INTRODUCING SYSTEMS SCIENCE TO PLANNING AND IMPLEMENTING FISH AND WILDLIFE RECOVERY IN THE WATERSHED

Bonneville Project: 9043

Applicant: Ducks Unlimited, Inc.

Business Acronym: DU

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NPPC Program Measure Number:

NPPC guidance - The Fish and Wildlife Program (FWP) and The Integrated Framework - Two Council initiatives support a new approach to watershed management. The first is the FWP (1994) which is replete with references to watershed and ecosystem approaches:

- Section **7** of the FWP (Coordinating Production and Habitat) calls for (paraphrasing)…an ecosystem approach to species recovery driven by the needs of species, populations and watersheds, building on the input of local communities…using a total watershed perspective, the elements of which….when viewed together constitute watershed planning, using model watersheds to pioneer watershed oriented techniques;
- **7.0B** describes a 10-year implementation plan in which managers are asked to employ

…acknowledged watershed plans, and…restore degraded areas;

- **7.6A** asks for the coordination of human activities on a watershed management basis;
- **7.6 B** describes coordinating habitat projects integrated across broader watershed improvement efforts with priorities cast in benefit:cost evaluations in dollars;
- **7.6 C** requests accelerated restoration across jurisdictional boundaries and watershed assessment stream reach-by-stream reach, leading to watershed management through locally adopted watershed plans;
- **7.6 D** discusses quantitative habitat objectives which imply some way of objectively projecting the effects of planned actions and auditing milestones toward achieving the objectives (e.g. <60^0 F in spawning areas and < 68^0 elsewhere in the stream);
- **7.6 E** reinforces the need for timely actions and results;
- **7.7 B** notes that the experience gained in the model watersheds will lead to approaches for other Sub-basins, a process which will take decades but which requires incremental progress (presumably measurable) each year, although the Council encourages experimenting with the approaches **-** the essence of adaptive management which is a basic premise of the program. In **7.7 B2** the Council encourages a gap analysis and implies something more when it encourages the identification of " …key factors limiting productivity"… and "identifying on-the-ground actions to address key limiting factors".

Sub-basin: Salmon River, Idaho Floodplain / Eastern Oregon Grande Ronde watersheds

SECTION 2. Key Words

Mark	**Programmatic Categories**	Mark	**Activities**	Mark	**Project Types**
__+_	Anadromous fish	_+__	Construction	_x__	Watershed
__+_	Resident fish	_+___	O&M	____	Biodiveristy/Genetics
__x_	Wildlife	____	Production	____	Population Dynamics
____	Oceans/ estuaries	___	Research	_+___	Ecosystems
____	Climate	_+__	Monitoring/Eval	____	Flow/survival
____	Other	_+__	Resource mgmt	____	Fish disease
		_x__	Planning/admin	____	Supplementation
		____	Enforcement	_+__	Wildlife habitat enhancement/restoration
		____	Acquisitions		

SECTION 3. Relationship to other Bonneville projects

Project #	**Project Title/description**	**Nature of Relationship**
	Floodplain inundation	**Restore hydrologic connections**
DOE/EIS-0265	**BPA Watershed Mgt EIS**	**Develop/analyze alternatives to site-by-site watershed mgt.**
	Loss of riparian component	**Restore native riparian communities**

SECTION 4. Objectives, tasks and schedules

Objectives and Tasks Table

Obj # (1,2,3)	Objective	Task (a,b,c)	Task
Phase 1: Obj #1	**Proposed Phase I** Watershed Analysis, Planning and Work Planning	A	Set up and run central office
		B	Coordinate, venue and materials
		C	Conduct workshops
		D	Data collection
		E	Develop models
		F	Data, parameterize, run, debug
		G	Review data and model
		H	Sensitivity tests
		I	Two model "exploration" workshops
		J	Adjust models
		K	Write-up
		L	Web site development
		M	Implementation planning
		N	Twelve nested watershed plans
		O	Set up subgroups
		P	Develop critical paths, budgets, for each watershed
		Q	Coordinators
		R	Work groups
		S	System-wide model integration
		T	PATH
		U	EDT
		V	Coordination with RASP
		W	Command, control and communication
		X	Publish
	Indicative Outyear Activities		
Phase 2: Obj #1	Watershed Analysis	A	Collect all historic and currently available data, both published and gray, as well as anecdotal from on-site discussions with residents;
		B	Focus on information which the model indicates is most important to goals defined by workshop participants
2	Channel Restoration and Riparian Revegetation	A	Identify nearby baseline stable reference streams
		B	Inventory/monitor/map stream width, velocity, discharge, slope, energy, roughness, sediment load, sediment size, sinuosity, particle size, entrenchment, soils, vegetation
		C	Classify stream
		D	Historic cause-effect analysis of

			problem
		E	Design channel
		F	Estimate cut and fill, equipment
		G	EIA
		H	Permits
		I	Construct temporary bypass and settling ponds
		J	Survey and stake alignments
		K	Construction
		L	Place revetments, barriers, culverts
		M	Revegetate
		N	Line or pipe ditches
		O	Fish screen ditches
3	Range restoration and management	A	Contour trenching/rilling
		B	Seeding and mulching
		C	Tubing/planting
		D	Fencing riparian (both sides) and upland pastures
		E	Gully stabilization and reclamation
4	Reforestation, forest and slope stabilization	A	Train planters
		B	Site evaluation for standoffs, snag/dead wood, and shrub retention
		C	Plant seedlings with inocula
		D	Decommission roads (seed)
		E	Install drain/culvert filters
5	Wetland restoration in the watershed	A	Wet meadow road re-alignment
		B	Raising culvert inlets, placing drop inlets in wet meadows
		C	Re-routing ditches, berms and drains and installing closely spaced culverts and lead-out ditches in wet meadows
		D	Planting woody buffer strips in wet meadows
		E	Levee setback/breaching, floodplain liberation
		F	Returning agricultural fields to wetlands
		G	Modification of impoundment’s (e.g. reservoirs arm) to wetland
		H	Riparian wetland restoration

Objective Schedules and Costs - note: for both phases, although FY 99 submission is for Phase I

Objective #	Start Date	End Date	Cost %
Phase 1, Obj #1	Oct/98	Sep/99	1,143,000 (2%)
Phase 2, Obj #1	July/99	Jul/00	23,760 (0.05%)
Phase 2, Obj #2	Jun/99	Jun/02	12,712,000 (30%)
Phase 2, Obj #3	Sep/99	Jun/02	5,128,000 (12%)
Phase 2, Obj #4	Sep/99	Mar/02	1,152,000 (2%)
Phase 2, Obj #5	Sep/99	Jun/02	23,040,000 (54%)
			TOTAL
			42,055,760 (100%)

Schedule constraints: Weather, river water levels, permitting,

Completion Date:Phase 1 will be complete in Sept/99. Phase 2, the implementation of restoration of nested watersheds, will be complete by Jun/02.

