapt management to further optimize beneficial impacts and deal with unforeseen adverse environmental impacts. Monitoring continues during the plan "life span" using the same *indicators* employed during steps 3, 4 and 6 so that all data are comparable over time.	• Tables and matrices • Models • Overlay maps and GIS • Trend Analyses

[1]Most often consist of applicable Resource Management Systems (RMS's) located in Section III of the Field Office Technical Guide and are applied, under ideal conditions, to all land uses and settings within the planning area boundary. Realistically, the combinations of practices and measures into a reasonable number of alternatives with estimates of participation rates and extent of future application will be more precisely determined during planning steps 5 and 6.

[2]The information and analyses from planning steps 1-6 are used to formulate the cumulative effects part of the Environmental Assessment (EA) and Environmental Impact Statement (EIS). Steps 1-6 provide the evidence for making findings of significance and determining what mitigation is necessary. Note that an EA or EIS can be physically included in an areawide plan if their elements are clearly identified and self-supporting. However, identify no alternative as "selected" within the context of planning steps 5 and 6.

Reactive Situations

The preferred way to carry out environmental evaluation of NRCS proposed actions is to use the 9-step planning "forward-thinking" process as a way to anticipate the magnitude and duration of cumulative effects. However, some of the agency's past planning has been dominated by analysis at the site level. This has generated concerns whether additional actions in the same geographic area will "tip the scales" of seemingly benign individual actions to an accumulation of actions that, in total, could cause harm. A much-referenced example of cumulative effects is the practice of installing rip-rap for stream bank and shoreline stabilization (see figure 6). Use of rip-rap on a site scale arguably has minimal effects on a stream's ecology. However, numerous site scale projects may accumulate to the stream reach scale generating adverse effects.

Figure 6. Rock rip-rap on a previously eroding streambank.

Challenges to the accumulation of the agency's past actions can limit opportunities to conduct forward-thinking planning. Planners may be faced with obstacles such as time constraints imposed by data gathering and analysis, resource limitations, lack of understanding or credibility with permitting agencies, or pending litigation. Increasingly it is simply more efficient to consider a focused reaction to specific challenges and claims. This requires objectively analyzing the impacts of NRCS actions in context with other actions in an area and, if necessary, a willingness to stop or change damaging actions.

Analysis of reactive situations is similar to the forward-thinking process in several ways:

- It relies on the same principles,
- Includes past, present and future actions,
- Includes all federal, nonfederal and private actions,
- Focuses on each affected resource, ecosystem, and human community,
- Focuses on truly meaningful effects,
- It uses the same sequence of steps (refer to pages 6 through 8),
- It may rely on the same analysis methods.

Reactive situations may, however, differ in specific fundamental ways:

1. <u>The scope of a reactive analysis may be determined by a challenging or inquiring entity and it is usually very narrow and focused.</u> Forward thinking is based on consideration of conservation RMS's; reactive situations generally occur because of the perceived effect of one or more individual conservation practices. A RMS is a prescribed combination of conservation practices and management that, when implemented, prevents resource degradation. Reactive challenges or inquiries are more often targeted to a single practice such as brush management, streambank and shoreline stabilization, dike, stream channel stabilization, or structure for water control. These practices, especially when used outside of the context of a RMS, have a greater potential for unintentional adverse environmental effects in certain resource settings.
2. <u>The time frame for the analysis may be more heavily historical in nature so that the planner's greatest challenge is to determine how far back in time is appropriate for the analysis.</u> An environmental organization might challenge the future installation of a single structure in a watershed where numerous stream channel stabilization structures have historically been installed. This challenge may be valid, for example, if the cumulative effect of the agency's work and the work of others on a population of an endangered fish species was never evaluated. The relevant issues become
   a) how to define a baseline ecological condition at some point in the past and then
   b) determining whether it is likely or not likely that one more structure would push the threshold of the impact to or above a level of adverse 'significance.'

3. Analysis techniques are extremely critical since reactive situations may require a "higher" standard of evidence as it pertains to environmental consequence. Because reactive situations are sometimes litigious in nature, all aspects of science and technology may be called into question. Data collected and analyzed must be done so according to accepted scientific protocols and where protocols do not exist, expert opinions and related case studies should be solicited and carefully documented.

4. Formal monitoring programs may be necessary to judge the adequacy of the analysis used and predictions made. Very often models or trend analyses are the basis for predicting cumulative effects. In a reactive situation, it is prudent to monitor the resource concerns in question to determine whether the predictions were within an acceptable range or actual measured conditions. Such monitoring provides an opportunity to include other agencies and organizations.

Generic Procedure for Dealing with Reactive Situations

A generic procedure with key elements tailored to reactive situations is provided in figure 7. This procedure or roadmap relies on narrowing the scope of the issues, using accepted science-based methods, peer review and appropriate mitigation activities and monitoring.

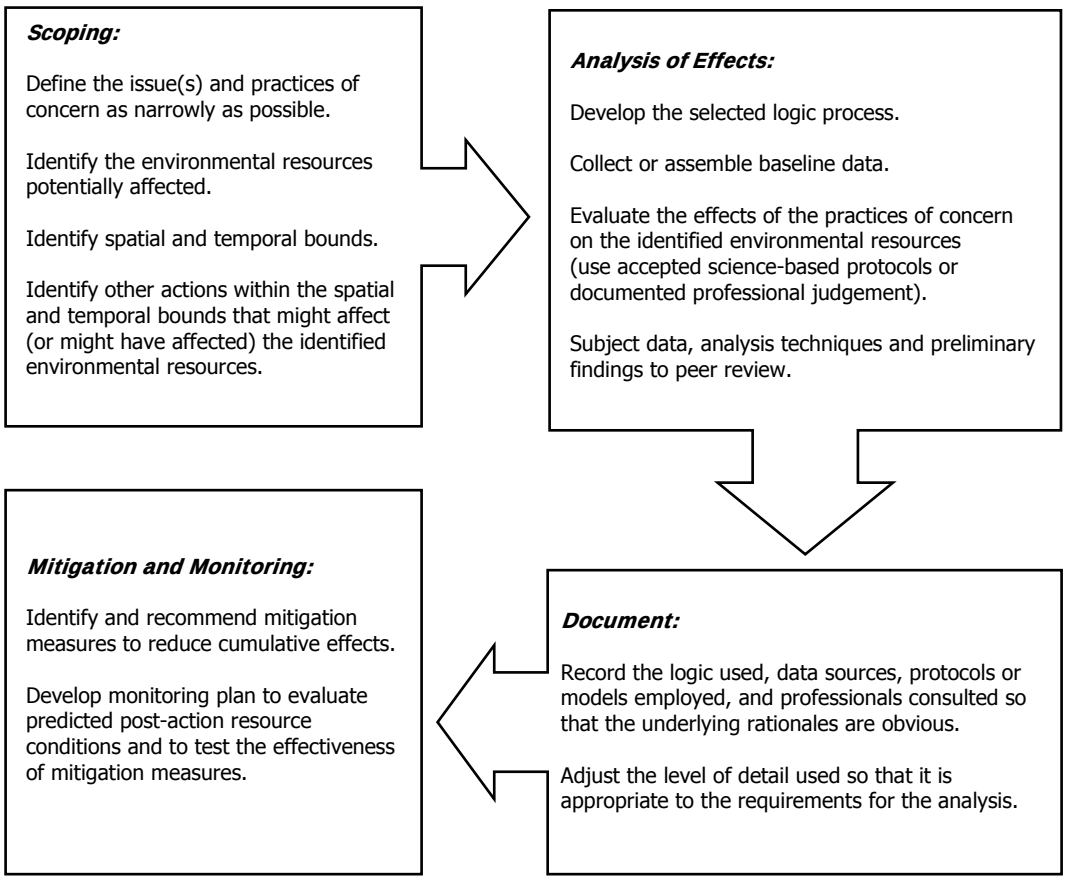


Figure 7. Generic procedure for dealing with reactive situations.

Cumulative Effects Analysis Methods: Examples

Methodologies for performing cumulative effects analysis of proposed actions range from a simple checklist to a complex, multiple-algorithm model tied to a Geographic Information System. Most methods developed for analyzing cumulative effects are adequate at describing problems but may be inadequate at quantifying cumulative effects (Council on Environmental Quality, 1997).

This section provides a description and examples of methods that have been used in the cumulative effects analysis process. More extensive examples, where applicable, will be noted and reproduced in an appendix. While no one method or tool will be appropriate for every situation, the tools presented in this section have been used to document cumulative effects on prior projects.

Primary methods include:

Questionnaires, Interviews, and Panels ***(page __)***

These are useful for gathering a wide range of information on multiple actions, resources, and effects issues. They are flexible and can deal with subjective information but cannot quantify or definitively compare alternatives. They also can help with predicting how individuals will react to preliminary findings, alternative scenarios, etc.

Checklists ***(page __)***

These are helpful in identifying a list of common or likely effects and juxtaposing multiple actions and resources. Checklists are systematic and concise but can be inflexible and do not address interactions or cause-effect relationships. They can be particularly useful as a reminder list during analysis.

Matrices ***(page __)***

These provide a tabular format to organize and quantify the interactions between human activities and resources of concern. Matrices are useful for comparison of alternatives but do not address space or time, can be cumbersome and do not address interactions or cause-effect relationships.

Network and System Diagrams ***(page __)***

These are more visual methods for delineating the cause-and-effect relationships resulting in cumulative effects. The diagrams facilitate conceptualization by visually linking proposed actions to direct, indirect and cumulative effects. The diagrams can become confusing as complexity is added and they typically do not address space or time considerations.

Modeling ***(page __)***

These quantify cause-and-effect relationships leading to cumulative effects. Generally models give quantified and unequivocal results, address cause-and-effect relationships, and can integrate space and time considerations. However, models are data intensive, have intrinsic assumptions, can be expensive, and may be difficult to understand as the number of variables and algorithms increase and interact. Underlying assumptions in a model must be fully understood and assessed for applicability to the local analysis.

Trends Analysis ***(page __)***

These evaluations assess the status of a resource, ecosystem, and human community over time and usually result in a graphical projection of past or future conditions. They are quite helpful in addressing accumulation over time, identifying problems and setting baseline conditions. However, trends analyses are data intensive and may be difficult to extrapolate beyond known data.

… no one method or tool will be appropriate for every situation …

The description of each evaluation method contains important attributes, strengths, weaknesses …

Overlay Mapping and Geographic Information Systems-GIS ***(page __)***

These methods address spatial pattern and proximity of effects and provide an effective visual presentation of no-action and proposed alternatives. However, they do not easily address indirect effects or the magnitude of effects.

Getting Started

The remainder of this section provides an overview and example of each evaluation tool and, as referenced, continues with more extensive examples in the Appendices section.

The description of each evaluation method contains important attributes, strengths, weaknesses, and examples.

Questionnaires, Interviews, and Panels

These methods can range from informal to highly structured such as documented interviews, focus groups and questionnaire surveys of community leaders, indigenous people, or multi-discipline teams of experts. Structured brainstorming (e.g., nominal group technique or Delphi method) with technical specialists and key stakeholders can be an effective approach during areawide planning for:

- identifying cumulative effects issues (step 1),
- thinking through the origins of problems (step 4),
- formulating alternatives (step 5),
- reaching consensus on effects of actions (step 6),
- making representational decisions (step 7).

In reactive situations, interviews can help validate and focus issues brought before the agency. For some cumulative effects issues lacking definitive scientific models or monitoring evidence, convening a panel of experts to formulate a judgment may be the most effective and acceptable approach.

All techniques in this section have been used repeatedly by various organizations and have supporting protocols to optimize the focus of questions and minimize bias. Some notable citations include the National Association of Conservation Districts, 1996 (overview of information gathering techniques); Center for Rural Studies, 1996 (nominal group process and brainstorming); Linstone and Turoff, 1975 (Delphi method); Morgan, 1998 (focus groups); and Salant and Dillman, 1994 (surveys and questionnaires).

Two examples help demonstrate the use of questionnaires, interviews and panels: 1) the Public Questionnaire for the Tillamook Bay National Estuary Project, and 2) the Sustainability Indicators Report Card for the City of Hamilton, Ontario, Canada. Both efforts focused on affected stakeholders with an objective of identifying and prioritizing environmental issues.

Example 1 - "Public Questionnaire, Tillamook Bay National Estuary Project" (TBNEP 1999)

As part of the National Estuary Project to determine public attitude and opinions on local environmental issues, 2,400 questionnaires were sent to landowners who were randomly chosen. The estuary watershed is 338,000 acres in area and falls predominantly in Tillamook County which had a 2000 census population of just over 24,000. A total of 465 questionnaires were completed and returned. Based on applying a research standard of 90 percent confidence level, the estimated margin of error was ±5 percent. Full results of the 27-item questionnaire are available from the project staff (TBNEP, 2000). Of most interest to cumulative effects analysis are summaries of replies for several questions:

- What aspects of the Tillamook Bay [area] have changed for the worse?

Summary (% responding)

%	*Aspect*
65	*Crowding*
61	*Abundance of fish and wildlife*
42	*Water quality*
35	*Job opportunities*
18	*Scenery*
4	*Overdevelopment*
3	*Other*

- How important are estuary project priority issues?

Summary (% responding)

Scale	*Bacterial Contamination*	*Sedimentation*	*Loss of fish and wildlife habitat*
Extremely important	*70*	*61*	*82*
Somewhat important	*20*	*26*	*14*
Neutral	*4*	*7*	*2*
Somewhat unimportant	*3*	*3*	*1*
Extremely unimportant	*2*	*1*	*1*
Don't know	*1*	*2*	*1*

Note: 10 other issues were identified but no more than 12% of respondents perceived them as important.

The summaries and interpretation for these two questions are straightforward: 1) stakeholders are primarily concerned about aspects of crowding, abundance of fish and wildlife, water quality, and job opportunities, and 2) the three project issues were validated as important. So, a set of aspects and issues have been scoped or identified by stakeholders. However, what are their attitudes about the cumulative effects of applied and proposed actions?

To answer this, an important item was asked near the end of the survey was:

- Please indicate your agreement or disagreement with the following statements by checking the appropriate box for each.

Summary (% responding)

Statements	*Agree*	*Disagree*	*Don't know*
a. Water quality in the bay has improved as a result of efforts to reduce dairy wastes in streams, upgrade sewage treatment plants, and repair failing septic systems.	*51*	*15*	*34*
b. All of the sources of bacterial pollution could be managed so the bay could be open to shellfish harvest all the time.	*42*	*28*	*30*
c. Estuaries naturally accumulate sediment.	*77*	*9*	*14*
d. Restoring the bay to higher productivity for fish and wildlife will require dredging.	*37*	*17*	*47*
e. Slowing the rate at which the bay is filling in will require work on forest roads to reduce erosion.	*54*	*18*	*28*
f. Harbor seal and cormorant predation on salmon must be controlled in Tillamook Bay before salmon numbers will rebound.	*63*	*20*	*16*
g. Efforts to improve salmon habitat in Tillamook streams is necessary even though poor ocean conditions can greatly reduce salmon survival.	*82*	*8*	*10*
h. Past human activities in Tillamook Bay and Watershed are continuing to negatively affect fish and wildlife habitat.	*68*	*12*	*20*
i. Current land use practices in Tillamook County are negatively impacting fish and wildlife habitat.	*48*	*23*	*30*
j. Landowners should take an active role in improving water quality.	*88*	*4*	*8*
k. Landowners should take an active role in improving fish and wildlife habitat.	*79*	*9*	*12*

This questionnaire item and its summarization are actually quite complex. Arguably, without access to scientific study and statistical analysis for each item, the "don't know" column should have approached 90-100 percent. Nonetheless, many stakeholders felt confident enough to agree or disagree with the statements. Statements "g, j, and k" were the most known (most stakeholders agreed) and "d" was the biggest unknown.

