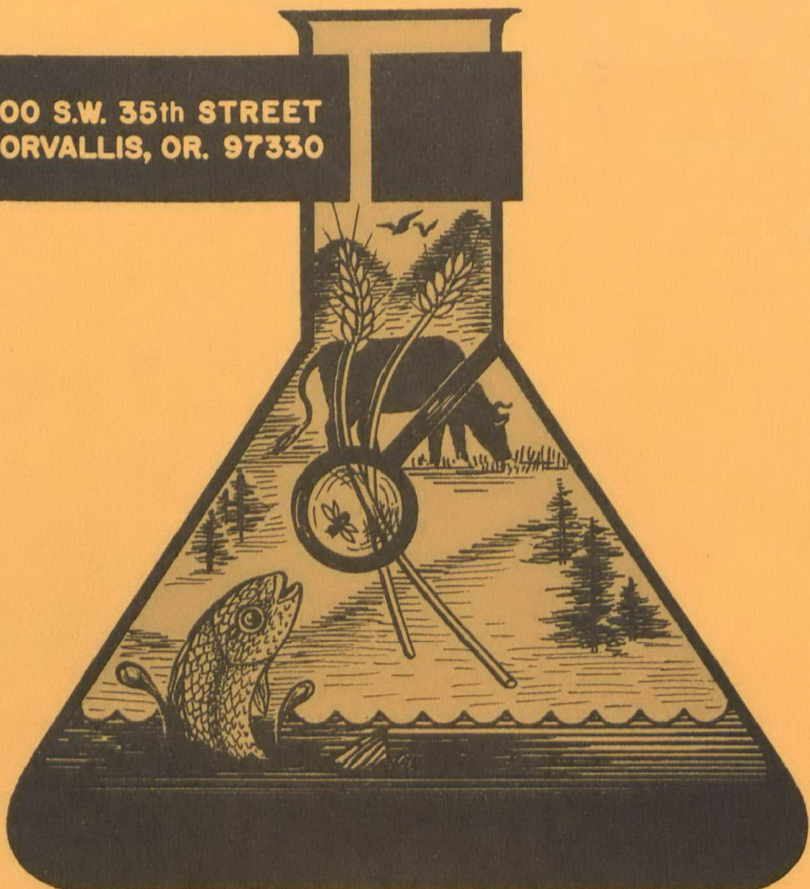
THE COLSTRIP, MONTANA CFPPP

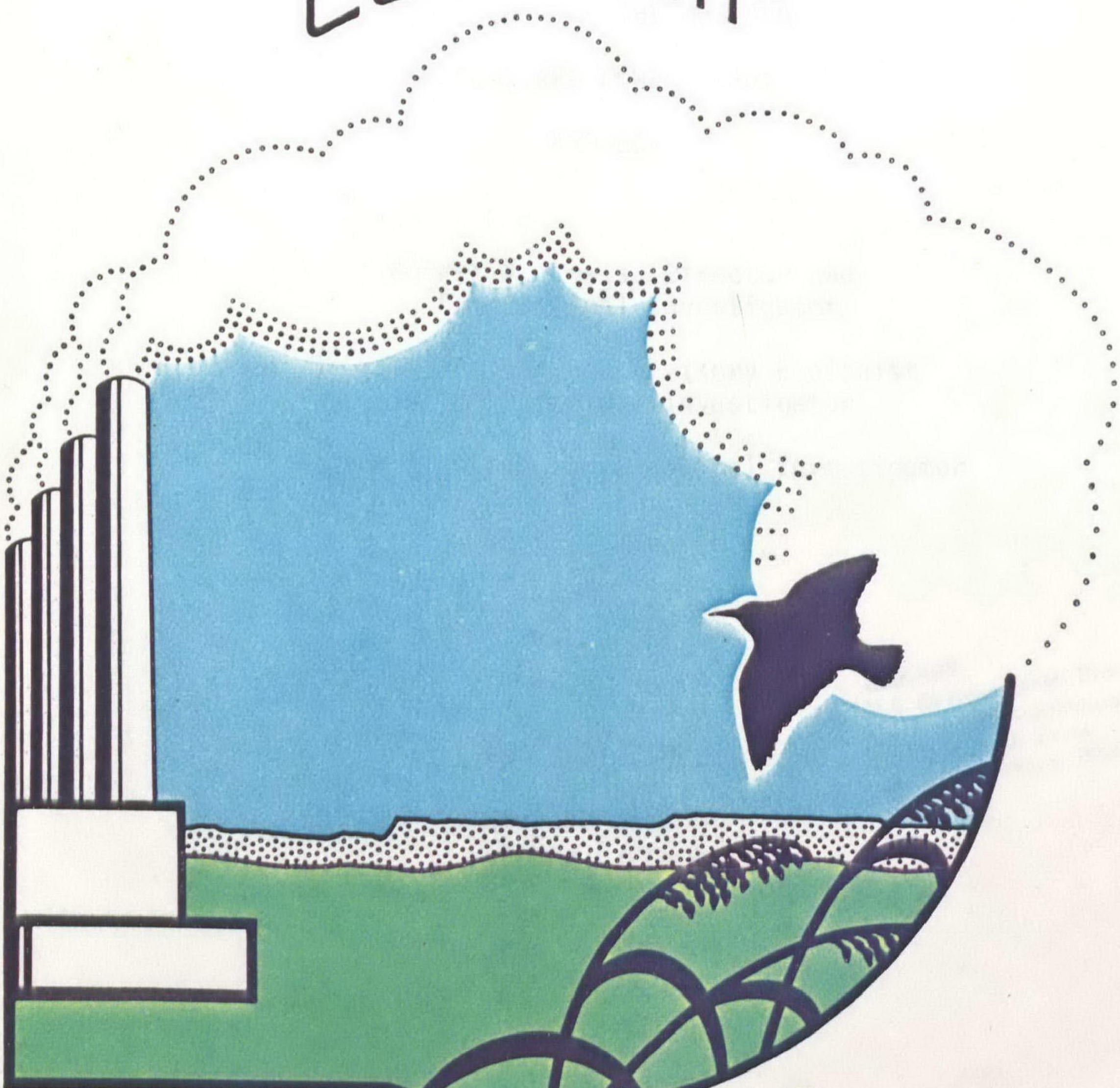
Corvallis
Environmental
Research
Laboratory

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
200 S.W. 35th STREET
CORVALLIS, OR. 97330



Workshop - 76
Summary

COLSTRIP



CFPPP

OFFICERS OF THE MONTANA

COAL-FIRED POWER PLANT

PROJECT

Robert A. Lewis, Director and
Co-principal Investigator

Eric M. Preston, Supervisory Ecologist
and Co-principal Investigator

Norman R. Glass, Co-principal Investigator

ADVISORY COUNCIL

Jerrold Dodd
Sharon Eversman
C. C. Gordon
Robert A. Lewis
Eric M. Preston
John E. Taylor

THE MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP '76

Corvallis, Oregon, November 1-4, 1976

CONTENTS

CONTRIBUTORS TO WORKSHOP '76

Clyde Bogel
W. J. Kerr Library
Oregon State University
Corvallis, OR 97331
503-754-2840

Jerry Bromenshenk
Department of Botany
University of Montana
Missoula, MT 59801
406-243-2671

Lee Callahan
Corvallis Environmental Research Laboratory
Ecological Effects Research Division
200 SW 35th Street
Corvallis, OR 97330
FTS-8-420-4671 or 503-757-4671

John Chilgren
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS-8-420-4667 or 503-757-4667

James Clapp
Institute for Environmental Studies
University of Wisconsin
WARF Building, 610 Walnut
Madison, WI 53706
608-263-4789

Eric Crecelius
Battelle Marine Research Laboratory
Route 5 Box 1000
Sequim, WA 98382
206-683-4151

Jerrold Dodd
Natural Resource Ecology Laboratory
Colorado State University
Fort Collins, CO 80521
303-491-5571

Sharon Eversman
Department of Biology
Montana State University
Bozeman, MT 59715
406-994-3231 or 994-4548

Donald Farner, Chairman
Department of Zoology
University of Washington
Seattle, WA 98195

James Gillett
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330

Norman R. Glass
Corvallis Environmental Research Laboratory
Ecological Effects Research Division
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4671 or 503-757-4671

C. C. Gordon
Dept. of Botany
University of Montana
Missoula, MT 59801
406-243-2671

Thomas Gullett
Corvallis Environmental Research Laboratory
200 SW 35th Street
Corvallis, OR 97330