SECTION 5. Budget

FY99 Budget by line item

Item	Note	FY98
Personnel		$398,000
Fringe Benefits		$ 92,000
Supplies, materials, non-expendable property		$ 30,000
Travel		$ 40,000
Indirect Costs	Overhead/Admin	$228,000
Subcontracts	Consultants	$355,000
TOTAL		$1,143,000

Outyear Costs

Outyear Costs	FY 2000	FY 01	FY 02	FY 03
Total Budget	$7,500,000	$16,400,000	$17,000,000	
O&M as % of total	2%	2%	3%	

SECTION 6. Abstract

The first goal of this project is the efficient employment of a tested ecosystem planning process using ecosystem theory and methods of systems analysis. Twelve nested watersheds will be examined for the costs and benefits of alternative management actions using simulation models built at user community workshops. Inputs will use EDT models and output will be linked to system-wide mainstem models (PATH). The 8-month planning element of the proposed four years of work is minimized because it is very efficient and product-oriented, using the Integrated Planning Technology protocol. The workshop products, systematically analyzed, objectively indicate the interventions most likely to be productive and economical, while pointing to impacts and costs of these policies. The requirement for local ownership of such a watershed-level effort is absolute for goal-setting, data collection, access, and sustainability.

The second goal is to employ methods of watershed management (including restoration and rehabilitation) specifically designed to reconcile western land uses with functions of wildlands.

SECTION 7. Project Description

a. Technical and/or scientific background

Recent efforts to analyze and manage watersheds in the Columbia River Basin demonstrate significant effort, commitment of resources, and progress in a number of useful but essentially dispersed and unrelated projects. However, contribution of science-based ecosystem-level analysis and planning at the watershed level is largely missing. It is our observation that to date, "watershed" work has attacked:

- the most obviously degraded areas in a watershed (an overgrazed riparian strip, point source of pollution, 'dozing in stream to divert for irrigation, etc.). The activities are identified by a sort of gap analysis - a logical initial step in prioritizing actions and usually used to identify critical acquisitions missing from the inventory of protected ecosystems - i.e. "gaps" in coverage. For example, the process in the Grande Ronde, involves an inventory and needs assessment of the tributaries and landscapes, and a review of relevant existing work and policy. Meetings of stakeholders are held to assess and plan actions which are then prioritized and implemented as the program continues to be managed and updated;
- the concerns and needs of the squeakiest wheels of a watershed planning group which do not necessarily relate as much to a systematic, integrated natural resource management and restoration effort as to the needs of an operator or agency (e.g. see Table 1. ODOT road work and upland fencing for ranchers are the two largest categories supported).

Table 1. Number and cost (x1000) by category of project - Grande Ronde Model Watershed 1996 early action projects

Fish Passage		**Roads/ trails**	**Irrigation**	**Range imprvmt**	**Ripar/ stream enhancmnt**	**Tourism - recreation**	**Forest mgt**	**Wildlife**	**Urban/ water quality**
#	1	8	3	10	10	2	0	0	0
$	49	228	39	175	145	6	0	0	0

- the inventory of watershed attributes, often optimistically called "watershed analysis" and particularly focused on pattern (e.g. features and elements such as number of redds or roads) rather than driving processes (e.g. trophic relationships and efficiency of energy transfer).

These approaches do not rely on understanding the integrated functioning and control of watershed ecosystems to identify implementation activities. Another problem of past and current efforts is identification of a useful, workable scale for watershed interventions. This proposal describes such a fundamental attribute of a watershed restoration and management intervention.

The above issues of integration and useful scale lead to addressing another shortfall of watershed work to date - the inability to rapidly, and effectively leverage a successful watershed approach to the several score sub-basins and hundreds of watersheds. Absent an objective and replicable systems vision and method, it is difficult to avoid floundering in process, and to avert the simultaneous expenditure of large sums of money and accelerated loss of faunal diversity and productivity. Naiman (1992) sees "an increasingly popular impression that the process of watershed management is becoming more important than the actual discovery and implementation of new knowledge”.

We propose to augment and assist current efforts by responding to the need for systems science in current and future watershed planning. We also propose to link such systems planning to implementation and monitoring of the plan.

b. Proposal Objectives - 1. Goals

1.1 The first goal of this project is the efficient (i.e. rapid) employment of a tested ecosystem planning process using ecosystem theory and methods of systems analysis. It is a process designed to *minimize process* and guide integrated watershed management actions, particularly restoration and rehabilitation. Because of the slide to extinctions and the lack of system-wide response to the interventions attempted to date, it is a goal of this proposed project to offer an alternative ecosystem planning approach which is immediately useful in most watersheds of the Basin while not suggesting a one-size-fits-all watershed planning process which is rigid. To achieve these goals requires marshaling knowledge and experience not yet deployed in the current watershed programs. The finality and certitude of extinctions are a specter of increasing probability in the Columbia Basin. Currently about half of the anadromous fish stocks have become extinct, many of the remainder are at the verge of extinction. “Relaxation” or loss of terrestrial fauna occurs as habitats are increasingly fragmented by land uses - e.g. a decline of 26% at Mt. Rainier National Park in 50 years (Harris 1984). These records of diminishing diversity generates an important requirement of a watershed approach, speed. The pace of extinctions has resulted in a clock ticking, which overshadows and influences the watershed management approaches we choose in the Basin. Many of the remaining stocks of anadromous salmonids in the Basin are below minimum escapement goals (roughly 300-1000 depending on run variability) for population viability and persistence (NMFS 1995). Given the lack of response of these stocks to the past 17 years of program efforts, their existence in the short-term is questionable (see, for example, the trend lines graphed in Section I of the NPPC Program 1994, and NRC 1996).

1.2 The second goal is to employ methods of watershed management (including methods of restoration and rehabilitation) specifically designed to reconcile western land uses (such as logging, grazing, agriculture, and recreation) with functions of wildlands (such as natural rather than engineered maintenance of natural diversity and productivity);

1.3 A good reason to use an ecosystem approach is the ability it provides to link the subject matter to larger issues and a conceptual framework. This is certainly a goal for the work proposed here. The decision to examine the effects of combining the dynamics of six watersheds in a sub-basin to examine the outputs and meaning for the larger unit is a novel departure. Although less interactive, input will employ the existing knowledge and spreadsheet models such as EDT, and output will be linked to system-wide mainstem models (PATH). Output can be used for a host of analyses from economic to political. An ecosystem model should not be a guild-centered and guild-used tool.

2 Objectives - Phase I Analysis and Planning (FY 99)

2.1 Develop twelve user defined, goal-directed ecosystem models of twelve watersheds;

2.2 involve watershed residents as well as experts in development of watershed models to inform the models, confer ownership, and enhance the likelihood of their understanding and use**;**

2.3 test at least four management/restoration policies for each watershed to assess plausible economic and environmental costs and benefits;

2.4 test the sensitivity of goal variables to different elements (variables) or combination of elements (feedback loops) in the ecosystem, thereby identifying priorities for restoration and management actions as well as missing or suspect data which need to be collected;

2.5 estimate by simulation, the time and effort required to achieve a measurable response to implementation actions indicated with policy testing. This level, analogous to the acceptable level of sampling on a species-area curve, will conclude the second phase of this project. It empirically establishes and demonstrates the utility of the systems method employed (the third phase being complete implementation);

2.6 producing a work plan based upon the simulated policies which show most promise and least impact;

2.7 making the data and simulations available on the Web;

Phase II (after the first year of analysis and planning which is Phase I propose herein)

2.8 initiate activities designed in the Watershed Plan (implement the Plan) to a stage where the integrated activities show measurable results and interactions at the watershed level (e.g. escapement, summer stream flows, or additional species) as well as at the site. This is termed the "threshold of effects" and is to be estimated by simulation. It is a form of validation of the method. Empirical evidence indicates significant response to treatments at about 2/3 of the implementation.