Continuing, an analyst looking at the summary of this item could presume: 1) the stakeholders were well informed through various media, and 2) scientific studies contrary to items with a heavy weighting to "agree" or "disagree" will likely be scrutinized closely. For example, if an inventory or model shows predation of salmon to be of little consequence (see statement "f") to salmon population recovery, about two-thirds of the stakeholders will need to reassess their individual understanding and attitude about predation. This has implications for the intensity and accuracy of cause-effect predation analysis and, perhaps more importantly, how and when such divergent information is communicated to stakeholders. Part of the communication should clearly discuss the degree of uncertainty of analysis findings.

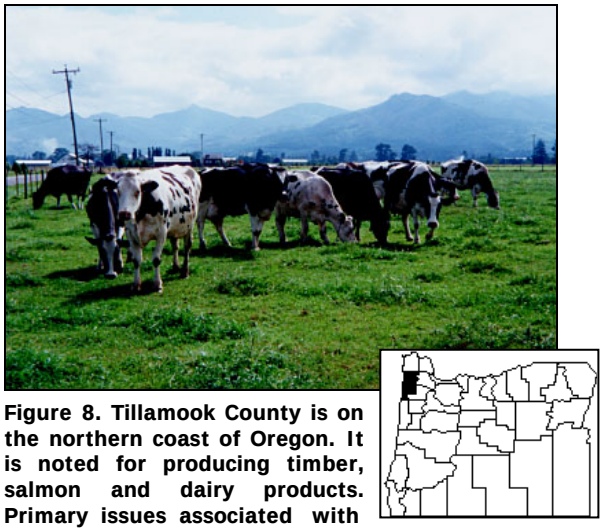
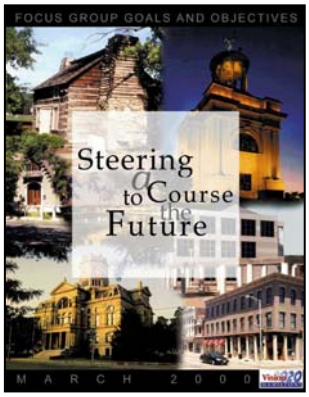


Figure 8. Tillamook County is on the northern coast of Oregon. It is noted for producing timber, salmon and dairy products. Primary issues associated with Tillamook Bay and connected streams and riparian areas are contamination of oysters, sedimentation, and lost of fish and wildlife habitat (TBNEP, 1999).

Example 2 - "Sustainability Indicators, City of Hamilton, Ontario, Canada" (VISION2020 1998)



In 1993, the Regional Council representing the City of Hamilton adopted *VISION 2020* (1998), a description of an economically vibrant, socially equitable and environmentally responsible community.

Numerous goals and strategic actions were developed and tied to *VISION 2020*. A crucial part of the process was the identification of "sustainability indicators" to serve three functions: 1) recognition of sustainability issues, 2) ways to assess them, and 3) tracking of applied actions. During the period 1994 to 1999, over one hundred individuals from a variety of organizations and different sectors in the community worked in small groups and, assisted by a project team, chose the suite of sustainability indicators. Essentially, the small groups acted as *focus groups* or *panels* to determine the most important issues and indicators linking to major strategy areas in *VISION 2020*.

In brief, the figures and captions that follow discuss three examples of indicators chosen by the panels. Each shows the specific sustainability issue, the unit of measure, and trend results of implemented actions.

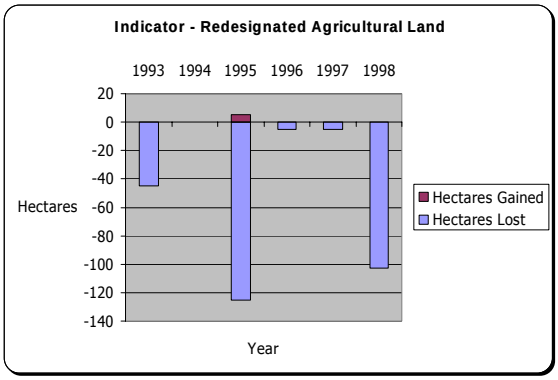
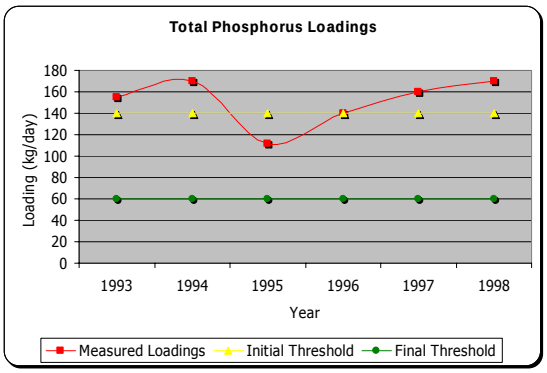


Figure 9. Preservation of agricultural land surrounding the City of Hamilton is a strategy of *VISION 2020*. The indicator tracks the amount of land redesignated from agriculture to other uses. A target value for this issue/indicator is no loss of land. Land "gained" is considered a positive step.



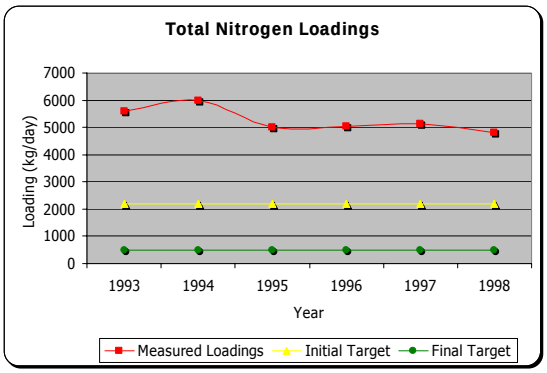


Figure 10. Phosphorus and nitrogen levels entering Hamilton Harbour come primarily from municipal sewage treatment plants, industries and area streams that drain the landscape. The water is sampled coming out of the Woodward Sewage Treatment Plant and therefore reflects the amounts coming into the plant as well as efficiency of the treatment process. By 1998, measurements remained above initial target values.

For the City of Hamilton, the value of the focus-group/panel methodology was establishing a consensus on the cumulative effects that were relevant. Because of the large number and careful selection of individuals, a reasonable level of representation of stakeholders was achieved. Moreover, with close access to and direction by the project team staff and specialists, the scientific basis of determinations were upheld.

Focus group/panel methodologies are a viable way to identify important effects, evaluate the significance of effects, and, in the case of Hamilton, quantify the trends of key indicators of desired or regulatory target values. Their approach combined the identification of effects issues related to strategies (planning steps 1 and 2) with the selection and use of indicators (steps 3 and 4), and set the stage for alternatives evaluation (step 6) and plan evaluation (step 9).

Checklists

The appeal of using checklists is that they offer the user a simple and relatively quick approach in thinking about and identifying the range of issues related to cumulative effects, including common and not so common effects of actions related to cumulative effects issues. They structure the analysis and reduce the chance that important effects are overlooked. Checklists should be comprehensive enough to offer a wide-ranging perspective to soil, water, air, plant, animal and human resource issues. A more comprehensive checklist can be used for both the preliminary identification of potential cumulative impacts and later as additional past, present and prognostic information is gathered relating to baseline conditions, proposed actions, and related foreseeable actions.

Drawbacks of checklists include: 1) being incomplete, 2) being too comprehensive in the sense that the same effect may be double counted, 3) not addressing interactions or cause-effect relationships, and 4) not quantifying impacts. Disadvantages can be minimized to some degree by developing lists for specific kinds of actions or using threshold-level qualitative terms like "no effect," "beneficial effect," or "adverse effect" that are precursors to quantification.

The generic but comprehensive checklist in Appendix _ was developed by Canter and Kamath (1995) in a study conducted to delineate the types of cumulative impact methods being used in scientific studies and environmental impact statements. The study revealed that a checklist approach consistently provided a good beginning for systematically addressing cumulative impacts. Canter and Kamath's checklist would not be applicable to all projects but serves as an excellent base from which a project or action-specific checklist could be developed.

Three examples help demonstrate the use of checklists: 1) Checklist - Hypothetical Cumulative Effects of Prescribed Burns on Rangeland Watersheds, 2) Checklist for Addressing the Cumulative Effects of Stream Restoration Projects, and 3) Checklist for Documenting Environmental Baseline and Effects of Proposed Action(s) on Relevant Indicators (Anadromous Salmonids).

Example 1 - Checklist - Hypothetical Cumulative Effects of Prescribed Burns for Brush Management on Rangeland Watersheds

A checklist of potential impacts was modified to include qualitative rankings of effects from past, present, proposed and foreseeable activities. In this example of a more complex checklist, the cumulative impacts *column g* reflects the magnitude of cumulative effect identified for the each specific potential impact in *column a.*

Table 2. Checklist - Hypothetical Cumulative Effects of Prescribed Burns for Brush Management on a Small Rangeland Watershed.
(Note: Burning is the proposed action to be done each year on a contiguous block that is 5 percent of the watershed area of which 5 percent is left in brush habitat patches and corridors. Successive burns are not adjacent to one another. The 25-year analysis period examines 5 years of past rangeland chaining and 20 years of "future" burning and post-burn conditions.)

a. Potential Impacts	b. Proposed Action[1]	c. Future condition from proposed action	d. Past Actions[2]	e. Other Present Actions[3]	f. Future Condition (c+e)	g. Cumulative Impacts (b+ f)
Soil Erosion	*	+	**	o	+	+
Sedimentation	*	+	*	+	+	+
Water Quality	o	o	*	+	+	+
Air Quality	*/** (smoke)	*/** (smoke)	* (dust)	o	*/** (smoke)	*/** (smoke)
Wildlife Habitat	*	+	***	+	+	+
Fisheries Habitat	o	o	*	+	+	+
Cultural Resources	o	o	***	o	o	o
Aesthetics	*	+	***	+	*/+	o
Forage	*	+	+	*	+	+

Key: * - low adverse effect; ** - moderate adverse effect; *** - high adverse effect; + - beneficial effect; o - no effect
[1]Intermittent/perennial stream corridors and cultural resource sites are located and protected by firebreaks and backburns.
[2]Past brush management consisted of large-block "chaining," a mechanical uprooting and wind-rowing of unwanted brush.
[3]Installation of fish stream improvement structures and expanded and ungrazed riparian buffers.

Example 2 - Checklist for Cumulative Effects of Streambank Stabilization Projects

This checklist contains items from the comprehensive checklist in Appendix B (Cantor and Kamath 1995) that are relevant to stream stabilization projects. The checklist has been left blank deliberately with the intention that it would be completed by an interdisciplinary team knowledgeable of local and regional issues and conditions. It is designed for an initial identification of both cumulative and site-specific effects issues.

The *project level* columns are spatially and temporally restricted to the confines of the stabilization work and the immediate downstream and adjacent areas for a time equal to the construction period plus vegetation establishment (e.g., 5 years). This allows a focus on a single project and, for the most part, its direct and indirect effects. The *cumulative impacts* columns allows assessment of the entire watershed encompassing the same kinds of stabilization projects for a minimum period equaling the life expectancy of the applicable structures or the time until expected full functionality of vegetation (e.g., creation of large woody debris, shading), whichever is longer. Unless the checklist is further modified, a basic assumption is that present-day management and activities continue at the same level during the analysis period.

Table 3. Checklist for Cumulative Effects of Stream Stabilization Projects.

Environmental Category	Project Level			Cumulative Impacts of Projects		
Will the project result in:	**Yes**	**Maybe**	**No**	**Yes**	**Maybe**	**No**
Physical environment landform:						
• compacting and settling?						
• deposition (sedimentation, precipitation)?						
• erosion of soils due to increased wind, floods, removal of vegetation?						
• impact to unique physical features?						
• impact to land classified as prime or unique farmland?						
• change to existing topography (ground contours, shorelines, river banks)?						
• disposal of construction debris?						
• changes in hydrology (water table, gradient, infiltration)?						
Water:						
• changes in the quality and quantity of surface drinking water?						
• alteration of flows due to construction?						
• increased tendency to flooding?						
• eutrophication?						
• increases in temperature and turbidity due to impoundment?						
• effects on conventional water quality parameters?						
• alteration the rate or direction of ground water flow?						
• impact to recharge area or recharge rate?						
Noise/Aesthetics:						
• increased existing noise levels?						
• vibrations?						
• impact to scenic views and vistas?						
Biological environment:						
• changes to diversity/productivity of upland, riparian or aquatic vegetation?						
• impact to rare or endangered plant species?						
• new species or disruption of replenishment/movement of existing species?						
• reduction of acreage or damage to agricultural, forest, other lands?						
• reduction to the habitat or numbers of unique, rare, or endangered fauna?						
• attraction, entrapment or impingement of fauna?						
• impact to existing fish, wildlife habitat, and nesting areas?						
• emigration resulting in human-wildlife interaction problems?						
• an affect on the food chain?						
Socioeconomic environment/land use/archaeological sites:						
• substantial alteration of existing or proposed land use of an area?						
• impact to wilderness or open-space qualities or Special Management Areas?						
• impact historical, archaeological, cultural and paleontological sites or objects?						
• impact to recreational pursuits (e.g., hunting, fishing, boating, swimming)						

Example 3 - Checklist for Documenting Environmental Baseline and Effects of Proposed Action(s) on Relevant Indicators (Anadromous Salmonids) (NMFS 1996)

The checklist consisting of 7 columns is designed to be used in conjunction with 6 resource conditions and 18 indicators (see bulleted items in first column) important to the sustainability of anadromous salmon and their habitat. The *Environmental Baseline* columns describe the condition of each indicator which, when taken together, encompass the environmental baseline. The specific criteria used for each indicator to delimit *Properly Functioning*, *At Risk*, and *Not Properly Functioning* are contained in the source document (NMFS 1996). The *Effects of Action(s)* columns describe the effects of the proposed action(s) on each indicator.

To demonstrate the use of the checklist, it was completed using information from the Tillamook Watershed Plan of northwest Oregon (NRCS 2001b). The underlying checklist was designed to be applied to a wide range of environmental conditions. When the ranges of criteria or descriptions in the matrix do not apply to a specific watershed or basin, professional evaluators need to provide more biologically appropriate values and documentation.

Table 4. Checklist for Documenting Environmental Baseline and Effects of Proposed Action(s) on Relevant Indicators (Anadromous Salmonids).