Don Hernandez
Corvallis Environmental Research Laboratory
Criteria and Assessment Branch
200 SW 35th Street
Corvallis, OR 97330

Susan Jones
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4727 or 503-757-4727

Daniel Krawzyk
Corvallis Environmental Research Laboratory
Laboratory Analytical Support Staff
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4639 or 503-757-4639

Frances Kreitzer
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330

William Lauenroth
Natural Resources Ecology Laboratory
Colorado State University
Fort Collins, CO 80521
303-491-5571

Jeffrey Lee
Corvallis Environmental Research Laboratory
Ecosystems Modeling and Analysis Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4758 or 503-757-4758

John W. Leetham
Natural Resources Ecology Laboratory
Colorado State University
Fort Collins, CO 80521
303-491-5571

John LeHuray
Corvallis Environmental Research Laboratory
200 SW 35th Street
Corvallis, OR 97330

Wayne Leininger
Dept. of Animal and Range Sciences
Montana State University
Bozeman, MT 59715
406-994-3271

Robert A. Lewis
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4836 or 503-757-4836

Bruce Lighthart
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4832 or 503-757-4832

J. D. Ludwick
Battelle Pacific Northwest Laboratories
Battelle Boulevard
Richland, WA 99352

Craig McFarlane
U.S. Environmental Protection Agency
Pollutant Pathways Branch
P.O. Box 15027
Las Vegas, NV 89114
FTS 8-595-2969

G. T. McNice
Wave Propagation Laboratory
Nat. Oceanographic and Atmospheric Admin.
Boulder, CO 80302
FTS 8-323-6569

James Miller
Corvallis Environmental Research Laboratory
Laboratory Analytical Support Staff
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4726 or 503-757-4726

Bruce Murray
University of Wisconsin
WARF Building, 610 Walnut
Madison, WI 53706
608-263-4789

Gordon Orians
Department of Zoology
University of Washington
Seattle, WA 98195
206-543-1658

Ernest Peterson
Department of Atmospheric Sciences
Oregon State University
Corvallis, OR 97331
503-757-4557

Eric Preston
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4636 or 503-757-4636

Karen Randolph
Corvallis Environmental Research Laboratory
Office of Public Affairs
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4792 or 503-757-4792

James States
Ecology Consultants Inc.
P.O. Box 2105, 1716 Heath Parkway
Fort Collins, CO 80522
303-493-8878

David Swift
Natural Resources Ecology Laboratory
Colorado State University
Fort Collins, CO 80521
303-491-5571

John Taylor
Dept. of Animal and Range Sciences
Montana State University
Bozeman, MT 59715
406-994-3721

Robert Terrell
University of Wisconsin
WARF Building, 610 Walnut
Madison, WI 53706
608-263-4789

Theodore Tibbits
University of Wisconsin
WARF Building, 610 Walnut
Madison, WI 53706
608-263-4789

Bruce Tichenor
Corvallis Environmental Research Laboratory
Criteria and Assessment Branch
200 SW 35th Street
Corvallis, OR 97330

David Tingey
Corvallis Environmental Research Laboratory
Terrestrial Ecology Branch
200 SW 35th Street
Corvallis, OR 97330
FTS 8-420-4621 or 503-757-4621

John Van Sickle
Corvallis Environmental Research Laboratory
Ecosystems, Modeling and Analysis Branch
200 SW 35th Street
Corvallis, OR 97330

Charles Van Valen
N.O.A.A.
Environmental Research Laboratories
Boulder, CO 80302

Daniel Willard
Institute for Environmental Studies
University of Wisconsin
Madison, WI 53706
FTS 8-262-1234, ask for 3-4787

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

SUMMARY OF AN INVITED PRESENTATION ON

THE QUILLAYUTE MONITORING STATION

by

J. D. Ludwick

An air reference station has been established at Quillayute, WA (Lat: 47°-56', Long: 124°-34'), on the west coast of North America, to monitor concentrations of gaseous and particulate pollutants in air that is relatively unaffected by local or regional sources. A preliminary study determined Quillayute to be the best of a number of possible sites for the accomplishment of this objective. Air that reached Quillayute after a trans-Pacific trajectory should be well mixed, with the influence of specific sources, or source areas, essentially washed out.