c. Rationale and significance to Regional Programs

The rationale has been stated earlier (a-Background, b.1-Goals) and in fact throughout this proposal. However, perhaps the most cogent statement of the need for the proposed work is given by the Independent Scientific Group (ISG) in its programmatic review for the NPPC (ISG 1996). The take-home message is simply that the FWP has suffered due to a confused and uncoordinated approach resulting from poor planning. The Council supported development of the report (Return to the River) and has accepted "An Integrated Framework for Fish and Wildlife Management in the Columbia River Basin" (NPPC 1997) which was generated by the findings described in Return to the River. The fundamental flaw identified by the (ISG 1996), was the attempt to fit a technical fix to environmental problems one-at-a-time (the laundry list approach), while not addressing interactions or dynamic behavior (over time) of ecosystem components in planning actions. They decry a pastiche or anarchy of fundamentally unrelated projects responding to a wide variety of goals, often not at a watershed or ecosystem level (e.g. "build a hatchery" or "de-list a stock"). Even though each project may appear to usefully address an issue of fish and wildlife in the Basin, there is no integrating thesis, and certainly, little science except in the conduct of the individual projects. The Framework describes a solution to the way the Program has developed over the past 17 years. In fact it represents a sea-change in planning. It is an iterative process of goal setting, science-based system bounding and defining (the conceptual foundation), strategy and tactic development, and feedback. This Framework is necessary to realize adaptive FWP management. The Framework and IPT describe nearly identical processes (below), although IPT depends upon the participation of the knowledge and acceptance of watershed residents (as suggested in Sections 7, 7.6 A, and 7.6 C of the FWP). A current issue is how to move toward the Framework given the inertia of hundreds of current individual FWP projects (some active for more than 10 years and projected out through the end of the (this) millennium). This proposal seeks to initiate such a process in the watersheds.

Two NPPC initiatives support a new approach to watershed management. The first is the FWP (1994) which is replete with references to watershed and ecosystem approaches:

- Section **7** of the FWP (Coordinating Production and Habitat) calls for (paraphrasing)…an ecosystem approach to species recovery driven by the needs of species, populations and watersheds, building on the input of local communities…using a total watershed perspective, the elements of which….when viewed together constitute watershed planning, using model watersheds to pioneer watershed oriented techniques;

- **7.0B** describes a 10-year implementation plan in which managers are asked to employ …acknowledged watershed plans, and…restore degraded areas;
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- **7.6 B** describes coordinating habitat projects integrated across broader watershed improvement efforts with priorities cast in benefit:cost evaluations in dollars;
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(d. Project history - NA as not an ongoing project)

e. Methods - I Watershed ecosystem analysis and planning - Phase I (proposed here) Analysis and planning are the thrust of first phase activities. Because every land management action takes place within a watershed, all activities from picking up garbage to grading a road could be considered watershed management. The fundamental difference between a number of useful but not necessarily related resource management activities, and a scientifically rationalized approach to watershed management turns on scaling and an ecosystem approach.

Watersheds (more accurately, catchments) are hierarchically nested, small ones in large (defined by USGS, 1987 and elaborated by the Forest Service 1995, corresponding to the 6 subregions and 53 sub-basins of the NPPC). The size depends on the purpose of the analysis or intervention. Smaller scales (drainage and site) are used for projects and site-specific impacts (e.g. on a threatened endemic plant) which tend to be more quantitative and cover shorter time spans. They usually evaluate a specific management action rather than ecosystem function and linkages. Larger scales such as Regions are used for formulating policy and regulation (e.g. FEMAT analysis leading to old growth reserves). Midscale analysis conforms to watersheds and ecosystem analysis. This scaling can be analogous to autecological studies at a site, community studies in a watershed habitat type, and metapopulation/migration studies in regions. The Forest Service watershed analysis guidelines state that as the size of the watershed unit increases, it becomes increasingly difficult to "provide meaningful information for this (project-level planning and decision-making) use". The quality and applicability of data needed for such activity scales as a riparian or wetland restoration led to the 20 - 200 mi^2 size watershed boundaries of the Forest Service and other agencies, a rationalized *scaling* approach (the aquatic ecosystem portion of FEMAT, 1963). The Grande Ronde is 5,265 mi^2 . In such large landscape units effects of relatively small and discrete projects can not be seen on the watershed scale. It is difficult to assess how effective an action has been at a very large watershed scale. Scaling leads to identifying hydrologic units of a size which permits the use of mapped data essential for on-the-ground management - i.e. of silvicultural treatments in compartments of a forest harvest plan, grazing systems and fencelines, stream characteristics, vegetation types on winter ranges, housing developments, etc. This is the level of resolution needed to actually plan an intervention, assign levels of effort, commit equipment on schedule, and budget. Selecting the right scale is analogous to stratification in statistical sampling. Both scaling and stratification generate a uniformity in potentially confounding variables such as widely differing habitat types, permits some measurement of confidence in the results, and help to avoid a dispersed effort on individually useful but collectively unrelated actions. Hence this proposal will plan integrated interventions in six nested watersheds (the average number) in each of two larger Sub-Basins (selected from the Grande Ronde, Salmon or Yakima) to embrace a range of habitat issues.

Watershed management is characterized by an *ecosystem approach*, which is achieved by identifying and integrating the driving elements of the watershed for some clear goal. In fact, a "system" is defined as a bounded collection of interacting elements which function together for some common purpose (Roberts, *et al.* 1983). A number of regional ecosystem analyses also raise the need for an integrated ecosystem approach. The team assembled for the Clinton Forest Plan (FEMAT 1963) observes that such"… (watershed planning) methods all suffer from a similar set of problems: unclear logic…and assumptions of direct linear relations between land use intensity and watershed response…typically not considering how key processes are distributed over watersheds...." "Naiman *et al* (1992), Sheldon (1988), and Williams *et al.* (1989) noted that past attempts to recover fish populations were unsuccessful because the problem was not approached from a watershed perspective. "Anadromous fish habitat is provided through ecosystem processes and functions" (from the NMFS proposed recovery plan, 1995).

We all employ modeling ("mental models") every day when we make a decision. To cash a check or take a trip we weigh pro and con, and then decide. These decisions can be described in words which explain the logic of problem solving, but must be kept fairly simple as complex relationships can get lost, particularly the effects of feedback loops on dynamic behavior. To center watershed planning and management around an ecosystem approach, we employ a modeling approach (system dynamics) which is icon based and very easy for the general population to use and understand in a workshop. It affords an intuitive and technically very rich depiction of integrated ecosystem patterns and processes. It also permits the capture and use of everyone's' mental models of forest, range, fish and wildlife, suburban development or any other sectoral activity important in a particular watershed. The method satisfies many of the requirements noted as desirable, including:

- conveyance of ownership and understanding;
- rapid results with a minimum imposition of time requirements;
- an analogue of the scientific method (inductive reasoning with hypothesis testing);
- a systematic but simplified, aggregated systems view (with linked system elements and dynamic behavior) addressing only the details which clearly relate to goals for the watershed;
- ease of use in planning the sequence and detail of implementation jobs;
- assessable and replicable;
- extreme difficulty in spinning an intervention to a private agenda, given the public and integrated nature of the system depiction process.