Resource Conditions • Indicators	Environmental Baseline			Predicted Effects of the Action(s)		
	Properly[1] functioning	At Risk[1]	Not Properly[1] Functioning	Restore[2]	Maintain[3]	Degrade[4]
Water Quality						
• Temperature	Forest land		Ag land	Ag land		
• Sediment	Forest land		Ag land	Ag land		
• Chemical Contaminants/Nutrients	Forest land		Ag land	Ag land		
Habitat Access						
• Physical Barriers	Forest land		Ag land	Ag land		
Habitat Elements						
• Substrate		Forest land	Ag land	Forest, Ag		
• Large Woody Debris		Forest land	Ag land	Forest, Ag		
• Pool Frequency		Forest land	Ag land	Forest, Ag		
• Pool Quality		Forest land	Ag land	Forest, Ag		
• Off-channel Habitat		n/a	Ag land	Ag land		
• Refugia		Forest land	Ag land	Forest, Ag		
Channel Condition & Dynamics						
• Width/Depth Ratio		Forest land	Ag land	Ag land	Forest land	
• Streambank Condition	Forest land	Ag land		Ag land	Forest land	
• Floodplain Connectivity	Forest land	Ag land		Ag land	Forest land	
Flow/Hydrology						
• Peak/Base Flows		Forest, Ag			Forest, Ag	
• Drainage Network Increase		Forest, Ag			Forest, Ag	
Watershed Conditions						
• Road Density & Location		Forest, Ag				
• Disturbance History		Forest land	Ag land	Ag land	Forest land	
• Riparian Reserves		Forest land	Ag land	Ag land	Forest land	

Watershed Name: TILLAMOOK Location: Northern Coast, Oregon

[1]These three categories of function are defined for each indicator in Table 1 in NMFS 1996. For example, the *Temperature* indicator has ranges of criteria for "properly functioning," "at risk," and "not properly functioning" of 50-57°F, 57-64°F, and >60°F, respectively.

[2]For the purposes of this checklist, "restore" means to change the value of an "at risk" indicator to "properly functioning", or to change the value of a "not properly functioning" indicator to "at risk" or "properly functioning." It does not apply to "properly functioning" indicators.

[3]For the purposes of this checklist, "maintain" means that the value of an indicator does not change.

[4]For the purposes of this checklist, "degrade" means to change the value of an indicator for the worse. In some cases, a "not properly functioning" indicator may be further worsened, and this should be noted.

Matrices

Basically, matrices are checklists set in a tabular format to quantify the interactions between human activities and the resources of concern. Originally designed to assess the magnitude and importance of individual interactions between activities and resources (Leopold et al. 1971), they have since been developed to consider the cumulative effects of multiple actions on resources (Bain et al 1986; Stull et al 1987; LaGory et al 1993).

Matrices range from the simple, where a "+, -, 0, or 1" documents the presence or absence of an effect to the more complex, where effects are scored on the bases of duration of impact, magnitude, past occurrences, etc. Simple matrices are easy to understand but they do not identify the size or extent of the effects. "Although complex weighting schemes allow the user to rank resource effects, the results may be difficult for others to understand, and the weighting schemes can be highly subjective" (CEQ, 1997).

One example is provided: *Salmon Habitat Suitability Index - Coho Salmon - Tillamook Watershed (NRCS 2001b)*

The matrix, table 5, was constructed by an interdisciplinary team familiar with local and regional habitat related to anadromous salmonid spawning, rearing, and migration. A spreadsheet format was used to organize and record the deliberations of the experts as they valuated the "influencing factors" that were strfatified by physiographic settings and major functions associated with salmonid population sustainability. The specialists used local habitat data, anecdotal accounts, and personal judgment to make the ratings. During this phase, the table or matrix consisted only of the items and values in boldface.

The numbers in the right 3 columns of table 5 display the index values on a scale of 0 to 1 for the influencing factors that correlate to the current and proposed action conditions. After all values were completed, various formulae were added to the spreadsheet (indicated by text and numbers in *italics*) which culminated in the calculation of a single composite, weighted index for each scenario at the bottom of the table. The summary values were:

- *BM = 0.39* - Benchmark condition,
- *RMS = 0.58* - Resource Management Systems applied on agricultural sector lands and waters,
- *CCMP = 0.67* - actions specified in the Comprehensive and Conservation Management Plan for the Tillamook Bay Estuary (TBNEP 1999).

The index values are defined as: 1.0=Optimum, 0.8=High, 0.6=Minimum, 0.4=Impaired, 0.2=Very Impaired, 0=Little or none. In this analysis, the RMS and CCMP scenarios bring "impaired" BM conditions to a "minimum" threshold.

Further explanatory details are given at the end of the table. Figures 11 and 12 display several of the matrix factors that influence salmonid populations in the Tillamook Bay basin.

Figure 11. Riparian vegetation along this stream has been largely removed on the South side (right). Intact, natural vegetation provides shade, large woody debris and detritus which influences water temperature, dissolved oxygen, pools and the dynamics of substrate replenishment.

Figure 12. A flood event in 1996 inundated large areas of lowland pastures in the Tillamook Bay watershed. As flood waters receded near a mainstem river (left edge) and adjacent to a small stream (middle), two "influencing" factors are illustrated: "riparian vegetation" and "% back-water unmodified." Most underwater areas depicted here are used for livestock forage production.

Table 5. Cumulative Effects Issue: COHO - SUSTAINBLE POPULATION (INDEX).

Cumulative Effects Issue: COHO - SUSTAINABLE POPULATION (INDEX)							
Analysis Area: TILLAMOOK WATERSHED; STREAM/AQUATIC AND NEAR-STREAM HABITATS							
(1) Function-Process	(2) Physiographic Setting			(3) Influencing Factor (wq = water quality; temp = water temperature; do = dissolved oxygen)	(4) Scenario (see legend)		
					BM	RMS	CCMP
(life stage)	*Scenario =*	*Weight x COMBINED Index Value*	Weight		Index Value		
Spawning		**Lowland-nontidal**	**35%**	**substrate adequacy**	**0.30**	**0.60**	**0.60**
	BM =	*0.13*		**wq (temp, do, nutrients)**	**0.60**	**0.80**	**0.80**
Sum from col. 2	*RMS =*	*0.23*		**riparian vegetation**	**0.30**	**0.60**	**0.60**
∑BM =	*CCMP =*	*0.23*		*COMBINED =*	*0.38*	*0.66*	*0.66*
0.49		**Mainstem**	**15%**	**substrate adequacy**	**0.25**	**0.30**	**0.35**
∑RMS =	*BM =*	*0.04*		**wq (temp, do, nutrients)**	**0.35**	**0.50**	**0.50**
0.65	*RMS =*	*0.07*		**riparian vegetation**	**0.20**	**0.60**	**0.60**
∑CCMP =	*CCMP =*	*0.07*		*COMBINED =*	*0.26*	*0.45*	*0.47*
0.67		**Upland-forest**	**50%**	**substrate adequacy**	**0.60**	**0.65**	**0.65**
	BM =	*0.32*		**wq (temp, do, nutrients)**	**0.75**	**0.80**	**0.85**
	RMS =	*0.35*		**riparian vegetation**	**0.60**	**0.65**	**0.70**
	CCMP =	*0.36*		*COMBINED =*	*0.65*	*0.70*	*0.73*
Rearing		**Lowland-tidal**	**5%**	**wq (temp, do, nutrients)**	**0.25**	**0.60**	**0.70**
	BM =	*0.01*		**%backwater unmodified**	**0.20**	**0.50**	**0.55**
Sum from col. 2	*RMS =*	*0.02*		**large woody debris**	**0.10**	**0.40**	**0.45**
∑BM =	*CCMP =*	*0.03*		**emergent vegetation**	**0.05**	**0.35**	**0.35**
0.29				**riparian vegetation**	**0.20**	**0.60**	**0.70**
∑RMS =				*COMBINED =*	*0.14*	*0.48*	*0.53*
0.51		**Lowland-nontidal**	**35%**	**wq (temp, do, nutrients)**	**0.20**	**0.55**	**0.60**
∑CCMP =	*BM =*	*0.06*		**%backwater unmodified**	**0.20**	**0.30**	**0.40**
0.65	*RMS =*	*0.19*		**large woody debris**	**0.10**	**0.50**	**0.70**
	CCMP =	*0.22*		**pools**	**0.20**	**0.50**	**0.60**
				screens	**0.05**	**0.80**	**0.80**
				riparian vegetation	**0.30**	**0.60**	**0.75**
				substrate/riffle	**0.20**	**0.60**	**0.70**
				COMBINED =	*0.16*	*0.53*	*0.64*
		Mainstem	**20%**	**wq (temp, do, nutrients)**	**0.20**	**0.50**	**0.60**
	BM =	*0.04*		**%backwater unmodified**	**0.20**	**0.25**	**0.30**
	RMS =	*0.09*		**large woody debris**	**0.20**	**0.40**	**0.50**
	CCMP =	*0.11*		**pools**	**0.30**	**0.50**	**0.55**
				screens	**0.05**	**0.80**	**0.80**
				substrate/riffle	**0.30**	**0.50**	**0.55**
				riparian vegetation	**0.20**	**0.50**	**0.55**
				COMBINED =	*0.18*	*0.47*	*0.53*
		Upland-forest	**40%**	**wq (temp, do, nutrients)**	**0.60**	**0.65**	**0.80**
	BM =	*0.19*		**large woody debris**	**0.40**	**0.45**	**0.70**
	RMS =	*0.21*		**pools**	**0.40**	**0.45**	**0.70**
	CCMP =	*0.30*		**riparian vegetation**	**0.60**	**0.65**	**0.80**
				substrate,riffles	**0.40**	**0.45**	**0.70**
				COMBINED =	*0.47*	*0.52*	*0.74*

Table 5. Continued.

Cumulative Effects Issue: COHO - SUSTAINABLE POPULATION (INDEX)							
Analysis Area: TILLAMOOK WATERSHED; STREAM/AQUATIC AND NEAR-STREAM HABITATS							
(1) Function-Process	**(2) Physiographic Setting**			**(3) Influencing Factor**	**(4) Scenario (see legend)**		
				(wq = water quality; temp = water temperature; do = dissolved oxygen)	**BM**	**RMS**	**CCMP**
(life stage)	*Scenario =*	*Weight x COMBINED Index Value*	**Weight**		**Index Value**		
Migration		**Lowland-tidal**	**5%**	**wq (temp, do, nutrients)**	**0.40**	**0.70**	**0.75**
	BM =	*0.02*		**barriers**	**0.50**	**0.60**	**0.75**
Sum from col. 2	*RMS =*	*0.03*		**riparian vegetation**	**0.20**	**0.60**	**0.60**
∑BM =	*CCMP =*	*0.03*		*COMBINED =*	*0.34*	*0.63*	*0.70*
0.40		**Lowland-nontidal**	**35%**	**wq (temp, do, nutrients)**	**0.40**	**0.70**	**0.75**
∑RMS =	*BM =*	*0.10*		**barriers**	**0.30**	**0.60**	**0.75**
0.60	*RMS =*	*0.20*		**pools**	**0.20**	**0.40**	**0.60**
∑CCMP =	*CCMP =*	*0.24*		**riparian vegetation**	**0.25**	**0.60**	**0.70**
0.71				*COMBINED =*	*0.28*	*0.56*	*0.70*
		Mainstem	**20%**	**wq (temp, do, nutrients)**	**0.50**	**0.60**	**0.70**
	BM =	*0.10*		**barriers**	**0.90**	**0.90**	**0.90**
	RMS =	*0.14*		**pools**	**0.60**	**0.70**	**0.75**
	CCMP =	*0.15*		**riparian vegetation**	**0.20**	**0.60**	**0.60**
				COMBINED =	*0.48*	*0.69*	*0.73*
		Upland-forest	**40%**	**wq (temp, do, nutrients)**	**0.75**	**0.80**	**0.85**
	BM =	*0.19*		**barriers**	**0.30**	**0.45**	**0.65**
	RMS =	*0.23*		**pools**	**0.40**	**0.50**	**0.65**
	CCMP =	*0.28*		**riparian vegetation**	**0.60**	**0.65**	**0.70**
				COMBINED =	*0.48*	*0.58*	*0.71*
(Note: All italic numbers on sheet are calculated.)	*Scenario*	*Grand Total Index (based on values of column 1)*	**LEGEND**	**Index Values: 1.0=Optimum, 0.8=High, 0.6=Minimum, 0.4=Impaired, 0.2=Very Impaired, 0=Little or none**			
∑	BM =	*0.39*	**BM:**	**Benchmark condition**			
	RMS =	*0.58*	**RMS:**	**Proposed Ag. Land Resource Management Systems**			
	CCMP =	*0.67*	**CCMP:**	**Proposed Comprehensive Conservation Mgt. Plan**			

Explanatory Notes:

- The *function-process* categories are chosen based on the cumulative effects issue, in this case, a Coho - Sustainable Population (Index). If all three processes or functions are not happening at some level, a sustainable population of Coho will be unlikely. The use of the term *index* was used because definitive Coho populations tied to different influencing factors were not known. Thus, the index is a conceptually based surrogate for population.
- The *physiographic settings* represent a local stratification of the overall landscape into more or less homogeneous units. If conditions were different within a setting, additional divisions would have been used.
- *Influencing factors* represent the elements within the *physiographic setting* that most affect the *index*. In this case, various reference materials about Coho salmon were consulted including the "Habitat Suitability Index Models: Coho Salmon" (McMahon 1983).
- Formulae: Calculations are performed as shown in the table. Totals use computed values rather than rounded values. The *COMBINED* and *Grand Total Index* values are special cases. The *COMBINED* product includes the values in the column segment immediately above it and equals $(V_1*V_2*V_3* \ldots V_n)$^(1/n). The *Grand Total Index* products use *scenario values* (BM, RMS and CCMP) from the first column and equal $(Scenario_{spawning}*Scenario_{rearing}*Scenario_{migration})$^1/3.

Network and System Diagrams

The strength of network and system diagrams used for cumulative effects analysis is the visualization of relationships of actions and their direct and indirect effects. As these effects accrue in time or space, *threshold* or *target values* established for key *indicators* help analysts judge the cumulative magnitude and significance of consequences. Diagrams are most useful during planning process step 3, Inventory Resources, step 4, Analyze Resource Data, and step 5, Formulate Alternatives.

Some weaknesses of network and system diagrams are: 1) they become more difficult to create and understand when depicting secondary and tertiary effects, and 2) they do not easily address elements of time or space (extent) associated with the effects. Limitations can be overcome by connecting additional diagrams for specific secondary and tertiary effects and/or combining diagrams with other methods such as modeling, GIS, or trends analysis.

Two examples are provided to illustrate network and system diagrams: 1) the NRCS Assessment of Agency Actions within the Platte River Watershed, and 2) The Cumulative Watershed Effects Assessment Project - Final Report. Additional examples of network diagrams used for assessing effects of practices planned for use in the 2002 Farm Bill are shown in Appendix D.

Example 1 - "NRCS Assessment of Agency Actions within the Platte River Watershed" (NRCS 2001d)

In 1995, a concern was expressed to the NRCS about application of conservation practices in the Platte River drainage cumulatively contributing to a change in the amount and timing of river flows. These flows, in turn, could affect recovery efforts for listed Threatened and Endangered (T&E) species. To assess this "reactive situation," the NRCS in Nebraska prepared a special analysis of consumptive water use of influencing practices. Using a water-balance budget approach, the NRCS concluded that there were no net adverse impacts on flows and T&E species. The thought process behind the finding is shown in figure 13. In this example, the original concern did not identify a flow level/timing *threshold* or *target value*.