The site is located about 5 km from the ocean at an elevation of 62 meters. The fetch to the westward is unobstructed. An air sampling stack was constructed at the site through which almost all air sampling and monitoring is accomplished. It is 32 m above the ground with a 15 cm diameter. An in-line filter housing was designed to fit near the bottom of the stack for particulate measurements. A high volume pump (2.25 m^3/min) established a linear velocity of 760 m/min across the face of an IPC filter for high efficiency collection. A "Y" joint located just upstream of this filter diverted air for other monitoring and sampling purposes. These are summarized in Table I.

Simultaneous records of O_3 and upper atmospheric source radionuclides are available for comparison from this station. These have been examined for similarities that might indicate common atmospheric processes involved in their transport to Quillayute, and thus that a significant portion of the O_3 being measured is also stratospheric in origin. Important correlations have been observed between many of these materials. There are also apparent relationships between changing concentrations and meteorological parameters. Interesting fluctuations in the ozone levels with incoming clean air masses may help explain some of the high ozone levels observed by workers elsewhere. Positive correlations between certain known high altitude source region particulate radionuclides and ozone on a daily basis point to the upper level origin of the higher ozone concentrations observed at this site. This view is reinforced by the more usual negative correlations observed between many of these particulate levels at Quillayute and ozone concentrations when monitored continuously.

Ozone concentrations in the clean air environment often exceed 40 ppb for extended periods of time and have been documented at 60 ppb during periods of downwind movement of upper level air.

TABLE I

SAMPLING AND MONITORING CAPABILITY

CONTINUOUS MONITORING		100 ft. Stack
•Ozone	Sensitivity	1 ppb
•NO_2, NO	"	1 ppb
•CO	"	50 ppb
•Methane	"	5 ppb
•Total Hydrocarbons		5 ppb
•Condensation Nuclei		<100
STABLE ELEMENTS		
•Daily 300 m^3 Particulate Samples X-Ray Fluorescence-Neutron Activation Gamma-Ray Analysis		100 ft. Stack (80 cfm)
RADIONUCLIDES		
•Weekly 25,000 m^3 Particulate Samples Radioisotope Identification		40 ft. Stack (600 cfm)
PARTICULATE SIZE DISTRIBUTION		
•Weekly 40 m^3 - 7 Stage Impactor Radionuclide Analysis		Ground Level (40 cfm)
•Weekly 40 m^3 - 7 Stage Impactor Neutron Activation Analysis		100 ft. Stack (1 cfm)
DEPOSITION STUDIES		
•Wet and Dry Fallout Collector Special Studies Analysis		
SPECIAL SAMPLING		
•SO_2 Clean-Air Samples Collected On-Shore Flow Periods		100 ft. Stack

THE MONTANA COAL-FIRED
POWER PLANT PROJECT

WORKSHOP 76

GUIDELINES FOR THE WORK GROUP ON
THE SCIENTIFIC (HYPOTHETICAL) FRAMEWORK OF THE PROJECT

It is not possible to establish or evaluate team objective unless they share the same hypothesis! Individual task objectives must be tested not only against the project objectives, but against a project level working hypothesis as well.

Provisional Objectives

1. To establish a scientific framework and rationale for the investigation.

2. To develop, if possible, a unifying (biological) hypothesis or set of related hypotheses that will give the project scientific coherance and validity as an investigation in its own right.

3. Identify the hypotheses that we are now testing (or have been testing during the preoperational phase of the study).

   1) Are these useful hypotheses?
   2) Are they moving us toward the achievement of our mission?
   3) What constitutes a valid test of each of these hypotheses?

4. In what areas of our program have we failed to follow sound scientific or conceptual approaches? What are the remedies?

5. Most of us agree that a broadly mechanistic or functional approach is desirable (or indeed, required) in this investigation. Delineate the real advantages (and need) for such as well as the disadvantages.

6. What changes in perspective and in "scientific method" are required if we are to satisfy our mission?

Suggested Products

1. A formal rationale and statement of the working hypothesis (together with corollary hypotheses), and suggested tests and application of these.

2. Restatements of this hypothesis for each task and conceptual models for each task based on this hypothesis.

Products

Methods can be developed to predict, prior to actual expression of damage, the relationship between pollutant concentrations and bio-environmental effects.