The planning element of the proposed four years of work is minimized because it is very efficient and product-oriented, using the Integrated Planning Technology (IPT) protocol (Berwick and Faeth 1993). IPT employs a 1 ½ to 2-day workshop bringing together and extracting knowledge from the resident ecosystem (in this case watershed) experts - ranchers, farmers, loggers, scientists, and other interested residents. The workshop protocol begins with the definition of management goals - no more than 3 or 4, followed by identifying the 3-4 problems most likely to frustrate the achievement of the goals. The key questions to be answered before the problems can be addressed, the information required to answer the questions, and the necessary variables implied by the data required are all listed. Variables are generally measurable accumulations or stocks like a population of fish or elk. Their input and output rates are identified (like births, deaths, and sales), and their relationships to each other are identified (such as feedback loops). Identifying the loops is key since they control the system and its outputs. Simple cause-effect-solution thinking is not dynamic and will not help to manage system behavior. In this way the workshop quickly elicits the desires and knowledge of the participants; their mental models. We demonstrate how experienced people can construct a reasonable representation of natural systems, but how the consequences of the simplest management actions (e.g. timing, quantities, linked impacts, etc.) are difficult to anticipate. Therefore we use the workshop to employ human facility in problem and system definition for later use through the computer's capabilities to process thousands of calculations. The product is agreed to and understood by the participants who created it. The flip charts are taken back to the office and transformed into a process (flow) diagram. The system simulation software used is known as STELLA, a systems teaching tool which is also very good as an analyst. It is used because it is easy to understand, graphic, and changeable in a workshop, responding to changing input by participants. We have conducted lively and productive workshops (over 1000 participants in total). As the ecosystem is drawn, the formulae and data requirements are not considered by the builders but are suggested by the software and used later. Non-linear relationships so typical in natural systems are accommodated, and STELLA accumulates inflows and outflows in short time steps (e.g. 6 weeks) over long periods (e.g. 30 year life-of-project) integrating changes in the variables (simulation) and showing their behavior over time (dynamics). Therefore, over a 30-year project, each of the hundreds of equations is calculated 260 times (every six weeks). Such models typically have about 100 data points for which information needs to be provided. The method employs just that sub-set of information about the watershed needed to address <u>only</u> the 3 or 4 goals and issues identified by participants. This is in contrast to the thousands of data points possible when attempts to improve the system lead to "modeling the system". Modeling the system rather than those elements to address specific goals or issues is the result of poor focus, confused goals, poor planning control, and is uniformly inefficient, if not unsuccessful. The workshop takes 2 days, formulation takes about 2 weeks, data collection (from secondary, existing sources) 1 month, and de-bugging/validation about 1 month, a total of three months. A second workshop follows. The efficiency of the entire process permits us to confidently propose to analyze/plan for each of the nested watersheds (up to 12) in two Sub-basins, based on extensive experience.. Part of the de-bugging and validation process involves presenting the working model to those who contributed to its formulation and construction, letting them test and analyze alternative policies for watershed restoration and management, and comment on the results and their implications. An example of diverse interests and skills coming together for a day to test and learn as a group from a system simulation is described by Ford (1996) for a model of the Snake River. Although in this instance the model was developed by experts, a variety of interest groups participated in examining its utility. As with the range and wildlife model, unexpected (counterintuitive) results generated a discussion dissecting the system and management policies. In this case, eliminating water lost from irrigation canals led to lower flows in the Snake River within a specific time lag (20 years). The utility of such a participatory examination was demonstrated although veteran modelers were nervous, and worried about the lack of years of testing. "They argued that only this (their) group would have the years of experience required to interpret properly model-based results." We believe that communal participation in the building of the model (scientists and other stakeholders), and validation will help address some of these concerns. We also believe that there is no alternative to a community-based process if the management objectives will require buy-off by those affected - i.e. an elegant model can be trivial if poorly understood and stoutly resisted by landowners and managers. At this point, based upon the priorities indicated by sensitivity analyses of the ecosystem, a work plan will be developed in detail, presented and discussed at a third set of meetings at each of the two sub-basins. The workshop products, systematically analyzed, objectively indicate the interventions most likely to be productive and economical, while pointing to impacts and costs of these policies.

Tasks - Systems analysis and planning

1. Coordinate Workshop venue and materials
2. Conduct Workshops
3. Data collection for model
4. Develop models
5. Run alternative watershed management policy tests and debug models
6. Sensitivity testing
7. Model "exploration" workshop
8. Adjust models
9. Web-site development
10. Develop twelve nested watershed implementation plans/work plans
11. System-wide model integration (e.g. with PATH and EDT)

Phase II - Implementation in the out years - Although not included in this proposal, the implications of integrated watershed plans should be estimated or they risk being underestimated. The workshops and models proposed here, will eventually specify the details of work in each watershed. The following are estimates based on the scale and experience of DU in such work. This will be revised following Phase I.

II Watershed Analysis - The Forest Service has the most organized, systematic, and extensive experience with watershed analysis in the northwest. The initiative of the FS is understandable when more than 95% of streamflow originates from forested and alpine lands in Washington and Oregon, most administered by the Forest Service. Initially in response to attempts to define "ecosystem management" and most recently in response to the watershed analyses mandated by the Northwest Forest Plan, the FS began analyzing watersheds in mid-1994. By early 1997 over 200 watershed analyses had been completed (USDA Forest Service 1997). About 265 more will be done in another 6-8 years, and about 50 will not be attempted because they are predominantly wilderness or private, and therefore beyond the FS management mandate. Each is done by a team of natural resource specialists (wildlife/fisheries/plant biologists, hydrologist, etc.) employing a 6-step process which takes abut 2 ½ months. The six-step process is analogous to the IPT workshop protocol. The cost of such an analysis ranges between $30,000 - $300,000 and averages $90,000 for a typical 100,000 acre watershed.

To date however, no systematic and objective way of integrating the analysis is used by the Forest Service. Absence of an integrating methodology can yield unreal results which come from omitting or subjectively estimating complex interactions and cause-effect feedbacks. A good example of the consequences of not using an objective integrating method in a watershed reclamation effort, is described for log sills/weirs placed in Camp Creek of the John Day basin to moderate water temperatures, the critical limiting factor for salmonids(Li *et al.* 1992). To increase the number of pools, 280 weirs at $750 each did not increase rainbow trout density or habitat. The lesson was that "…efforts to rehabilitate stream habitat on a site-specific basis without examining the entire river and riparian landscape contributed to the lack of success of many projects (from a review of habitat rehabilitation projects by Beschta *et al.* 1991)."

Tasks: Watershed Analysis (assume four analyses are available from the Forest Service)

1. Collect all historic and currently available data which the model indicates is most important to goals. Data published, gray (e.g. agency allotment analyses, comparative photographs,

timber stocking, fish and wildlife counts, infrastructure development, fire history, stream modifications, etc.), and anecdotal (from residents);

III. Alteration of Stream Character

Issues - Two of the most extreme forms of stream and river alteration are complete de-watering (often seasonal) by diversion and/or pumping, and drowning reaches in impoundment's behind dams. In either case the free-flowing river does not exist. Another alteration results from blocking interactions with the riparian and floodplain area though channelizing, levees, and flood control. The importance of a floodplain connected to the lotic system is described for a typical downwelling at the upstream end of a flood plain, flowing through aquifers to reappear as a springbrook some distance downstream in abandoned meander channels (Stanford and Ward 1992). These springcreeks have elevated nutrients, clarity and stability and exceed the biomass of main channels by several orders of magnitude forming important biological hot spots and key salmonid production areas. Such functions are often cut off in constrained channels (e.g. with roads and associated ditches and culverts).