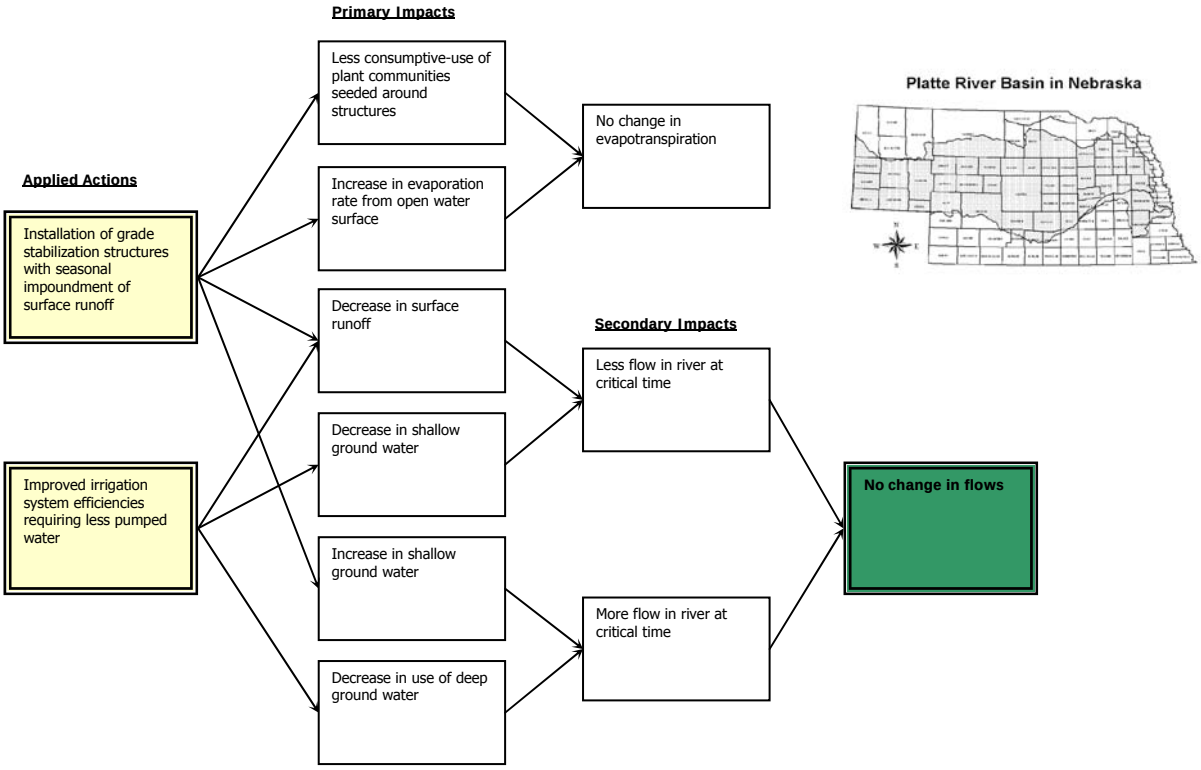


Figure 13. A simple network diagram depicts the primary and secondary impacts of applied conservation practices in the Platte River Basin. Note that the scope of the study was narrowly focused with only specific practices being evaluated. The diagram expedites the visualization of key actions-effects by agency personnel and concerned stakeholders. The diagram went through several iterations during its development.

Example 2 - "The Cumulative Watershed Effects Assessment Project - Final Report" (Citizens for Better Forestry 2000)

The cumulative effects of human activities have significantly degraded terrestrial and aquatic ecosystems throughout the Pacific Northwest (Meehan 1991; FEMAT 1993; Mount 1995; NRC 1996; Spence et al. 1996; Gregory and Bisson 1997; Lee et al. 1997; Naiman et al. 1998). Progressive land-use changes over the last 150 years have caused increasing impacts on water quality, watershed hydrology, channel morphology, and aquatic habitat. The recent listing and potential additional listing of numerous fish species stock under the federal Endangered Species Act (ESA) and the listing of numerous watersheds as impaired water bodies under Section 303(d) of the Clean Water Act (CWA) illustrate the extent and severity of this system-wide degradation.

The primary objective of the assessment project was to identify the interacting effects of multiple human activities on resource values or beneficial uses of concern. A detailed system diagram showing some of the potential interacting effects of past and present human activities on salmonid populations is shown in Figure 14. Note that some of the effects listed are likely to be more important based on intensity and/or extent. Again, other methods may be used in tandem with the system diagram to display the magnitude and trends of consequences.

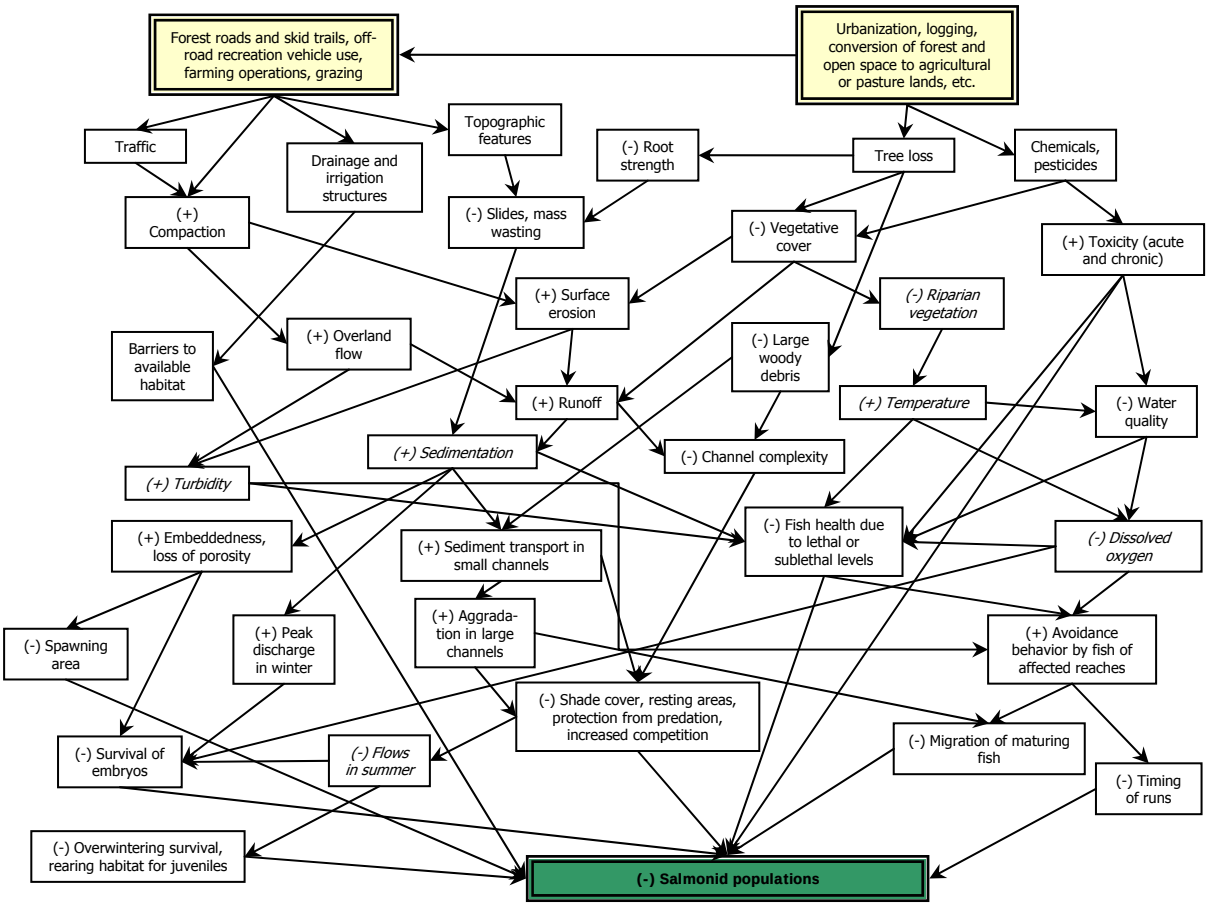


Figure 14. A detailed system diagram depicting direct and indirect effects of human activities in the Pacific Northwest (adapted and redrawn from figure 39, Citizens for Better Forestry, 2000). Effects in *italics* denote those typically exceeding ESA/CWA *thresholds* or *target values* of concern. Values in parentheses indicate an increase (+) or decrease (-) in the stated effect.

Modeling

Modeling is a powerful method for quantifying action-effects relationships leading to detection of cumulative effects. This method can range from algorithms or equations with multiple variables to expert systems that compute interconnected conditions under changing scenarios of proposed actions. Models are most useful during planning process steps 4, Analyze Resource Data, and 6, Evaluate Alternatives. Step 9, Plan Evaluation, can be used to good advantage to fine-tune or modify models as needed.

Models give clear results but may be disputable if local validation and parameterization are not carefully considered and integrated. As with other methods, models usually focus on a single effect in the context of environmental conditions within the analysis boundary and time period.

Two examples illustrate the use of modeling: 1) A Method for Developing Best Management Practices for Riparian Areas Using the Water Erosion Prediction Project (WEPP) Model, and 2) Dynamic Simulation Modeling of Phosphorus Exports to the Inland Bays, Delaware. The first ties to small watersheds and the second addresses land use sectors of a large ecosystem.

Example 1 - "A Method for Developing BMP's for Riparian Areas Using WEPP©" (CEASA 1998)

To contend with cropland-source sediment entering surface waters in Canada's central Alberta, proposed actions were formulated by specialists of the Soil Quality Program, Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA). Using the WEPP model (ARS 2001), some representative scenarios were analyzed and compared for a 150-acre headwater watershed. WEPP was used because it links hillslope profile erosion and sediment production to channels and impoundments within small watersheds up to 640 acres in which the sediment yield at the outlet is significantly influenced by hillslope and channel processes. The model simulates channel detachment and sediment transport, deposition, and removals due to impoundments such as terraces, filter fences, buffers and check dams. Figure 15 displays the results of the analysis. Extending the output to higher-order and larger watersheds exceeds the capacity of WEPP. However, the analysis of this small, representative watershed gives a clear comparison of agricultural alternatives that contribute to the larger, more complex drainage.

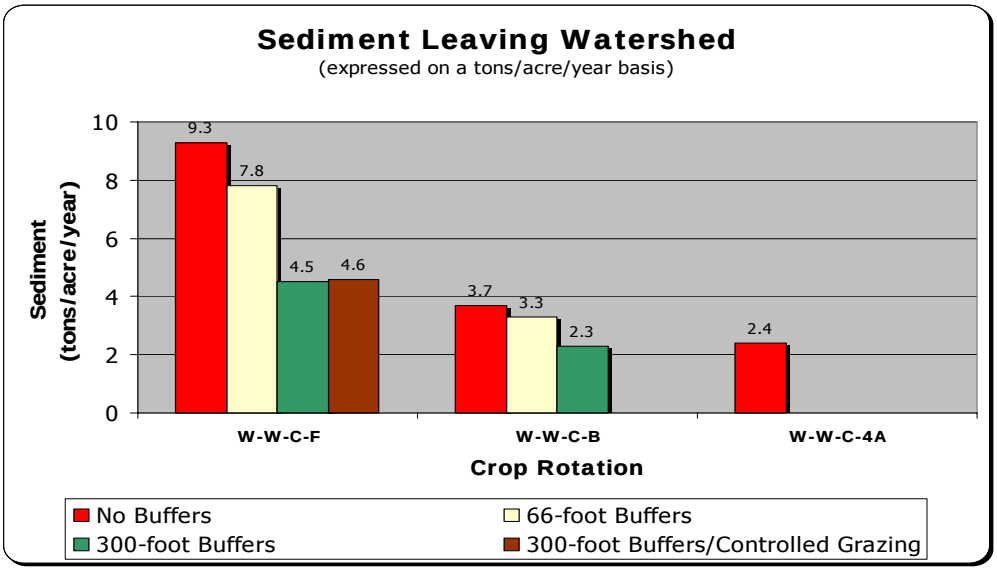


Figure 15. Crop rotations using conventional tillage include wheat-wheat-canola-fallow (W-W-C-F), wheat-wheat-canola-barley (W-W-C-B) and wheat-wheat-canola-alfalfa 4 years (W-W-C-4A). The red bar for each crop rotation represents scenarios without buffers. Scenarios for buffers 66 feet (yellow) and 300 feet (green) wide were computed only for the W-W-C-F and W-W-C-B rotations. The effect of controlled grazing (brown) is shown only for W-W-C-F. If an annual average soil loss of 2.7 tons/acre/year was set as the soil loss tolerance, only two of the eight computed scenarios (two bars furthest right) would meet *thresholds* or *target values*.

Example 2 - " Dynamic Simulation Modeling of Phosphorus Exports to the Inland Bays, Delaware " (Cassell and Meals 1999)

Watershed ecosystem nutrient dynamics (WEND) modeling is a strategic, long-term approach in analyzing how watersheds process phosphorus (P). Underlying WEND-P is STELLA® (High Performance Systems, Inc., 2001), a process mapping-simulation software program.

Using WEND-P, complex watersheds are modeled as ecosystems which import, export, and process P according to an infrastructure that includes all major pathways through which P moves. In WEND models, the P infrastructure can vary over time to reflect how change in urban development activities, natural processes, and resource management decision-making interact to influence the export of P from the watershed.

In this project, the model assessed how P is processed through the Inland Bays Watershed (IBW) of southeast Delaware (see Figure 16). The explicit goal was to track the export of P to the Inland Bays over the long-term as influenced by proposed actions for the management of P.

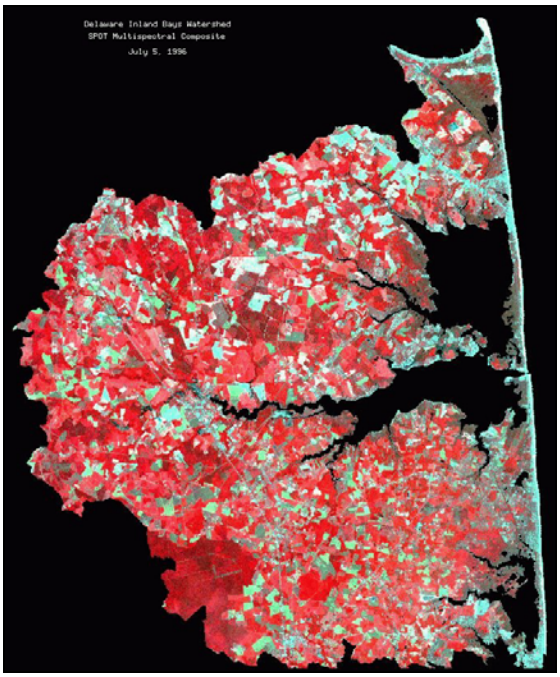


Figure 16. Inland Bays Watershed, southeast Delaware. (from SPOT satellite imagery July 5, 1996). IBW has a 137,300-acre land base with approximately 50 percent and 16 percent in agriculture and urban development, respectively.

The diagram in figure 17 on the next page provides an overview of the WEND-P-IBW model. It depicts P imports, exports, movement and storage in the IBW at a watershed-scale level. It shows the major pathways for the import and export of P and the internal cycling of P that link three primary activity sectors and two accumulation "stocks." The three activity sectors in the IBW P diagram are urban, agriculture, and natural areas. Storage or accumulation of P are accounted for in two stocks: 1) Long Term Storage and 2) Drainage Network. Each activity sector and stock processes P uniquely in accordance with the many anthropogenic and natural functions that occur. More explanation is given in the caption under the figure.

Figure 17 is essentially a network or system diagram. However, the various connecting arrows represent model algorithms with outputs that vary based on changing conditions in the 190,000-acre IBW ecosystem. The crucial outcome from the model (depicted in the lower right corner of the diagram) is the "P discharge from the watershed" that enters the Inland Bays in southeast Delaware.