Assumptions:

1. Air pollutants are the major contributors to damage (defined as negative changes in the system's component processes).

2. The source terms can be defined in relationship to power plant outputs, meteorological and climatologic factors, soil chemistry, energy inputs, and a mathematical model incorporating these factors.

3. A quantitative inventory of the temporal and spatial components, with particular focus on annual cycle phenomena of key species, will reveal sensitive or vulnerable components (systems, processes, species) responsive to pollutants, if such study were conducted on areas subjected to known levels of insult.

4. Methods, such as remote sensing, indicator species inventories, etc., can be integrated in terms of relationships to critical processes and/or components.

5. The relationships can be described by mathematical models of systems and processes.

6. Results of laboratory studies of single species subjected to controlled exposures of pollutants can be related through physiological, biochemical, or physical mechanisms, to effects observed in field studies under known pollutant challenge.

7. Parameters of mathematical models of field studies can be obtained under controlled laboratory conditions.

8. Statistical processes are applicable to analysis of changes observed in controlled exposure of field plots.

9. Secondary or alternate stressors (disease, physical factors, mutational, environmental and other agents) can be discerned as definable interactions and similarly quantified as modifiers of pollutant relationships.

10. The nature of the relationships of pollutant and effect will be a function of the character of the exposure set.

11. The impact of a pollutant may involve disposition (temporal or spatial) other than that derived directly from the source term and is describable in relation to the source term and base line environmental factors.

12. Indirect effects can be detected and linked to pollutants by laboratory experiments and/or correlation of such effects with known pollution gradients.

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP '76

PROTOCOL DEVELOPMENT WORK GROUP

The goal of this work group was to "lay the basis" for the development of a Coal-fired power plant siting protocol. We felt it inappropriate, because of time constraints, to attempt to develop the protocol itself. The work group developed the following concepts and ideas:

<u>Scope</u>: The protocol for the Colstrip project will be a segment of a "total" energy facility siting protocol.

This segment should be limited to assessment of the biological effects of CFPP emissions on terrestrial ecosystems (native and nonnative) of the Northern Great Plains. It should:

1. be generally applicable to all terrestrial ecosystems of the region, the Colstrip project providing a specific example of application.

2. when applied, produce biological effects information useful in the total siting decision making process.

3. be developed in such a manner that it will interface with complementary protocol segments on socioeconomic, land use, engineering, political, and other aspects of the siting problem to form a total protocol for CFPP sitings.

Several assumptions (stated and unstated) are inherent in the above constraints and should be considered in the development of the "final" biological effects protocol:

1. Implementation of the protocol should be predictive (i.e., useful in forecasting future impacts).

2. The data provided by the protocol should be in a form that is useful to the decision makers. Data such as:

   -bushels of alfalfa destroyed
   -board feet of timber lost
   -number of trees damaged
   -acres of habitat lost

   would provide immediately useful information. Data such as: species diversity, biomass affected, number of insects per hectare, distribution of rodents, etc. do not convey information useful to the non-scientist. The protocol must include a mechanism for "translating" information into non-technical language.

3. The output of the protocol should be available to decision makers at all levels (local, regional, state, Federal) in the socio/political spectrum.

4. The protocol segment should be developed in cooperation with other research groups to provide effective interfaces with other segments (i.e., socioeconomic, land use, engineering, water use, etc.). Communication with these "other groups" is important at the formative stages of the protocol development process.

5. The protocol should provide for the evaluation of alternatives. Alternative site locations, facility sites and pollution control technologies all need to be evaluated.

6. The protocol should be amenable to "step wise" application. The following temporal pattern should be followed in the decision making process:

   a. Background assessments should be conducted on numerous sites with limited field data supplemented by existing literature.

   b. For a few sites with favorable characteristics, a Selection Assessment should be conducted, involving a more rigorous field investigation.

   c. For the site selected, a Pre-Construction Assessment should be conducted, including a complete and comprehensive field survey.

   d. Finally, a long term Operation Assessment should be conducted to verify impact predictions and determine multi-year ecological effects.