Many restoration efforts have been unsuccessful because of inadequate analysis: the patterns of water and sediment transport determined by reference baseline stream morphology and vegetation determined from old aerial photos and maps, soil types, etc. (NRC 1992). Necessary tools of hydrology and fluvial geomorphology need to be applied. The NRC notes that in addition to the lateral flood plain linkages, restoration needs to incorporate changes upstream which are inevitably communicated in an upstream-downstream continuum of land uses and water quality. For these reasons and because the streams and rivers can be migratory pathways, the NRC analysis (1992) explicitly calls for a watershed and systems perspective (p. 175).

Design - The restoration process follows the soft engineering approach of D. Rosgen (NRC 1992) who matches the morphology of baseline stable streams which he finds in the area, to a reconstruction design for the subject stream which has been channelized and straightened leading to stream bank failure and erosion. The ensuing hydrologic problems such as broadening and shallowing, pool loss, full freezing and others are common in the west. Similar problems can come from the extensive clearing of riparian willow bottoms for hay and grazing, or pumped withdrawals (Kondolf 1990). The variables which are monitored and which will reflect the success of the reconstruction are river width, depth, velocity, discharge, slope, energy, roughness, sediment load, sinuosity, channel entrenchment, erodibility, stability, etc. First, the reference channel geometry is matched to the stream and a classification of the stream is made for the region in which it is found. Then a historic review of the problems helps to determine the causes of the problems. Comparing the existing flow and form with the stable reference, a design of channel patterns, curvature and proportions is developed which produces desired flows, pools, sediment and cobbles, in the same proportions as the empirically observed natural river. The calculated cross sections to estimate cut and fill required leads to an evaluation of environmental impacts and mitigation's, and the necessary permits are secured from such agencies as USFWS, State Wildlife Department, USFS, EPA to comply with the Clean Water Act (e.g. Section 404). A downstream settling pond and diversion bypass is finished so channel work is done in a dry streambed. The bulldozers and scrapers transform the river from a shallow, braided stream impacted by grazing, logging and roads which is not likely to self-correct. Once the correct geometry (and cross-sectional dimensions) are attained, flow patterns are further determined by bank revetment work, using native materials such as logs, boulders, root wads, and live vegetation. Riparian cover is established with woody (e.g. cottonwood, willow) and herbaceous bank cover. Banks are stabilized by sinking logs and boulders in layers, covering them with soil, and planting them. The results include new meanders, deep pools, new flood terraces, re-constituted flood plains, riparian vegetation, and stabilized natural appearing banks.

Tasks: Channel Restoration and Riparian Revegetation

1. Identify nearby baseline stable reference streams;
2. Inventory/Monitor/map stream width, velocity, discharge, slope, energy, roughness, sediment load, sediment size, sinuosity, particle size, entrenchment, soils, vegetation;
3. Classify stream/Historic cause-effect analysis of problem;
4. Design channel/Estimate cut and fill, equipment;
5. EIA/Permits;
6. Construct temporary bypass and settling ponds;
7. Survey and stake alignments;
8. Construction/Place revetments, barriers, culverts;
9. Revegetate, where needed.
10. Line or pipe ditches/Fish screen ditches.

IV. Grazing and Range Management

Issues - Behnke and Zarn (1976, cited in Platt 1991) state that livestock grazing is the single biggest threat to salmonid habitat in the west. Grazing is permitted on over 90% of federal lands and 32% of the land in private range in the 11 western states - a total of 77% of the landscape (Armour *et al.* 1991). Between 1/2 and 2/3 of these federal rangelands are in classed as in poor to fair condition.

The elimination of riparian vegetation by foraging (direct removal), compaction, or through bank failure leading to loss of vegetation (Berwick 1978), leads to loss of associated fauna, lower water table, channel widening, poor water quality from nutrients and sedimentation, and cascading related changes such as increased water temperature. A northern Nevada stream under heavy use went from 8 to 13 m in width. A stream in Utah which had been rested 10 years was compared with nearby grazed areas. A 40% increase in stream width and 45% increase in bank angle resulted from grazing. To illustrate one possible feedback relationship, water pumping/diversion, overgrazing and riparian logging leading to loss of riparian vegetation will drastically lower the value for beaver which consume willow, aspen, cottonwood, and other associated vegetation. Loss of beaver means no beaver dams which divert water to side ponds and channels, reducing extreme flows and enhancing diversity including fish and waterfowl habitat. Further, sediment is reduced by 90% below beaver dams. There is a 400% increase of salmonid rearing sites which can be more limiting than spawning areas (Swanston 1991).

Design - Sheridan (1986) has estimated dryland restoration costs ranging from $60 - $ 3000/ac. Land imprinting (holes drilled for water infiltration) and bulldozer rilling (water collection ditches) at $25 and $200/ha, inoculation of seedlings planted with mycorrhizae, native grass mixes seeded at $45/ha are some of the range restoration options. Fencing ($3500/mile) and institution of grazing control systems are also common restoration actions. In addition to stream reconstruction, grazing management and revegetation, a combined erosion control-riparian reveg technique known as Vleckport reclamation is described by Heady and Child (1994). It is spectacularly successful but otherwise similar to other varieties of check dams. Typically, about half of an average watershed can be considered range (including open forests). R^3 for 100 mi^2 will involve restoring 10 mi^2 of reseeding and browse plantings, 5 miles of fencing on each side of riparian zones, and 100 miles of pasture fence.

Tasks: Range Restoration and Management

1. Contour trenching/rilling;
2. Seeding and mulching;
3. Tubing/Planting;

4. Fencing riparian (both sides) and upland pastures;
5. Gully stabilization and reclamation.

V. Timber Harvest and Roading

Issues - Logging can be a major source of watershed disturbance. The activities associated with logging include felling, yarding, site prep, fire reduction, regeneration, tending or reducing competition by brush removal and thinning, road building, and chemical applications. The smaller streams (2^{nd} - 4^{th} order) where most logging occurs in the watershed, are also where most spawning and rearing of salmonids occurs and which are most impacted by logging (data below from Chamberlin, Harr, and Everest 1991). Large clear cuts (over about 1000 ft. diameter) have more snow and release it much faster (e.g. 38% faster in a 5000 ft clear cut in British Columbia, 40% increase at the Andrews forest in Oregon). Small cuts average a 20% increase in melt water runoff. Therefore, it is good to desynchronize cutting. Roads and skid trails are the primary sources of sedimentation. Studies in the coast range of Oregon show increases of 2 - 22 fold from clear cuts, and 20 - 350 fold in slides from roading (Hicks *et al.* 1991). Pools decrease, riffles increase, gravels are sedimented, and obstructions to migration increase. Increased solar insolation results in an average monthly increase in small stream temperatures of 8^o F. Cable logging increased sediments 0.6 fold, where as roads increased sediment 220-fold. Over 85% of sedimentation above natural levels in a cut was due to roading. A 7% cut on the 19 mi^2 Dollar Creek, ID drainage required about one road per mi^2 With simple mitigation such as moving fill off-site, a 46% reduction in sediment was realized. With drainage filters, graveling the road, and seeding cut and fill, sediment as reduced 76%. Clearly, the roads generated the sediment which reduced fish production to less than 20% of potential.