After model developers parameterized WEND-P-IBW for local use on the IBW, various proposed action scenarios were discussed with key stakeholders and established as follows:

Scenario	*Conditions*
1. Baseline	*1996-1998 situation with projections for agricultural and urban management and growth into the future*
2. Phytase	*Add Phytase to poultry feed to reduce P assay of feed by 17%*
3. Comprehensive Agriculture	*Phytase scenario + export 20% of litter production + implement stringent agriculture management practices*
4. Comprehensive Urban	*Enhance P removal by waste treatment plants + implement stringent urban land management practices*
5. Comprehensive Watershed	*Comprehensive agriculture + comprehensive urban*
6. Growth Management	*Comprehensive agriculture + comprehensive urban + reduced urban growth rate + 10% reduction in poultry production capacity by year 10*

These scenarios, in turn, had applicable inputs entered into the WEND-P-IBW simulation and, except for the baseline scenario, were implemented between years 5 and 10. The baseline was started in year 0 of the simulation and resulted in imports of about 3,000 tons of P/year and exports of 1,100 tons of P/year. With imports exceeding export, P is accumulating in agricultural soils of the watershed. Of the exports, about 64 tons P/year enters the Inland Bays initially in year 0.

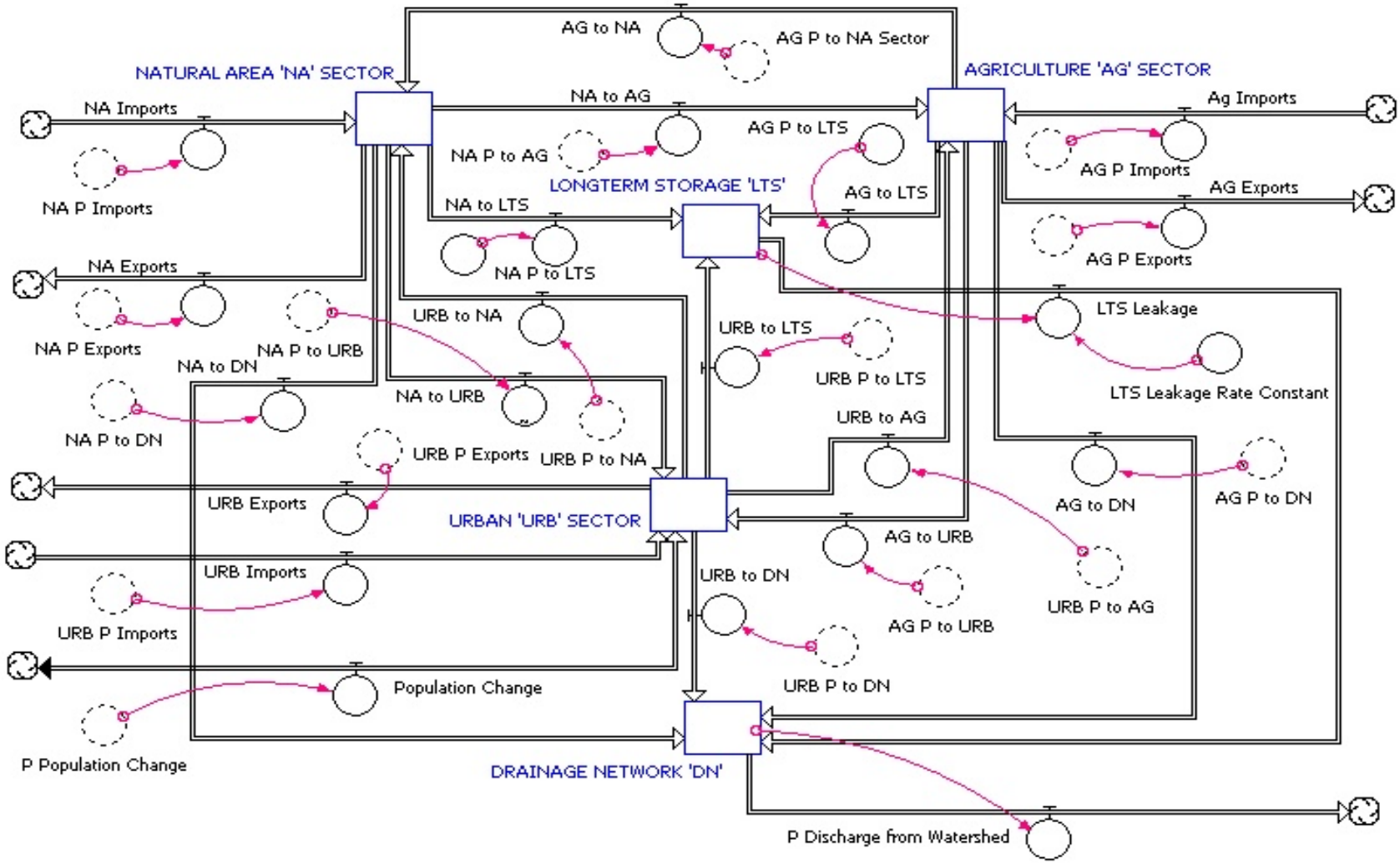


Figure 17. Phosphorus (P) processes and relationships used in WEND-P-IBW are displayed. Boxes denote current "sectors/stocks" or accumulations of P at any one time: NA=Natural Areas, AG=Agriculture, URB=Urban, LTS=Longterm Storage, and DN=Drainage Network. Pipelines (⇨) show the direction of the flow of P between sectors, stocks, into the watershed (imports) and out of the watershed (exports). Imports and exports comes from sources and sinks of P represented by small clouds on the edges of the diagram. The regulation of a flow is accounted for by underlying algorithms denoted by circles and single line (→) arrows. The small "T" at the top of each circle is a flow "spigot" controlled by algorithms. The crucial output flow from the model (see lower right corner) is the "P discharge from the watershed" that enters the Inland Bays in southeast Delaware.

The long-term patterns of P export to the Inland Bays predicted by WEND-P-IBW for the 6 scenarios are shown in figure 18. Presently, about 53 percent and 36 percent of the export to the Inland Bays is derived from agricultural and urban activities, respectively.

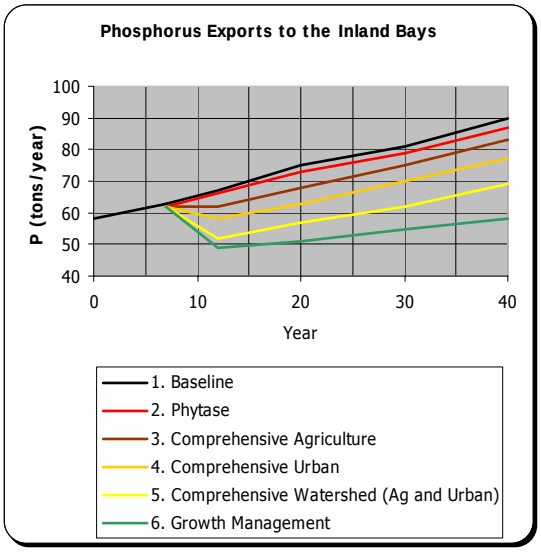


Figure 18. Phosphorus export to the Inland Bays predicted by the WEND-P-IBW model for 6 P management scenarios. "Action" alternatives were considered to be implemented in years 5 to 10 of the simulation.

The model suggests that rates of import, export and accumulation of P in the IBW will increase if residential populations, agriculture, tourism and industry continue to grow. If present-day growth continues, the baseline export of P to the Inland Bays is estimated to increase by 24 percent in 20 years and 50 percent in 40 years.

The "Phytase" scenario (scenario 2) is very similar to the baseline predictions. Adding Phytase to animal feeds does little to reduce the export of P over the long-term. Scenarios 3 through 6 controlled or decreased P export dramatically at least initially. However, all scenarios except one show a greater export of P to the Inland Bays than at present. If the: 1) 1996-98 level of P exports is used as the threshold or target value, and 2) the "Growth Management" scenario is adopted by decision-makers, the proposed actions would bring P exports to desired levels at least out to a 40-year period.

For the WEND-P-IBW simulation, it is important to note that the model aggregates all data parameters so that the identity of individual soil parcels, farms, and communities are unknown and specific effects of individual practices cannot be isolated. Additionally, the model carries out all computation in annual time steps. Thus, there is no capability to assess seasonal variations nor individual runoff events.

The model's strengths include: 1) a reasonable but detailed representation of the P infrastructure (imports, production, storage, exports and movements) satisfactory to regional and local experts, and 2) the capability of being fine-tuned or modified as P infrastructure behavior becomes better understood through research and monitoring. A major weakness, of course, is verifying the long-term predictions for each scenario. This weakness points out the importance of forming a credible team to develop the model.

Trends Analysis

A critical influence on cumulative effects analysis is the trend or direction of change in conditions or condition indicators chosen to evaluate past, current and projected resource circumstances. The results are usually displayed graphically and are bounded by sensible past and future times. Knowing trends is particularly important during NRCS planning process steps 4, *Analyze Resource Data*, and 6, *Evaluate Alternatives*, to insure that thresholds or target values set to measure effects of proposed actions are reasonable and doable. Of course, step 9, *Evaluate the Plan*, is largely comprised of trend analysis of pertinent indicators into the future after the proposed actions are applied.

Trend analyses are data intensive and may be difficult to extrapolate beyond known data. Extrapolation must be clearly identified during analysis and uncertainty explained using scientifically based rationale and references.

Two examples are provided: 1) Stream Water Temperature Conceptualization, and 2) Soil Erosion in the Palouse River Basin: Indications of Improvement (Ebbert and Roe 1998).

Example 1 - Stream Water Temperature Conceptualization - Cold Water Fishery.

Figure 19 displays proposed action scenarios of water temperature for a cold water fishery over an 85-year time period. The conceptualization is based, in large part, on West coast conditions and analysis for salmonid recovery. In this example, the riparian vegetation is removed from the stream corridor during the period 1965 to 1995 to accommodate additional agricultural, home sites and urban development. Scenarios include various levels of restoring shade-producing vegetation all beginning in the headwaters and progressing downstream.

Several important notes about the graph include: 1) the black line is the trend for 1965 to 2000, 2) the red line is the no-action projection, 3) the oscillation of all lines represents the influence of year-to-year variations of climate and hydrology on water temperature, and 4) the typical level of proposed actions are anticipated to be at the "75% of area and some channel improvement" level (see the dark green line that crosses the 64°F threshold line at year 2030).

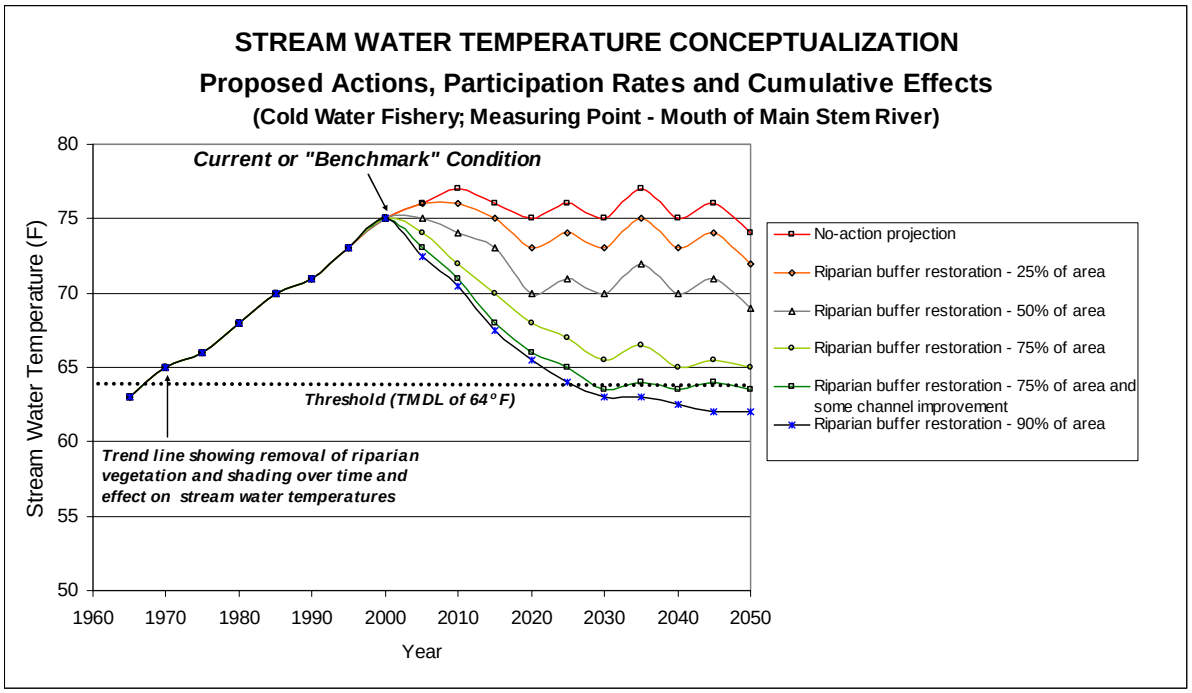


Figure 19. Conceptualized trend of stream water temperatures for historical, current and proposed action scenario conditions. Temperatures above the 64°F threshold are considered sub-lethal and stressful for cold water fish species. Measurements of temperature are typically a 7-day moving average made during summer low stream flow periods.

Example 2 - Soil Erosion in the Palouse River Basin: Indications of Improvement (Ebbert and Roe 1998).

Land use in the Palouse River Basin is predominately "dryland" agriculture. See figures 20 and 21. Farming in the basin began in the late 1800's. Steep lands, first used for hay and pasture, were converted to grain production in the early 1900's.

Figure 20. Loessial materials created the dune-like hills that dominate the Palouse farming region.

Because of the growing concern of soil erosion from rainfall impact and rainfall/snowmelt runoff, the first soil conservation district in the state of Washington was organized by a group of farmers in the Palouse in 1940. In 1972, concern for water quality from dryland Palouse farming was addressed by Public Law 92-500 (Clean Water Act) that mandated a water-quality management plan. By 1979, a final plan was adopted by the state that consisted of recommended "best management practices" to control erosion and reduce runoff of nutrients and agricultural chemicals.

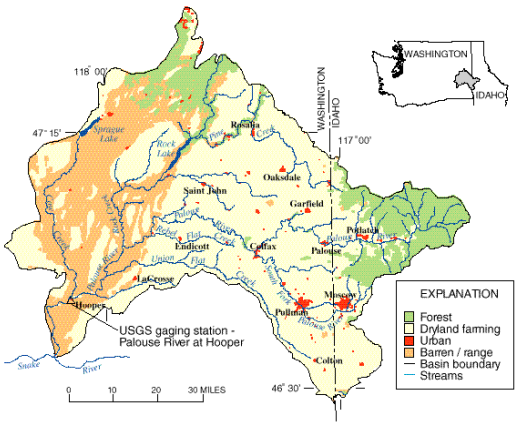


Figure 21. The Palouse River Basin is approximately 2 million acres in size.

Trend analysis for this example takes two forms: 1) A *table*, table 6, showing 1979 and 1994 application statistics for conservation treatment and the corresponding, predicted reduction in annual average soil erosion, and 2) a *bar chart*, figure 22, displaying recorded sediment load per unit of water discharge for the periods 1962-71 and 1993-96.

Table 6. Conservation treatment in the Palouse River Basin and predicted annual erosion reduction.

Conservation Treatment	Treated Acres		Annual Erosion Reduction	
	1979	1994	Tons/ Acre	Tons/ Year
No-till seeding	600	56,000	9	500,000
CRP	6,400	60,600	5	270,000
Strip cropping	0	239,000	1	240,000
Terraces	680	4,500	2	7,600
Tree planting	0	3,670	10	37,000
Cons. tillage	0	81,000	8	650,000
TOTAL =	7,680	444,770	--	1,704,600

Note: Basis for values contained in Ebbert and Roe 1998.