7. The bio-effects protocol segment developed for the CFPP (Colstrip) project whould consist of three "sub-segments" or modules:

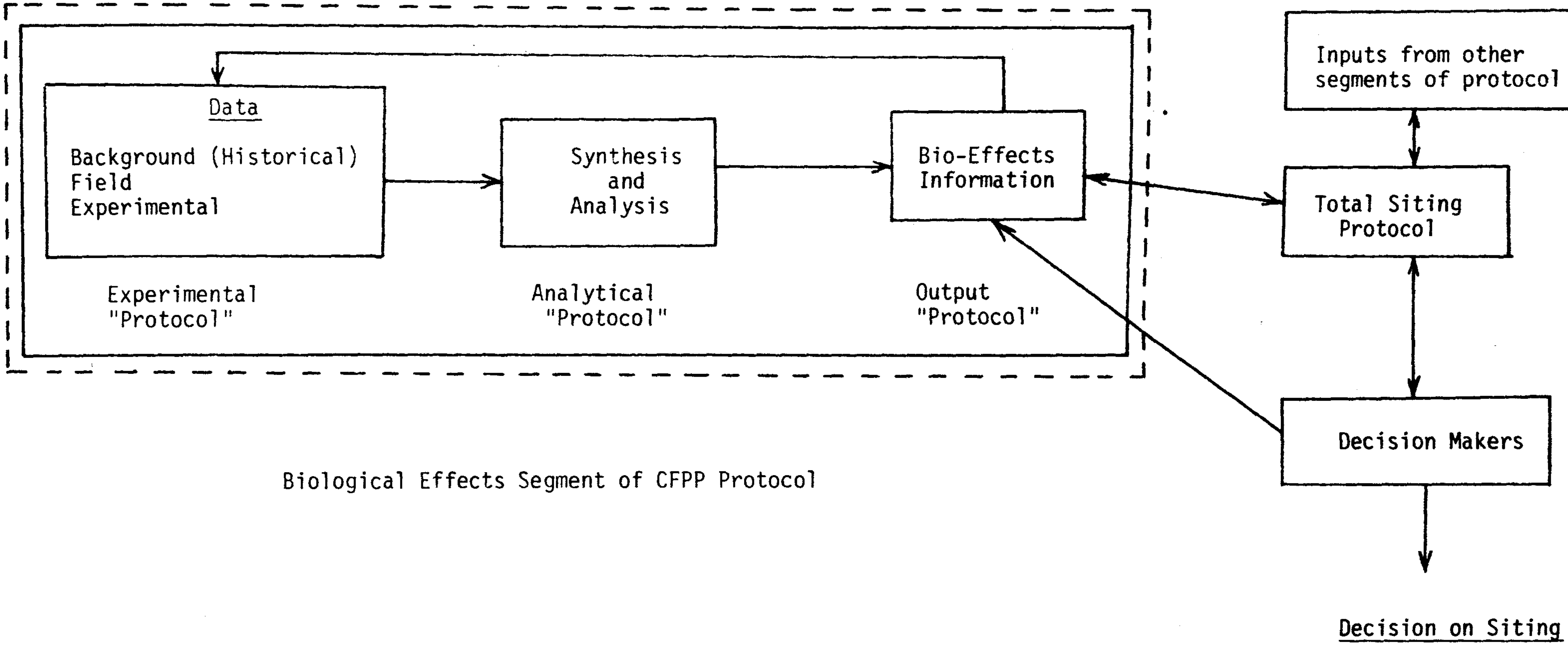
   a. Experimental Protocol - define data collection requirements and procedures.

b. Analytical Protocol - define data handling and synthesis requirements and procedures; recommend physical and biological modeling activities.

c. Output Protocol - define how bio-effects information should be presented to the decision makers (i.e., put it in terms he/she can understand); define how "values" can be placed on ecosystem effects.

8. The protocol must provide feedback mechanisms, both internally and externally. Internally, project personnel should be able to assess outputs and require further information. Externally, decision makers should be able to acquire additional data or clarification of existing information; other protocol segments may also need new or improved bio-effects data.

The assumptions, ideas, and concepts are expressed schematically in the following sketch:



Conceptual model of biological effects segment of CFPP protocol and its relationship to total siting protocol and the decision making process.