Design - Reforestation needs to speed up succession. Seedlings planted with innocula (above) shortly after cutting will generally permit desired survival and spacing. Several steps are involved in reforestation (Horowitz 1990) including:

- more thorough site evaluations which do not use regional formulae as much as ecological interactions and features (shrubs, snag retention, standoffs, etc);
- skilled planting;
- greater use of species mixes to avoid a vulnerable artificial monoculture;
- wider spacing reducing the need for early thinning.

Tasks: Reforestation, forest and slope stabilization

1. Site evaluation for standoffs, snag/dead wood, and shrub retention;
2. Train planters/Plant seedlings with innocula;
3. Decommission roads (seed)/Install drain/culvert filters.

VI. Restoring watershed wetlands

Issue - As dramatic as the loss of old-growth forest in the watershed, has been the loss of wetlands from riparian zones. Wetlands continue to be lost at a rapid rate (about 460,000 acres/yr). About half of pre-settlement wetlands have been lost (see Tiner 1984). Wetlands purify the water delivered to streams, retaining sediments, heavy metals, fecal coliform and denitrify the water (Pastor and Johnston 1992). The quantity and quality of the water delivered from 15 watersheds was studied by Pastor and Johnston (1992) who statistically analyzed 33 attributes. The most important determinant of water quality (29% of the variance) was wetland extent followed by wetland position (14%), and others such as ratio of agricultural to urban land, length of streams, watershed diversity, forested riparian area, etc.

Design - A brief outline of the requirements in a typical 200 mi^2 watershed would include:

- **wet meadow restoration** (Zeedyk 1996)- grazing impacts and their mitigation have been described above. Road management practices which impact wet meadows include building on them instead of alternative alignments, installing channel crossings below gradient thereby accelerating runoff and channel incision, installing ditches and drainage ditches below meadow surfaces leading to gully erosion, diverting surface and groundwater from meadows causing them to dry, surfacing roads with inappropriate aggregates leading to sedimentation, and borrowing gravel and fill from stream channels. Remedies include realigning roads, raising culvert inlets with geotextile based encased rock berms for 20 ft upstream of the culvert ($200/ structure), drop inlets so that water drops around railroad tie weirs to the culvert ($500/structure), rerouting ditches, berms, and cross drains which divert runoff from roads as well as meadows**,** using closely spaced lead-out ditches and culverts to distribute water to the meadow, and planting buffer strips while reducing use of them by livestock by fencing;

- **agriculture to wetland conversion, levee setback, and impoundment modification -** These are the most common remaining wetland restoration activities which biologists and engineers at Ducks Unlimited confront in the Pacific Northwest. We have estimated costs for these related and common activities. Generally, existing levees will still need to be maintained to a degree for effective flood control, although they can be moved back and selectively breached. Pumping is avoided in favor of gravity flows if possible. Examples are the Wood River in the Klamath Basin and Toppenish and Satus Creeks in the Yakama Indian Nation. Often these activities co-occur at a site and are packaged. Average costs per acre for 9 separate projects are (not every activity is conducted at each site): survey and design - $ 65, materials - $ 93, land leveling/berms/levees - $ 244, construction management - $ 39, labor and equipment - $ 45, culverts - $ 375. Total project cost/ac - $ 534 [1]

These averages are influenced by economies of scale - the larger the project, the less per acre cost. Since they do not include permitting costs which can amount to 10-15%, the likelihood is a per acre average of $600. Although these costs are real, DU engineers were asked to estimate maximum total restoration costs (permitting, design, and restoration) which were likely to be encountered for projects of different sizes (Charney, pers. comm.). At 30 acres, costs could reach $8000/acre, for 300 acres, $ 2500/acre. We estimate a crude but realistic 1% of the typical watershed as requiring wetland restoration/rehabilitation- 2 mi^2 of 200 mi^2. A further 1% will require wet meadow rehabilitation.

Tasks: Watershed Wetland Restoration

1. Wet meadow road re-alignment;
2. Raising culvert inlets, placing drop inlets in wet meadows;
3. Re-routing ditches, berms and drains and installing closely
   spaced culverts and lead-out ditches in wet meadows;
5. Riparian-wetland restorations./Levee setback/breaching, floodplain liberation;
6. Returning agricultural fields to wetlands;
   Modification of impoundment's (e.g. reservoirs arm) to wetland;

f. Facilities and Equipment

The facilities and equipment for the first phase are primarily in hand (e.g. GIS at DU and

[1] Note: 1996 dollars and costs which do not include permitting, contracts, acquisition or easements which must be established before work is initiated

MESC). An office facility is required, although, if successful DU will occupy donated space in Portland. Equipment to be purchased primarily includes hardware and software (computer, computer projector, software). All requirements are costed in the budget or reflected in overhead/admin costs. It should be underlined that DU intends to form the partnerships and cost sharing arrangements for the second (implementation) phase which characterize its ability to leverage partnership funds (e.g. with the North American Conservation Act funds). See the appended descriptions on Idaho and Washington projects from the DU Magazine.

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SECTION 8. Relationships to other projects

Many, if not most of the roughly 72 projects in the FY 98 Fish and Wildlife Program Work Plan classified here as having a watershed focus (51 in anadromous fish) will inform and be influenced by the work proposed here. We are suggesting a planning approach particularly suited to the general and integrated requirements of watershed analysis and management. Geographically, this work would particularly relate to the eight watershed projects in the Yakima Sub-basin, seven watershed projects in the Grande Ronde and five in the Salmon Sub-Basins. Of particular use to the proposed work are inputs from the spreadsheet Ecosystem Diagnosis and Treatment (EDT) method now concluded(DOE/BP-61148-1, 1997) although uses are being explored in the Deschutes Sub-basin. These are not interactive/integrated (e.g. feedback) analyses but are useful and objective determinations of the gap between desired and existing states of watershed resources. Discussion for collaboration has been initiated. We believe the watershed analyses described in this proposal can constitute inputs to mainstem analyses (e.g. PATH, Projects 9600600 and 960800) which do not currently treat the contributions of tributaries in integrated, real-time system-wide analyses. For both EDT and PATH the proposed work is complementary.

SECTION 9. Key Personnel

Crafting just the right team is always one of the most important guarantees of success. It is particularly critical to the type of integrated systems approach advocated here. Not only does the right mix of capabilities and technology need to be marshaled, the coordination of the whole effort requires the command, control, and communication capabilities not often found in natural resource management. Planning and implementing can not be realistically or successfully separated. Furthermore, the emphasis on planning *and* implementing with quality and speed points to the biological orientation and hands-on experience of a private sector eco-engineering organization like Ducks Unlimited. DU is proposed as the prime contractor for this effort. It is arguably the most experienced and respected restorer and enhancer of riparian and wetland ecosystems in the world, filling this function for, among others, the US Fish and Wildlife Service on many of their refuges. Furthermore, we are the organizer of teams of “Partners” for the ecosystem and flyway-based Joint Ventures of the North American Waterfowl Management Plan. The 60-year history of DU features the integration of hydrology, engineering, and biology. It also features extensive work with private landowners with results that can be seen on over 7 million acres of the landscape. The Western Regional Office of Ducks Unlimited will take the lead for this managing this project.

The Program in Environmental Sciences at the University of Washington is the only facility in the Northwest offering training and graduate degrees in system dynamics and STELLA simulation. Professor Ford has just published a book treating such uses. Much of the work has addressed regional environmental issues.