Annual erosion reduction was primarily attributed to voluntary implementation of conservation treatments by basin farmers. The predicted values of erosion reduction in the table generally correlate with suspended sediment amounts displayed in figure 22. However, a large storm in February 1963 skewed or elevated the 1962-71 average and points out a maxim in determining statistical significance during any trend analysis: *related variables (in this case, storm frequencies and water discharge) must be carefully studied and accounted for in any comparison analyses to draw definitive findings.*

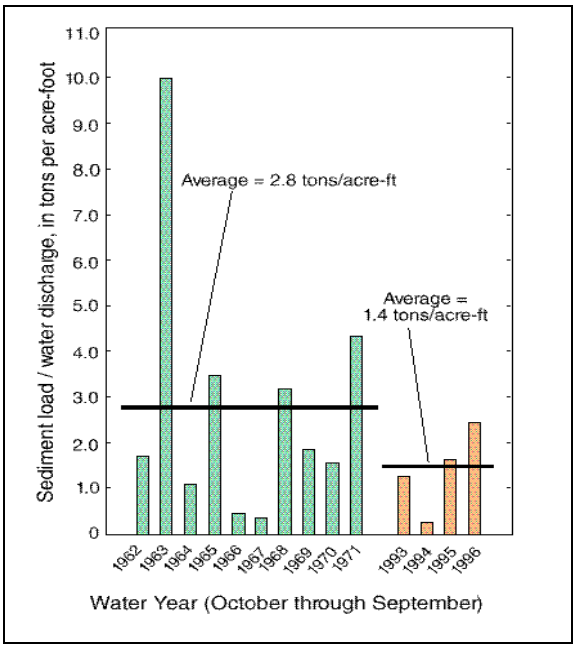


Figure 22. Comparison of historical records of suspended sediment in the Palouse River at the Hooper USGS gauging station.

Overlay Mapping and Geographic Information Systems

Overlay mapping and geographic information systems (GIS) are excellent for visualizing "layers" of resource conditions and proposed action impacts (figure 23). They are particularly well suited for:

- bounding of multiple effects each with a different size and shape "footprint" in the landscape,
- displaying spatial proximity or overlaps of individual effects,
- viewing baseline and current connectivity or fragmentation of the land uses and conditions being studied (see figure 24), and
- using various data sets of conditions that can be mathematically related for likely degree of impact and spatially displayed at a desired map scale.

Manual construction of overlay maps and the tedious chore of calculating size or extent of various map units have, of course, given way to powerful GIS applications. Modern GIS systems can perform these tasks in seconds using underlying, spatially correlated databases, e.g., ArcGIS developed by ESRI, Environmental Systems Research Institute (http://www.esri.com/). A growing trend is the development of uncomplicated interfaces of GIS with the Internet or World Wide Web to allow users to choose desired layers of data and construct needed maps. In many situations, the display of an underlying, ortho-corrected digital aerial photograph can orient and improve understanding of project reviewers.

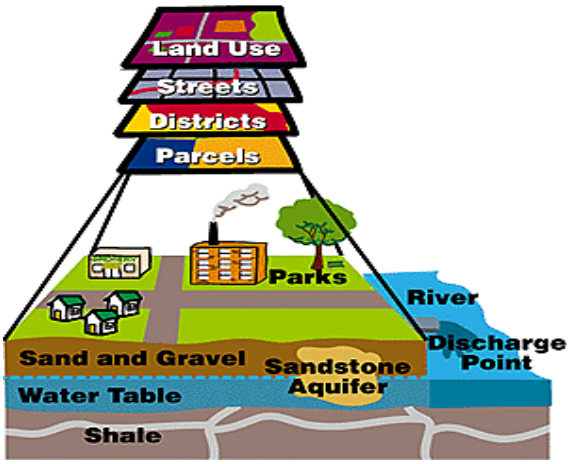


Figure 23. GIS systems link to underlying databases that are tied to spatial coordinates. GIS users can produce 2 and 3-dimensional maps of selected features, conditions, and effects that can be viewed or printed using a variety of visual media.

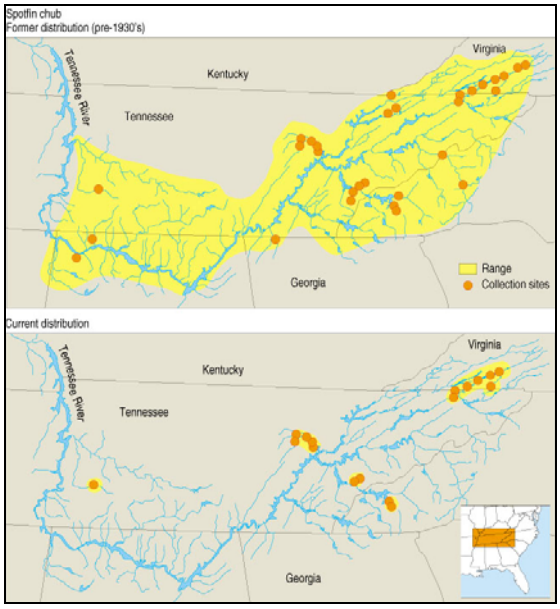


Figure 24. An example of habitat fragmentation, decline, and isolation of populations of a southeastern freshwater fish, the endangered spotfin chub, *Cyprinella monacha* (USDI 1995). Former (pre-1930's) and present range in yellow. Proposed actions in and near current populations will receive a higher degree of scrutiny.

GIS can also be tied with analytical models in combination with other software. For example, the "Heat Source" model (DEQ 1996) is used in Oregon to calculate water temperatures in stream networks for *current* conditions as well as *future* conditions based on improvements in riparian vegetation (e.g., more shade) and stream stability (e.g., more pools). The model's algorithms work against data contained in a Microsoft® Excel spreadsheet that is populated by stream corridor conditions measured using GIS-sampling (figure 25a) and ground sampling. The figure displays a GIS generated view of a stream reach, sampling points, and *current* stream corridor conditions. After the data is transferred from the GIS to the spreadsheet, the model is activated and water temperature calculations are made for the stream network. Figure 25b shows the result of the modeling for a northwest Oregon river. In addition to the current or baseline condition (red line), data can be manipulated in the GIS and spreadsheet for "potential" changes based on improvement projects. Improvement scenarios are the lines shown beneath the red line.

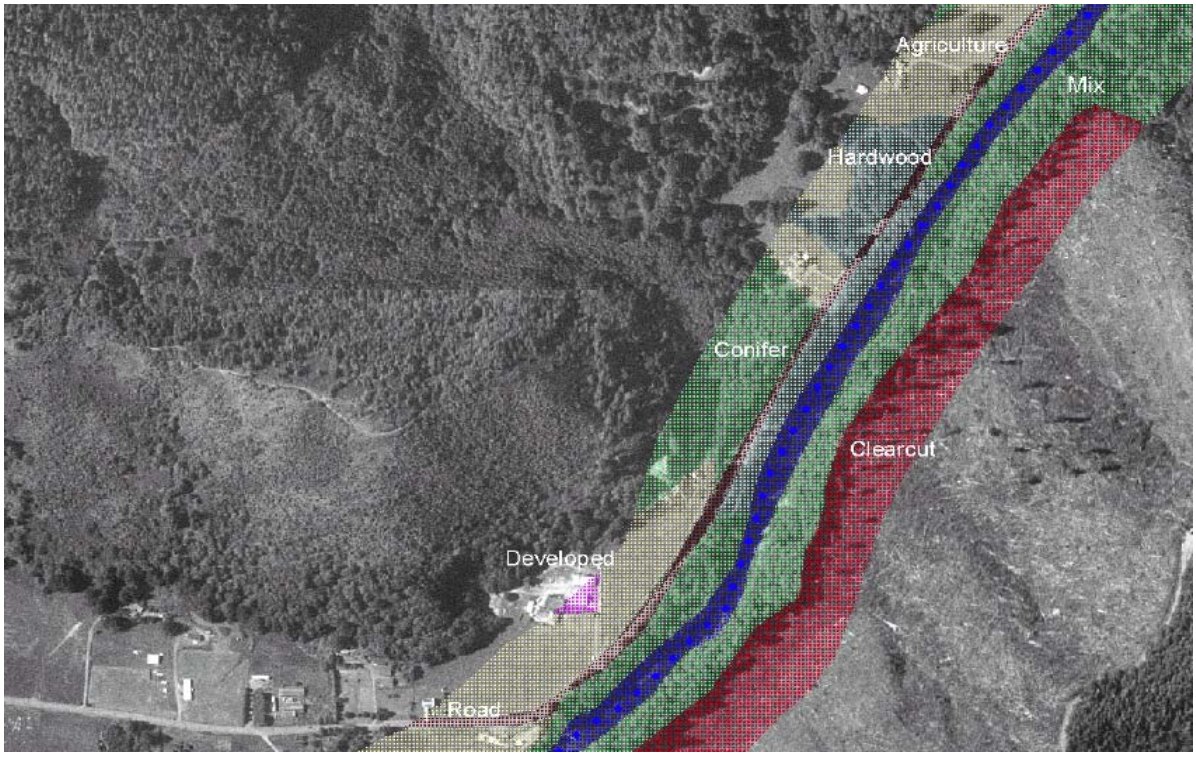


Figure 25a. An example of stream reaches digitized from orthophotos at a 1:5,000 scale. (A digital orthophoto is a digital image of an aerial photograph with displacements caused by camera angle and terrain removed.) Reaches were then segmented into data points at 100-foot intervals. The point data form the basis for automated sampling at each point of vegetation at 15-foot intervals out to 120 feet from the channel edge for both stream banks. A total of 18 vegetation samples are taken at each stream distance node.

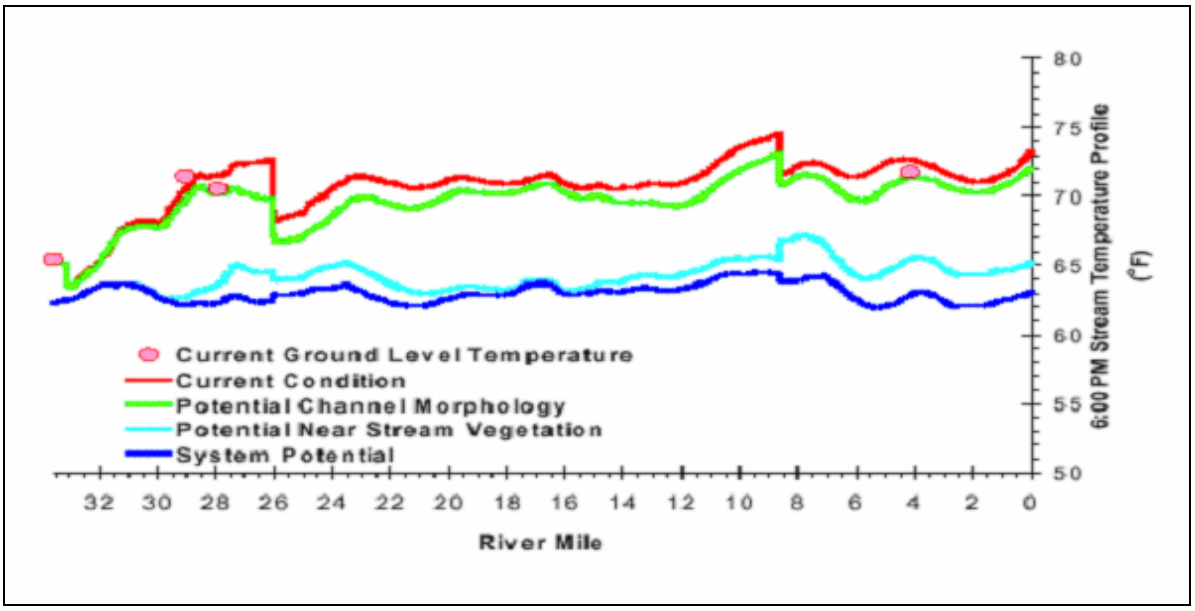


Figure 25b. The results of the analysis using GIS and Heat Source expressed as temperature (°F) by river mile (0 denotes the mouth of the river; river mile 32 is near the headwaters). In contrast to the current or baseline condition (red line), data can be manipulated in the GIS and spreadsheet for "potential" changes based on improvement projects. Improvement scenarios include stability projects which recreate the pools (green line), reestablishment of natural riparian vegetation (light blue line), and a combination of both (dark blue line). The desired "threshold" temperature is 64°F.

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Appendices

- **Appendix A - Definitions**
- **Appendix B - Generic Questionnaire Checklist or Addressing and/or Summarizing the Cumulative Environmental Impacts of Projects**
- **Appendix C - Example: Watershed-scale RMS/Effects Formulation**
- **Appendix D. Practice Effects Diagrams**

Appendix A - Definitions

(Footnotes are listed at the end of the appendix.)

Affected Environment - All potentially affected resources (soil, water, air, plants, animals), ecosystems, and human communities.[1]

Areawide Conservation Planning - The 3-phase, 9-step iterative process (figure 3, column A, and figure 4) used by NRCS to help clients plan and apply conservation treatments for a watershed or other geographical area (referred to as the planning area) defined by the clients and stakeholders. The areawide conservation plan addresses all identified resource problems including cumulative effects issues, contains alternatives that meet the minimum quality criteria for each resource, and addresses applicable laws and regulations.[2]

Baseline Conditions - Conditions of resources, ecosystems and human communities used as the bases or levels of comparison for analyzing effects of proposed actions. These may be established or estimated from historical or current day conditions.[1]

Biological Assessment - A document prepared for the Section 7 (Endangered Species Act) consultation process to determine whether a proposed major construction activity under the authority of a Federal action agency is likely to adversely affect listed species, proposed species, or designated critical habitat.[3]

Benchmark Condition - The status or quality of one or more current planning area situations, circumstances, or settings projected over a future specified time period. Status and quality are usually measured and defined by using one or more relevant indicators and target values. The projection of benchmark condition accounts for reasonably foreseeable future actions as well as past and present actions but does not include the effects of alternatives (proposed actions) being contemplated by the planning group. The benchmark condition is used as a point of reference to: 1) compare against projected resource conditions anticipated for an alternative, and 2) measure change in resource conditions resulting from applied conservation treatment.[2]

Bounding - The process of establishing spatial and temporal boundaries to encompass all the effects on the resources, ecosystems, and human communities of concern during a cumulative effects analysis.[1]

Candidate Species - Any species being considered by the U.S. Fish and Wildlife Service or National Marine Fisheries Service for listing as an endangered or threatened species under the Endangered Species Act but not yet the subject of a proposed rule.[3]

Common Resource Area (CRA) - A geographical area where resource concerns, problems, and treatment needs are similar. Landscape conditions, soil, climate, human considerations, and other natural resource information is used to determine the geographical boundaries of the common resource area.[2]

Conservation Practice - A specific treatment, such as a structural or vegetative measure, or management technique, commonly used to meet specific needs in planning and implementing conservation, for which standards and specifications have been developed.[2]

Conservation Practice Standards - National standards commonly used by NRCS to treat natural resource problems. Each practice standard includes the following components: name, unit of measurement, code number, definition, purpose, condition where practice applies, criteria, considerations, plans and specifications, and operation and maintenance.[4]

Council on Environmental Quality (CEQ) - A three member council appointed by the President that is responsible for the implementation of NEPA throughout the Federal Government.[5]

Critical Habitat - Specific geographic areas, whether occupied by listed species or not, that are determined to be essential for the conservation and management of listed species, and that have been formally described in the Federal Register.[3]

Cumulative Effects - The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other action. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. (40 CFR § 1508.7).[6] See *Types of Cumulative Effects*.