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP 76

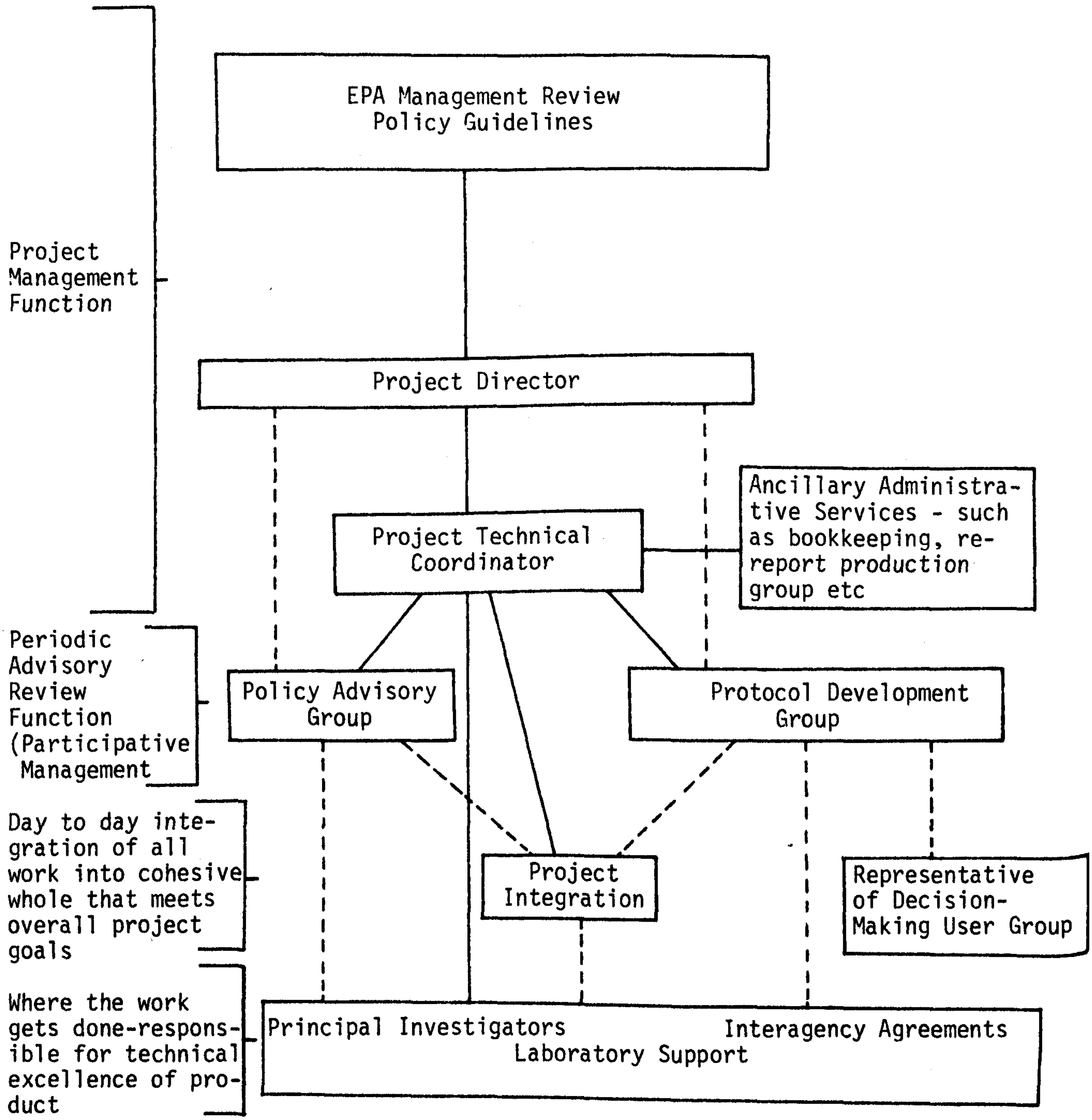
PROJECT MANAGEMENT WORK GROUP

Introduction

Members of this group were not managers on this project so we began with few project-related preconceptions about how it is being or should be managed. At the outset, Bob Lewis was asked to provide a basic explanation of current project organization and an overview of the functions served by key people in that orginization. In the early rounds the ensuing discussion, general agreement was reached that by virtue of distances between project participants, travel restrictions, and the history of the project there seemed to be an overriding need for forcing the information exchange and project integration which is critical to achieving the project mission. With this as a starting point the work group went on to identify a new organization structure by which these important interactions could be made to happen. Finally, specific suggestions were given as to how each structural element in the organization might function so as to facilitate (drive, manage) the necessary interactions and to resolve specified problems.