The USGS’ Mid Continent Ecological Science Center has a long history of western land use, watershed and biosystems analysis. Its early applications were responding to the new requirements of NEPA and ESA as the Western Energy Land Use Team of the US Fish and Wildlife Service (the developer of HEP and other models), later as the NBS lab addressing 17 river basins using spatial and numeric data basis in collaboration with EPA. Most recently as MESC, the lab has focused on river basin and ESA-related data management, particularly on interactive Web sites under the Technology Applications Team directed by Don Hunters. MESC has developed customized analytic procedures using the Web as the delivery platform (with many GIS applications) for issues faced by various USDI bureaus.

Sampsel Consulting Services is a leading trouble shooting, conflict resolution, and facilitation provider for the Fish and Wildlife Program. It has served in these capacities since the inception of the Program and has particularly strong contacts with the Tribal governments and leaders in the Columbia Basin. Reflecting this history and the perspective it offers, services can be characterized by fidelity to the larger context and regional history (understanding the big picture) to generate appropriate solutions as individual programs become focused on increasingly discrete issues. These will be the skills required as watershed programs become more numerous, dispersed and complex.

The Nez Perce and Yakama Tribes have long experience in the FWP and each has managed early watershed programs. They offer the skill and experience mix as well as the variety of landscapes (particularly watersheds dominated by mesic forest and semi-arid rangeland uses, as well as agriculture) needed to test and quickly leverage the integrated planning technology suggested in this proposal.

Table 2 outlines the team leaders and their responsibilities. Detailed descriptions are given in attached CVs. The leaders will mobilize the additional human resources at their disposal as needed (incorporated in the budget calculations).

Table 2. The Project Team (tentative and will not include all for first phase)

Organization/Location	Lead(s)/%FTE[2]	Responsibilities
Ducks Unlimited, Sacramento CA	Dr. F. Reid - 33 A. Engilis, M. Biddlecomb - 33 Robert Charney - 40 Dr. S. Berwick - 85	Project management Biological Restoration Restoration Engineering Workshop facilitation Restoration/construction
Nez Perce Tribe Lapwai ID and Enterprise OR	Si Whitman Don Bryson Ira Jones[3]	Watershed Lead, workshop, implementation contracts
Yakima Indian Nation, Toppenish WA	Tom McCoy Dr. Bill Bradley	Watershed Lead, workshop, implementation contracts
Salish-Kootenai, Pablo MT	Joe Dos Santos	Watershed Lead, workshop, implementation contracts
USGS/MESC	D. Hunter - 20	Data acquisition/mgt
Sampsel Consulting Services	R. Sampsel - 20	Facilitation, Tribal liason
Washington State Univ, Spokane, WA	Dr. A. Ford - 25	Systems plan and simulation

SECTION 10. Information/Technology Transfer

Workshops will be conducted to yield models for implementation of habitat restoration. Results will be placed on the web for concensus building among stake holders. Watershed data and models (run versions) will be available on the web for interactive use. This is the current thrust of MESC work for USDI client offices. DU will oversee habitat restoration work. DU has a rich history of publication of lay, educational, extension (e.g. Valley Habitats), and technical literature. The Ducks Unlimited

[2] based upon a 2000 hour year
[3] the tribal participation has been costed at one FTE for each of twoSub-basins plus support.

Magazine (see appended description of Northwest Projects) is a recognized conservation forum and source of information/education.

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Ph.D. (Fisheries and Wildlife ‘89) - Univ of Missouri

Nearly 20 years experience with wetland and waterbed management, especially on migration and wintering areas. Major research and extension effort in moist-soil and green-tree reservoir management in Midwestern and Western wetlands. Specific experience in western North America includes Central Valley of California; Klamath Basin; high altitude wetlands of Arizona, New Mexico, and the northern Sierras; revering Wetlands of the Rio Grande, Pecos, Snake, and Colorado; alkaline wetlands of the Great Salt Lake and Mono Lake; coastal wetlands of Oregon and California; wetland complexes associated with Innoko-Iditarod, Copper, and Yukon-Black Rivers, North Slope and Lake Iliamna in Alaska; and tropical freshwater wetlands on the Hawaiian islands. International experience includes advice on wetland management or research projects in Canada, Mexico, Sweden, Lithuania, Belarus, Ukraine, Russia, New Zealand and Viet Nam.

Results of research published in over 45 papers and presented in over 40 scientific meetings and 90 wetland management workshops. Invited lecturer at 23 Universities and colleges in North America. Consulted on waterbed or water regime management for 92 National Wildlife Refuges, 110 state wildlife areas (in 44 states), 29 National Forests, 45 other federal (COE/TVA/NPS/BLM) and 25 private (DU/TNC/Audubon) wetland areas. Advised 128 private duck clubs in 12 states on water, vegetation invertebrate management techniques (1981-97). Remote sensing work completed in several major wetland complexes of Alaska and California, mapping more than 60 million acres of landcover. Formally a visiting assistant professor in the Biology Department at Southeast Missouri State and a postdoctoral fellow in wetland ecology at the University of Missouri, I am currently the director of conservation planning of Ducks Unlimited for western North America.

ABBREVIATED VITAE

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Education*:*
B.S. Fish & Wildlife Management, Utah State University 1989
M.S. Wildlife Management, University of Alaska Fairbanks, 1992

Employment:

1995-present:	Regional Biology, Ducks Unlimited, Inc.
1992-1995:	Resource Area Biologist, Bureau of Land Management, NV
1989-1992:	Graduate Research Assistant, Univ, Alaska Fairbanks
1988:	Biological Aide, Bureau of Land Management, NV
1987:	Conservation Aide, Nevada Division of Wildlife

Professional Societies:
The Wildlife Society
Society of Wetland Scientists
Cooper Ornithological Society

Summary:
Current responsibilities include delivering the DU MARSH wetland restoration program and DU's conservation easement program in Alaska, Idaho, Nevada, New Mexico and Utah. Experience in range management, threatened and endangered species management, tundra, wetland, and Great Basin desert ecosystems.

Andrew Ford
Program in Environmental Science and Regional Planning
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Education

DE 1976	Doctor of Engineering, Program on Public Policy and Technology, Dartmouth College, Hanover, NH
MS 1968	Applied Mathematics, Harvard University, Cambridge, MA
MS 1967	Applied Science, University of California, Davis, CA
BS 1966	Electrical Engineering, University of California, Davis, CA

Academic & Professional Appointments

1992-1997	Associate Professor, Environmental Science, Washington State University
1985-1992	Associate Professor, Systems Management, University of Southern California
1982-1985	Staff Member, Energy Technologies and Policy, Los Alamos National Laboratory
1982	Sabbatical, Corporate Planning Department, Pacific Gas and Electric Company
1975-1982	Staff Member, Energy Systems and Economics, Los Alamos National Laboratory

Selected Publications

A. Ford, “System Dynamics and the Electric Power Industry.” System Dynamics Review, Spring 1997.
A. Ford, “Testing the Snake River Explorer,” System Dynamics Review, Winter 1996.
A. Ford “Electric Vehicles & the Electric Utility Company,” Energy Policy, July 1994.
A. Ford M. Bull and R. Naill, “Bonneville’s Conservation Policy Analysis Models,’ Energy Policy, April 1987.
A. Ford, Building System Dynamics Models of Environmental Systems, draft textbook, forthcoming, Island Press.
A. Ford, “A New Look at Smaller Power Plants,” special collection of articles in Environmental, March-June 1980.