Cumulative Effects Analysis - A procedure with an objective to account for the full range of consequences from proposed actions. The process will involve assumptions and uncertainties but must be conducted with the best techniques and data available.[1]

Direct Effects - Caused by the action and occurs at the same time and place (40 CFR § 1508.8).[6]

Ecosystem - Dynamic and interrelating complex of plant and animal communities and associated nonliving (e.g. physical and chemical) environment.[3]

Endangered - The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.[3]

Endangered Species Act of 1973, as amended (ESA) - Federal legislation intended to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, and provide programs for the conservation of those species, thus preventing extinction of native plants and animals.[3]

Environmental Assessment (EA) - A concise public document that briefly provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement or finding of no significant impact.[2]

Environmental Evaluation (EE) - The part of planning that inventories and estimates the potential effects on the human environment of alternative solutions to resource problems. A wide range of environmental data together with social and economic information is considered in determining whether a proposed action is a major Federal action significantly affecting the human environment. The environmental evaluation for a program, regulation, or individual action is used to determine the need for an environmental assessment or an environmental impact statement. It also aids in the consideration of alternatives and in the identification of available resources (7 CFR § 650.4).[6]

Environmental Impact Statement (EIS) - A document detailing the impacts on the quality of the human environment of proposed programs, policies, construction projects, and other major Federal actions that may significantly affect the quality of the environment. EIS's are required by the National Environmental Policy Act (NEPA) and environmental laws in some states.[2]

Fecal Coliform - A grouping of bacteria that originate from the intestinal tract of warm-blooded animals. This group is the most commonly used indicator of bacterial pollution in watersheds.[7]

Field Office Technical Guide (FOTG) - The official NRCS guidelines, criteria, and standards for planning and applying conservation treatments.[2]

Impacts - The difference between the anticipated effects of alternative treatment in comparison to existing or benchmark condition effects. Differences may be expressed by narrative, quantitative, visual, or other means. Impacts are used as a basis for making informed conservation decisions.[2]

Indicator - The description or measurement of a resource concern that, when observed periodically, indicates or demonstrates trends.[2] See related definition, *Target Value*.

Indirect Effects - Caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable (40 CFR § 1508.8).[6]

Long-term Impacts - Impacts that occur during or after an action and may take the form of delayed changes or changes resulting from the cumulative effects of many individual actions.[8]

Minimizing Significant Cumulative Effects - Avoiding, altering or mitigating adverse effects by modifying, eliminating or adding alternatives to the proposed actions.[1]

Mitigation - (a) Avoiding an impact altogether by not taking a certain action or parts of an action; (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; (e) Compensating for the impact by replacing or providing substitute resources or environments. Mitigation may be used to alter significant adverse effects so an EIS need not be prepared and a finding may be made of no significant impact (40 CFR § 1508.20).[6]

National Environmental Policy Act (NEPA) - This Act established a Federal policy of using all practicable means to create and maintain conditions under which humans and nature can exist in productive harmony, fulfilling the social, economic, and other requirements of present and future generations. It also requires a detailed report

for all major Federal actions significantly affecting the quality of the human environment. CEQ was required by the Act to prepare NEPA implementing regulations. These regulations require Federal agencies to prepare environmental impact statements and environmental assessments as the means of ensuring the National environmental policy is carried out.

Proposed Species - Any species of fish, wildlife, or plant that is proposed in the Federal Register to be listed under Section 4 of the Endangered Species Act.[3]

Resource Management System (RMS) - A combination of conservation practices and resource management, for the treatment of all identified resource concerns for soil, water, air, plants, and animals, that meets or exceeds the quality criteria in the FOTG for resource sustainability.[2]

Scoping - an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action (40 CFR § 1501.7).[6]

Short-term Impacts - Temporary changes occurring during or immediately following an action and usually persisting for a short while.[8]

Target Value - Identifies a specific value to be used in conjunction with an indicator.[2]

Threatened - The classification provided to an animal or plant likely to become endangered within the foreseeable future throughout all or a significant portion of its range.[3]

Threshold - The specific measure or quality of a condition of the resource, ecosystem, and human community beyond which adverse or beneficial change would cause significant degradation or enhancement of the resource, respectively. The impact is usually scientifically or legally based.[1]

Tiering - The coverage of general matters in broader environmental impact statements (such as national program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statements subsequently prepared (40 CFR § 1508.28).[6]

Types of Cumulative Effects (Types 1, 2, 3 and 4)[1]

- Type 1 - Repeated "additive" effects from a single proposed project, e.g., construction of a new road through a national park resulting in continual draining of road salt onto nearby vegetation.
- Type 2 - Stressors (e.g., substance, compound or material) from a single source that interacts with receiving organisms to have an "interactive" net effect, e.g., toxic compounds that build up disproportionately at higher levels within food chains.
- Type 3 - Effects arising from multiple sources that affect environmental resources additively, e.g., agricultural irrigation throughout a community that draws down a groundwater aquifer.
- Type 4 - Effects arising from multiple sources that affect environmental resources in a countervailing or synergistic fashion, e.g., discharges of nutrients and heated water to a river that cause an algal bloom and subsequent loss of dissolved oxygen that is greater than the additive effects of either pollutant.

[1]CEQ 1997
[2]NRCS 2003
[3]USF&WS 2001
[4]NRCS 1992
[5]U.S. Congress 1970
[6]NARA 2002
[7]NRCS 2000
[8]USPS 1991

Appendix B- Generic Questionnaire Checklist for Addressing and/or Summarizing the Cumulative Environmental Impacts of Projects (Canter 1995).

	Will the Project Result in:				Will the Cumulative Impacts of Projects Result in:			
Environmental Category	Yes	Maybe	No	Comments	Yes	Maybe	No	Comments
Physical environment landform:								
• fractures on geologic strata?								
• landslides and land subsidence?								
• seismic activity?								
• compacting and settling?								
• deposition (sedimentation, precipitation)?								
• erosion of soils due to increased wind, floods, removal of vegetation?								
• impact to unique physical features (due to destruction, modification, or covering)?								
• impact to land classified as prime or unique farmland?								
• change existing topography (ground contours, shorelines, river banks)?								
• extensive use of existing mineral resources (mining, oil and gas)?								
• disposal of construction debris?								
• excessive fields and radiation (magnetic fields electromagnetic radiation)?								
• Changes in hydrology (water table, gradient, Infiltration)?								
Air/Climatology:								
• impact on air quality due to gases, particulates and fugitive dust)?								
• air pollutant emissions that will exceed federal or state standards or cause deterioration of ambient air quality								
• objectionable odors?								
• changes in climate due to alteration in humidity, air movement, or temperature?								
• emissions of hazardous air pollutants (VOCs, SOCs, and other toxins regulated under the Clean Air Act?								
• acid rain?								
Water:								
• changes in the quality and quantity of surface drinking water?								
• discharge of wastewater to potable drinking water systems?								
• alter flows due to construction?								
• increase tendency to flooding?								
• salinate water bodies?								
• unsightly appearance of water bodies?								
• eutrophication								
• increase in temperature and turbidity due to impoundment?								
• destruction of streams?								
• considerable effects on conventional water quality parameters (that is, DO, fecal coliforms, pH, BOD_5, NO_3, PO_4, temperature deviation, turbidity, total solids)?								
• alter the rate or direction of ground water flow?								
• introduce pollutants to ground water due to land application of wastes?								

(continued)

Environmental Category	Will the Project Result in:				Will the Cumulative Impacts of Projects Result in:			
	Yes	Maybe	No	Comments	Yes	Maybe	No	Comments
• contamination of public water supplies?								
• impact to recharge area or recharge rate?								
• make ground water vulnerable to contamination (due to wells, boreholes, cracks, etc.)?								
• impact on or construction in a wetland or floodplain?								
• thawing snow, ice, and permafrost?								
• impact to a wellhead protection zone?								
• Impact on fisheries?								
Solid waste:								
• generation of significant solid waste?								
• impact existing landfill capacity?								
Noise:								
• increase existing noise levels?								
• expose people or wildlife to excessive noise?								
• vibrations?								
Hazardous waste:								
• generation, transport, storage, or disposal of regulated hazardous wastes?								
Biological environment flora:								
• change to the diversity or productivity of vegetation (namely trees, shrubs, grass, crops, microflora, and aquatic plants								
• impact to riparian habitat?								
• impact to rare or endangered plant species?								
• introduce new plant species into the area or create a barrier to the normal replenishment of existing species?								
• reduce acreage or create damage to any agricultural crop?								
• impact forests?								
Fauna:								
• reduce the habitat or numbers of unique, rare, or endangered species of birds or animals?								
• affect to land animals, benthic organisms, insects, and microfauna?								
• Attraction, entrapment or impingment of animal life?								
• impact to existing fish, wildlife habitat, and nesting areas?								
• introduction of new species of animals into an area or create a barrier to the migration or movement of animals or fish?								
• cause emigration resulting in human-wildlife interaction problems?								
• affect to food chain?								
Socioeconomic environment landuse:								
• substantially altering existing or proposed land use of an area?								
• impact to wilderness qualities and open-space qualities?								
• impact to or destruction of wetlands?								
• impact to Special Management Areas (SMAs)?								
Recreation:								
• impact to hunting, fishing, boating, swimming, camping and hiking, picnicking and holiday resorts?								

(continued)

Environmental Category	Will the Project Result in:				Will the Cumulative Impacts of Projects Result in:			
	Yes	Maybe	No	Comments	Yes	Maybe	No	Comments
Aesthetics:								
• impact to scenic views and vistas?								
• impact to landscape design?								
• impact to unique physical features?								
• impact to parklands and reserves?								
• impact to monuments?								
• presence of misfits (out of place)?								
Archaeological sites:								
• impact to or destruction of historical, archaeological, cultural and paleontological sites or objects?								
Health and safety:								
• health hazard or potential health hazard?								
• exposure of people to potential health hazards?								
• risk of accidents due to explosion, release of oil, radioactive materials, toxic substances, etc.?								
Cultural patters:								
• change existing cultural patterns (or life style)?								
Local services:								
Need for new or altered services in any of the following areas:								
• health care?								
• police?								
• fire protection?								
• education?								
• churches?								
• child care?								
• other services?								
Public utilities:								
Need for a new or alterations to the following utilities:								
• electricity?								
• natural gas?								
• Potable water?								
• wastewater treatment and disposal?								
• stormwater control?								
• solid waste collection and disposal?								
• communications systems?								
• Transmission pipelines?								
• Other utilities?								
Population:								
• alteration of location or distribution of human populations in the area?								
• change to demographic characteristics in the area?								
• change to housing and household?								
Economic:								
• adverse effect on local or regional economy?								
• changes in per capita income?								
• changes in the standard of living?								
• employment?								
Transportation:								
• change to existing rail, road, waterway and/or air traffic?								
• increase in movement?								
• increase in accident and traffic hazards?								

(continued)

Environmental Category	Will the Project Result in:				Will the Cumulative Impacts of Projects Result in:			
	Yes	Maybe	No	Comments	Yes	Maybe	No	Comments
• affect to transportation network?								
• construction of new roads?								
• change in existing patterns of movement of men and materials?								
Natural resources:								
• deplete natural resources?								
• destruction of natural resources?								
Energy:								
• substantial use of fuel or energy?								
• increase in demand for existing sources of energy?								

Notes: Due consideration has to be given to the time and space scales. The projects may have short-term or long-term impacts, and the geographical extent of the impacts may be either in the vicinity of the project or considerable distances away.

Appendix C - Example: Watershed-Scale RMS/Effects Formulation

NRCS (2001a) policy calls for the formulation of sample Resource Management Systems (RMS) that treat resource concerns common to the field office service area. These RMS's are maintained in Section III of the local FOTG. The RMS's consist of conservation systems that achieve the quality criteria that are also listed in Section III of the local FOTG for soil, water, air, plants and animals. The quality criteria are characteristics or the condition a resource has when it is considered to be sustainable. These criteria can be stated in either qualitative or quantitative terms.

Section V of the FOTG contains data illustrating the effects of typical systems applicable at the field office; appropriate procedures and methods for collecting, analyzing, and displaying conservation effects data; and case studies for the most important resource concerns.

Currently, the majority of materials in Sections III and V of the FOTG are prepared from a site-level (farm, ranch or equivalent ownership) perspective. The example below provides a stepwise procedure for aggregating information and data to the watershed scale.

Watershed-Scale RMS/Effects Formulation Process Steps (NRCS, 2001b)
Example Information in Italics (Source: NRCS, Portland State Office, Oregon)

1. Develop sample RMS guide sheets for each land use/setting in the watershed.

Headquarters	
AFO, Confined	*Benchmark + RMS Alternatives 1, 2, and 3*
AFO, Non-Confined	*Benchmark + RMS Alternatives 1, 2, and 3*
Pasture	
Floodplain	*Benchmark + RMS Alternatives 1, 2, and 3*
Wetland	*Benchmark + RMS Alternatives 1, 2, and 3*
Terrace	*Benchmark + RMS Alternatives 1, 2, and 3*
Pasture/Hay	
Floodplain, Grazed	*Benchmark + RMS Alternatives 1, 2, and 3*
Hay	
Terrace, Aftermath Grazing	*Benchmark + RMS Alternatives 1, 2, and 3*
Terrace, Not Grazed	*Benchmark + RMS Alternatives 1, 2, and 3*
Floodplain, Not Grazed	*Benchmark + RMS Alternatives 1, 2, and 3*
Wildlife	
Riparian	*Benchmark + RMS Alternatives 1, 2, and 3*
Wetland	*Benchmark + RMS Alternatives 1, 2, and 3*
Upland	*Benchmark + RMS Alternatives 1, 2, and 3*
Forest	
Overstocked – Commercial	*Benchmark + RMS Alternatives 1, 2, and 3*
Overstocked – Pre-Commercial	*Benchmark + RMS Alternatives 1 and 2*
Understocked/Non-Stocked	*Benchmark + RMS Alternatives 1 and 2*

2. Identify acres of land use in the watershed.

Headquarters	*80 acres*
Pasture – Low Land	*2,000 acres*
Pasture – Upland	*18,000 acres*
Wildlife	*90 acres*
Forestland	*4,000 acres*
Total	*24,170 acres*

3. Identify the number of landowners in the watershed.

Headquarters	*80*
Pasture – Low Land	*10*
Pasture – Upland	*30*
Wildlife	*5*
Forestland	*20*

4. Link each guide sheet to each land use in the watershed.

   Reference step 1.

5. Estimate the landowner participation rate for each land use.

Headquarters	*75%*
Pasture – Low Land	*60%*
Pasture – Upland	*80%*
Wildlife	*95%*
Forestland	*20%*

6. Estimate the acres of land use participating in the watershed program.

Headquarters	*75%*
Pasture – Low Land	*65%*
Pasture – Upland	*80%*
Wildlife	*95%*
Forestland	*25%*

7. Estimate the participating acres for each RMS guidesheet alternative.

Headquarters	
AFO, Confined	
RMS Alternative #1	*30 Acres*
RMS Alternative #3	*20 Acres*
AFO, Non-Confined	
RMS Alternative #2	*10 Acres*
Pasture – Low Land	
Floodplain, Grazed	
RMS Alternative #1	*100 Acres*
RMS Alternative #2	*400 Acres*
RMS Alternative #3	*30 Acres*
Pasture – Upland	
Terrace	
RMS Alternative #1	*12,000 Acres*
RMS Alternative #2	*2,400 Acres*
Wildlife	
Riparian - RMS Alternative #2	*700 acres*
Wetland - RMS Alternative #1	*70 acres*
Forestland	
Overstocked – Pre-Commercial	
RMS Alternative #1	*1000 Acres*

8. Identify individual system/practice conservation effects and impacts for each land use using guide sheets.

Land Uses: Headquarters and Pasture (letters correlate across columns).

RESOURCE CONCERNS	*SYSTEM/EFFECTS*	*IMPACTS*
a) Soil Deposition – Onsite Damage	*a) Frequent sediment deposition during high water events.*	*a) Some sediment deposition during high water events*
b) Water Quantity – Pond/Flooding	*b) Ponding may occur during storm events.*	*b) Reduced ponding during sever storm events*
c) Water Quantity – Water Outlets	*c) Ponded water slowly discharged*	*c) Ponded water discharged*
d) Water Quality – Groundwater – Nutrient and Organic Waste	*d) No leaching of nitrates.*	*d) Significant reduction in nitrate leaching*
e) Water Quality – Surface Water – Pesticides	*e) Negligible surface runoff of pesticides*	*e) Significant reduction in pesticide runoff*
f) Water Quality – Surface – Nutrient andOrganic Waste	*f) Negligible surface runoff of nutrients*	*f) Significant reduction in nutrient runoff*
g) Water Quality – Surface Water – Low Dissolved Oxygen	*g) Negligible runoff of nutrients and organics creating conditions for low DO*	*g) Negligible contribution to low DO*
h) Water Quality – Surface Water – Pathogens	*h) Negligible runoff of pathogens*	*h) Negligible runoff of pathogens*
i) Water Quality – Surface – Aquatic Habitat Suitability	*i) Improved water quality and habitat*	*i) Improved water quality and habitat*
j) Air Quality – Undesirable Odors from Agricultural Sources	*j) Objectionable odors minimized*	*j) Objectionable odors minimized*
k) Plants – Plant Condition – Productivity – Pasture and Hayland	*k) Plant production can meet soil capability and target yields*	*k) Plant production can meet soil capability and target yields*
l) Plants – Management – Nutrient Management	*l) Nutrients balanced with plant needs*	*l) Nutrients balanced with plant needs*
m) Plants – Management – Pests	*m) Noxious weeds/insect pests do not reduce forage productivity*	*m) Moderate reduction in noxious weeds and insect pests*
n) Animals – Wildlife - Population Balance	*n) Minimize loss of Threaten and Endangered species habitat*	*n) Improved Threaten and Endangered species habitat*
o) Animals – Wildlife- Wildlife Habitat	*o) Improved water quality*	*o) Improved water quality*
p) Animals – Wildlife – Health	*p) Farm activities less disruptive to fish and wildlife*	*p) Farm activities less disruptive to fish and wildlife*
q) Human – Economic Consideration – Land	*q) Proper application of manure on limited land base*	*q) Proper application of manure on limited land base*
r) Human – Economic Considerations – Profitability	*r) Increased forage productivity increases profits*	*r) Increased forage productivity increases profits*

9. Run predictive models and use other evaluation tools to document and verify "net" conservation effects, over time, of all RMS's interacting and functioning within the watershed. Account for other influencing past, present or reasonably foreseeable actions.

Model/Tools Examples:

Accumulated RUSLE Field Data	*Stream Visual Assessment*
Phosphorus Index Worksheet	*Oregon Stream Habitat Data Sheet*
Nutrient Management Specification Sheet	*Oregon Biology Technical Note-12*
Pest Management Specification Sheet	*Oregon Water Quality Decision Aid*
Stream Classification Worksheet	*Woodland Inventory Worksheet*
Environmental Evaluation Worksheet	*Watershed & Stream Corridor Overview*
Stream Type & Habitat Data	*Stream Classification Worksheet*
Stream Visual Assessment Protocol	*Grazing Lands Applications (GLA) Reports*
HEAT Source - Stream Temperature Model	*Pasture Utilization Estimate*
MANURE - Fecal Coliform Population Model	*Pasture & Hayland Trend & Condition Rating*
Pasture Production/Clipping Data	*Non-Certified Wetland Determination*

10. Qualify and quantify conservation effects.

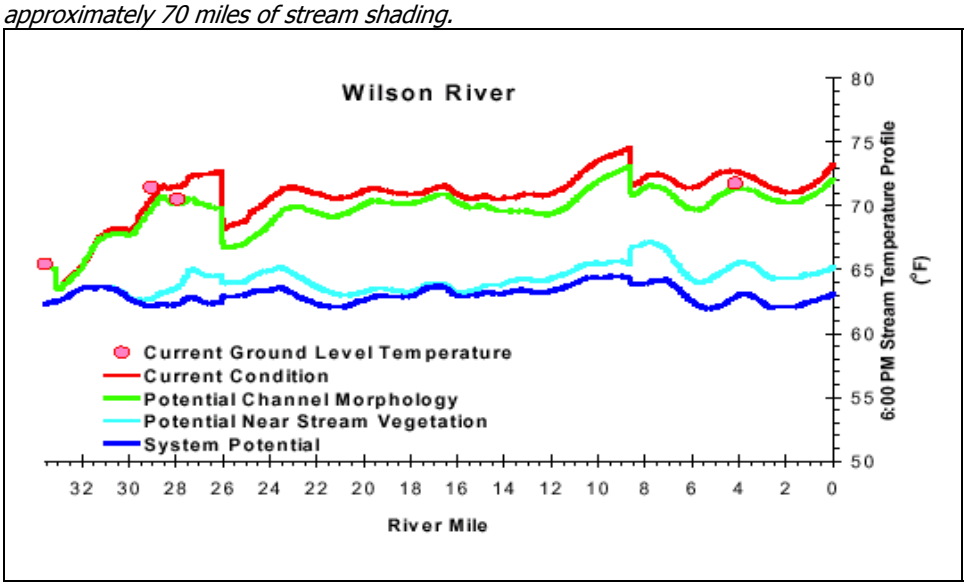
Example: Stream water temperature vs. salmonid habitat (desired threshold = 64°F)

Current Conditions 7- Day Maximum Temperatures			
(Temperature ° F)	*River A*	*River B*	*River C*
Entering Agricultural Zone	*70.2°*	*72.3°*	*72.5°*
Maximum in Agricultural Zone	*75.2°*	*73.2°*	*77.9°*
Effective Shade (Percent)	*20%*	*18%*	*9%*

Potential Future Conditions 7- Day Maximum Temperatures (see Step 7: Wildlife - Riparian-RMS #2 - 700 acres)			
(Temperature ° F)	*River A*	*River B*	*River C*
Entering Agricultural Zone	*61.3°*	*64.0°*	*65.8°*
Maximum in Agricultural Zone	*63.7°*	*63.0°*	*67.6°*
Effective Shade (Percent)	*80%*	*76%*	*59%*

11. Prepare summary report including illustrations, diagrams, trend analysis graphs and other display techniques to facilitate decision-making.

Example: Stream water temperature trends for "river B" with and without proposed actions (desired threshold = 64°F). "With" condition primarily due to application of Wildlife-Riparian-RMS#2 on 700 acres or approximately 70 miles of stream shading.



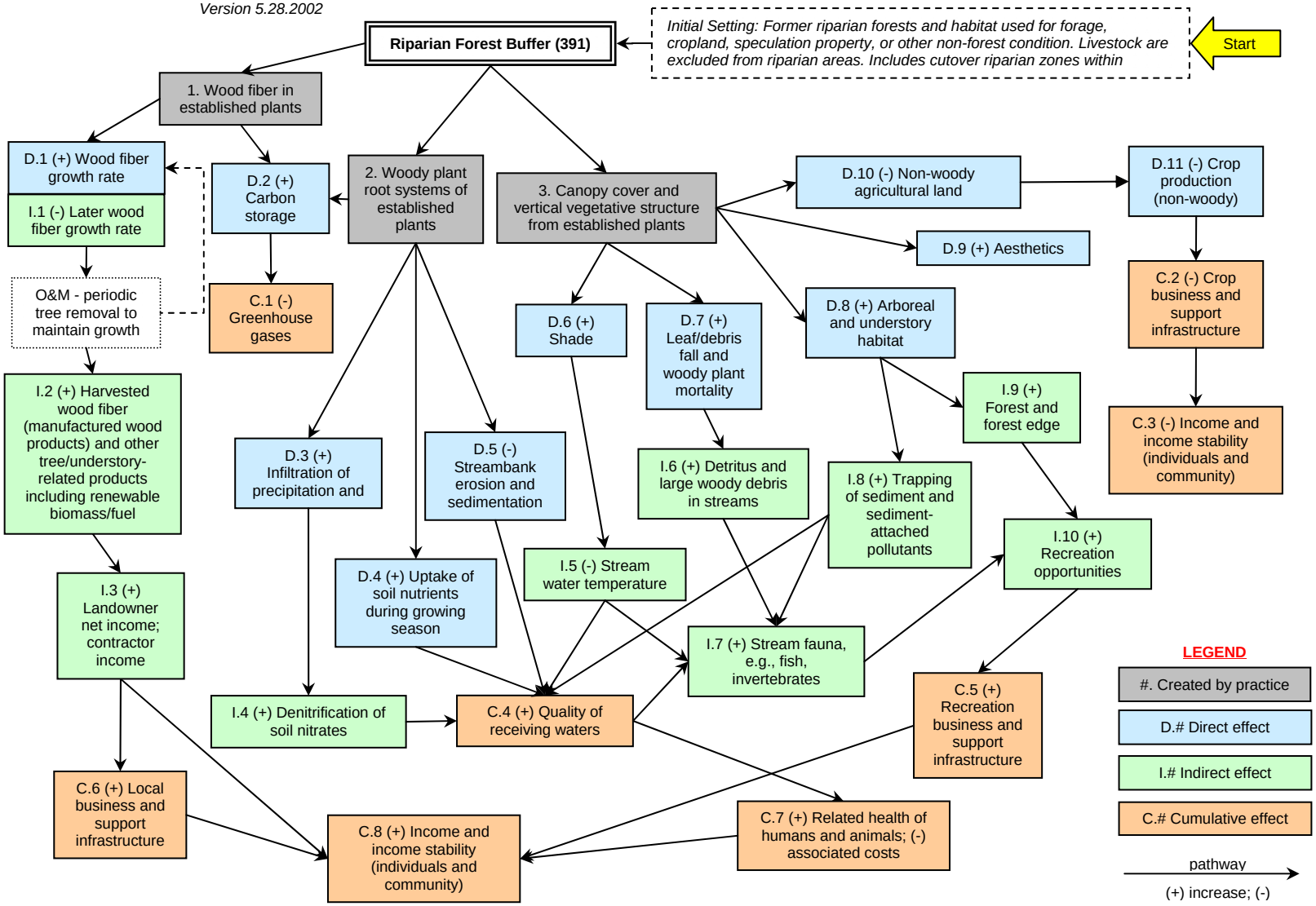
Appendix D - Practice Effects Network Diagrams

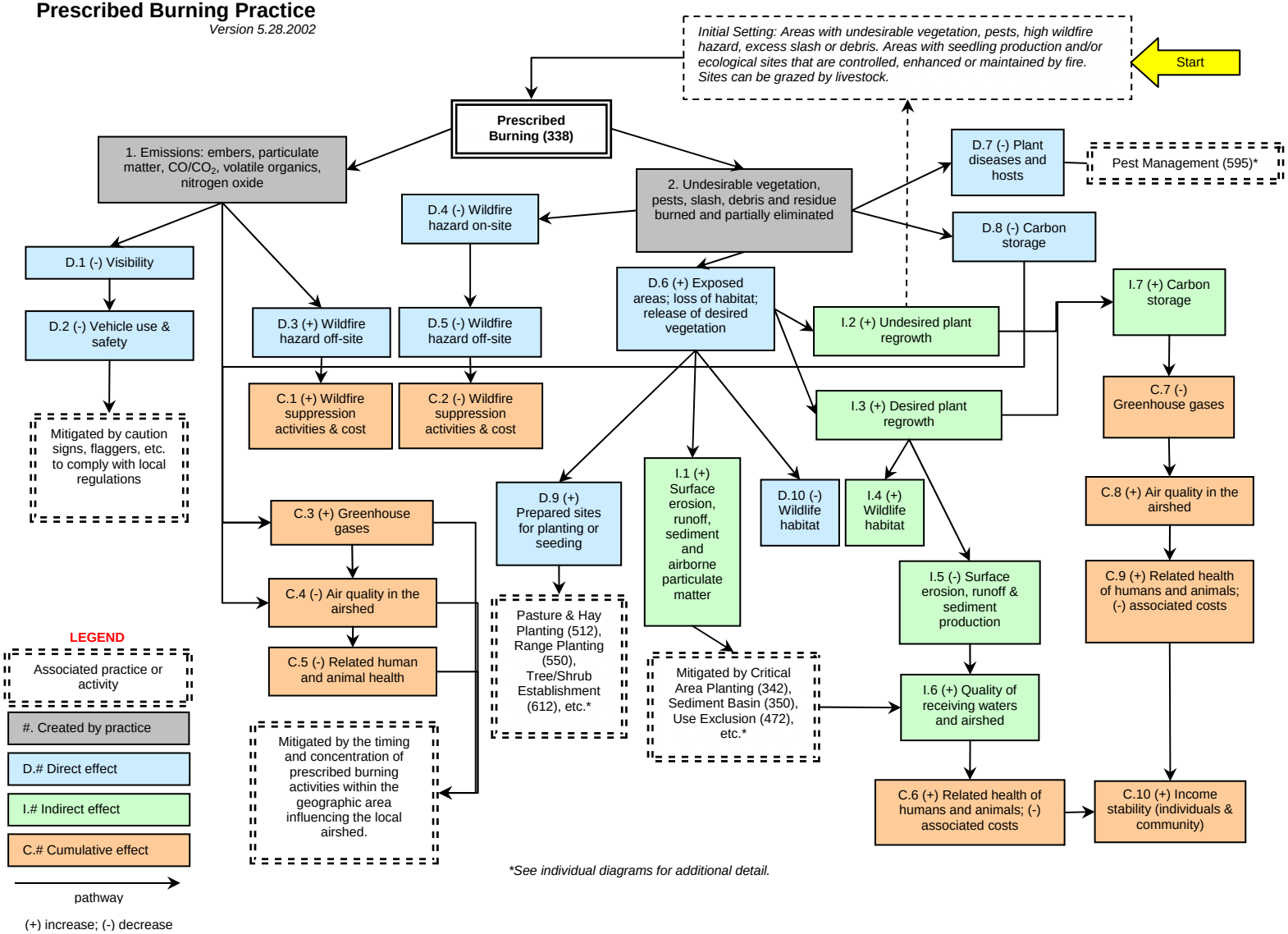
Examples of two practices assessed for use in the 2002 "Farm Bill" (Farm Security and Rural Investment Act of 2002 at the federal level) are displayed on the following two pages. Direct, indirect and cumulative effects are shown for primary practices (double solid-line boxes) in context with associated practices (double dashed-line boxes). The "+" and "-" symbols in effects boxes denote *increase* or *decrease*, respectively, for the particular effect and do not equate with "good, bad, positive or negative."

The increase or decrease in effects are formulated from professional judgement, anedotal information, research and field trials. They are estimated from the change in conditions caused by application of the practice(s) in comparison to conditions without the practices.

Riparian Forest Buffer Practice

Version 5.28.2002



Prescribed Burning Practice

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