Biosketch

Dr. Ford’s research concentrates on the use of simulation modeling to aid in policy analysis of environmental problems in the west. He is especially interested in the utility companies that manage our electric power and water infrastructure.

He is best known for many years of work to improve the way computer simulation models may be used in the electric power industry. His doctoral research focused on financial and environmental problems of the nation’s investor owned utility companies. His research and consulting has been supported by a variety of large organizations such as the Bonneville Power Administration, the California Institute for Energy Efficiency and the Southern California Edison Company. His work has also been supported by smaller clients such as the Attorney General of New Mexico and City El Paso.

Dr. Ford publishes in a variety of energy journals (such as Energy Policy) and methodological journals (such as the System Dynamics Review and Operations Research). His Operations Research article on the uncertainties in the northwest electric system was honored with the 1996 Jay W. Forrester Award, the highest academic award in the field of System Dynamics Society, and he is the Managing Editor of the System Dynamics Review.

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Education:

1974 B.S. Biology
University of Tennessee
Tennessee Technological University

1977 M.S. Wildlife Ecology
Tennessee Technological University

1997 Ph.D Candidate
Colorado State University

Experience:

1987-Present <u>Ecologist</u> Leader, Technology Applications Team (TAT) Midcontinent Ecological Science Center (MESC)
As leader of TAT, I manage an R&D laboratory and guide the work of specialists in ecology and information technology. My work blends ecology and advanced information system development, building applications directed at ecological issues confronting conservation agencies. With an area specialty in Asia, about 25% of my time is devoted to international studies.

1981-1987 <u>Ecologist</u> Rapid Assessment Methods Group U.S. Fish and Wildlife Service
This position was the foundation for my GIS experience. I helped develop GIS-based computer techniques and methods or conducting environmental assessment and land use plans.

1978-1981 <u>Environmental Specialist</u> Bureau of Land Management
I assured environmental compliance of land use activities on the Burley District (approximately 3 million acres) located in South central Idaho. As Team Leader of an interdisciplinary group of resource specialists, I supervised the preparation of land use plan /EIS. This job provided a unique exposure/education in range ecology and the land use planning process.

1977 <u>Environmental Specialist</u> Tennessee Department of Transportation
I conducted ecological assessments to determine the effects of proposed highway construction on aquatic and terrestrial ecosystems. Data gathered from field studies were independently assessed and included in environmental impact statements. The job required interagency coordination and a working knowledge of endangered species (plant and animal) and environmental laws and regulations.

Technical Publications:

Jackson R. and D. O. Hunter. 1996. Snow leopard survey and conservation handbook. International Snow Leopard Trust, Seattle, WA. pp.

Hunter, D. O. and R. Jackson. 1996. A range-wide model of potential snow leopard habitat. In proceedings. Eight International Snow leopard Symposium.

Hunter, D. O. et,al. 1995. Project show leopard-a model for conserving central Asian biodiversity. In Proceedings, Seventh International Snow Leopard Symposium.

Hunter, D. O. 1992. GIS (GRASS) aids wildlife studies in India. In press, Proceedings National Park Service GIS Conference. NPS Denver Service Center, Denver, CO.

Hunter, D. O. 1991. Science and spirit: GIS tracks the elusive snow leopard. Geo Info Systems, January 1991. Aster Publishing Corp., Eugene, OR pp 20-28.

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Education:

BA, Portland State University

Experience:

Assistant to the Secretary of Interior, USDI

Founder of the Columbia River Inter-Tribal Fish Commission

Project Manager for the Yakima/Klickitat Production Project for the Yakama Indian Nation

Senior Tribal Liason to Northwest Power Planning Council, Federal Agencies, and states of Washington, Oregon, Idaho for implementation of the Columbia River Fish and Wildlife Program

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EDUCATION

Ph.D. Ecology, Yale University, 1974
M.Phil. Yale University, 1972
M.S. Wildlife and Range Management, University of Montana, 1968
B.A. Zoology, University of California, Berkeley, 1966

SUMMARY OF EXPERIENCE

Dr. Berwick, Director of WILD Systems, is a senior ecologist who has carried out numerous environmental impact assessments, resource harvest feasibility studies, field research projects, and training workshops for USAID, the World Bank, the U.S. Department of Defense, Universities, and private sector clients. Recent work has focused on bridging difficult issues of private property management and environmental protection. These efforts have led, for example, to Habitat Conservation Plans in the Pacific Northwest, protected area/land use planning in the former Soviet Union, and assessments of dams in a biologically unexplored area of Laos.

PROFESSIONAL EXPERIENCE

1991 - present. Director, WILD Systems Ecologist for a policy and technical development group addressing mitigations of 50 years of hydroelectric development in the Columbia River basin of the western United States, resource development, nature-based tourism development and Endangered Species Act issues for American Indian Tribes, private landholder issues, and biodiversity/protected area planning for the World Bank. Since 1991, work for the World Bank has focused on land use planning and protected area design to enfranchise strict nature preserves in the Former Soviet Union and Central Europe. A recent evaluation of wildlands to be impacted by one of the largest dams in Asia dealt with poorly known areas of high biodiversity in Laos.

1990 - 1991. Planner and ecologist, Development Alternatives, Inc.
1989 -1990, Senior Vice President -- Wildlife Systems Division, International Resources Group
1985 - 1988, Chief Scientist, North American Office – International Institute for Environment and Development
1983 - 1985 Director, Environmental Planning and Management Project , IIED
1980 - 1983 Chief Scientist, Sciences Division -- Henningson, Durham & Richardson
1974 - 1980 Assistant Professor of Wildlife Ecology and Management -- Yale University
1972 - 1974 Assistant Professor - Texas A&M University, Department of Wildlife and Fisheries Sciences
1969 - 1971 Research Manager in India -- Smithsonian Institute, Washington, D.C.
1966 - 1967 Montana Department of Fish and Game, Missoula, Montana

PUBLICATIONS

Dr. Berwick has authored or edited three books and over 35 articles on various technical topics in such fora as the New York Times, American Scientist, and publications of the professional Wildlife Society. Recent publications include a book on Wildlife Techniques (Oxford Press), articles on international development behavior, the Global Environmental Facility of the World Bank/UN, and an ecosystem model simulating policies for managing a game ranch (The Wildlife Society). Other publications include:

Berwick, S. and V. B. Saharia (eds.). 1995. The development of international principals and practices of wildlife research and management. Oxford University Press, Delhi. 481 pp.

Berwick, S., 1987. Integrated Planning Technology: a new policy analysis technique for resource planning. *Tropical Coastal Area Management ICLARM*, Manila, 2(1):10-11.

Berwick, S., A. Bond, and A. Schumacher, Jr. 1995. Wildlife and parks in Eastern Europe and the former Soviet Union. *In* Bissonette, J.A. and P. R. Krausman (eds.). 1995. Integrating people and wildlife for a sustainable future. The Wildlife Society, Bethesda, MD, USA: 107-110.

Berwick, S. and R.S. Brightman, 1995. Extrapolating from the American experience in environmental impact assessments - problems and opportunities. In Berwick, S. and V. B. Saharia (eds.), 1995. The Development of International Practices and Principles of Wildlife research and Management: Asian and American Approaches. Oxford University Press, Delhi,