A. Suggested Project Organization

The following diagram illustrates the organization structure and relationships between its elements which is perceived by the work group as providing the necessary project management framework:



Note: Solid lines represent chain-of-command one way lines of responsibility; dotted lines represent coordinative, integrative and information flow responsibilities. 2-way possible arrowheads

B. Organization Characteristics

Once the above structural framework had been agreed upon, the remainder of work group time was spent in elaborating the characteristics of each structural element, especially with regard to "forcing functions" and strategies by which the critical flow of information (which makes the essential difference between separate units doing their own things, and a cohesion of units meeting the overall goals of the project) can be made to happen. In essence the function of good project management is to see that manpower is distributed among the separate tasks in a way that meets these overall goals. The following is a summary of work group thinking about characteristics of each structural element and related functions which could help to bring this about.

1. Project Director - This is where the day to day decision making must occur. Although the effectiveness of his decisions may be reviewed by upper management, he must have the authority to make and act upon his decisions prior to that review. Thus, the buck stops on the Project Director's desk and this is perceived by all others involved in the project. It will be critical to his function that he participate in the two advisory groups in their periodic meetings and that he be involved in day to day functions to maximum extent possible through daily contacts with his technical coordinator and project integration group.

2. Project Technical Coordinator - This could be one or more individuals having clearly defined (delegated) responsibilities for field activities and project administration. This "box" and the project

Director should work with the other groups, especially the integration group and the investigation team, in such a way they can provide administrative "backup" for each other. A problem noted by several grantees is that on a number of occasions they have been unable to contact either for extended periods of time, discouraging future attempts. It is recommended that a clear understanding be established as to who in the Corvallis office is available to answer questions or to initiate the question answering process at all times. The perception must be created on the part of investigators that any and every call by them to the Corvallis office will initiate the feedback they need in a timely fashion. (Make sure this is fully understood by the people answering telephone!)

3. Project Integration - This is the most critical and urgently needed "box" identified by the work group. There was strong feelings that it should be separate from management but highly interactive with management. The "box" should be manned by system analysts or modelers who are familiar with information processing and exactly what it takes to identify and effectuate the necessary interactions. At the same time there was concurrence in the group that a special type of modeler was needed, one who would see his fundamental role as integration by explicit mathematical and conceptual simulation models which weave the tapestry of hypotheses to be tested and interactions to be performed in meeting project goals. He should see his function as one of "facilitation" of the work of technical and management teams toward these goals rather than one of creating a grandiose mathematical model which would serve to "direct" the whole project.

It was pointed out that current hiring ceilings and travel restrictions may prevent the most straight forward solution to this "lack of integration" problem--that of hiring into EPA. The work group respectively suggests a single solution to both problems. Contract the work out to a highly competent individual or group (essentially providing a full-time project integration function) with a liberal allowance made for travel. This would enable the person to perform part of his integration function as a "circuit rider" visiting all grantees and checking to see that necessary interactions are occuring. If not, he takes steps to initiate them, under authority (and by whatever process) delegated from project management.

Certain other critical integration functions are suggested for the integration group. It should most effectively take charge of project data received from all groups, seeing to it that the data are ultimately compiled in a single format that is compatible with the needs of all potential users of their data. Similarly this group could take responsibility for the literature-derived data base, periodically seeing that it is updated and that the updates are communicated to other project participants. Particularly, this group should take responsibility to see that if one investigator identifies a new reference potentially of use to another investigator, it is brought to the other investigators' attention.

4. Policy Advisory Group - Another consensus of the project management work group was that the grantees, as the "experts" on the project should have considerable involvement in the

periodic overall technical review and revision necessary to the success of this kind of basic research project. Thus it is recommended that at least quarterly, and more frequently as needed, some of the Principal Investigators should meet with project managers in a policy review forum. This is necessary to establish and maintain the technical cohesion of the project in a "participative management" framework.

5. Protocol Development Group - Just as it was deemed necessary to establish a periodic internal review, it is also recommended that periodically a designated group look outward - toward the ultimate application of the impact assessment protocol being developed. A major concern expressed by all members of the work group is that the project is not adequately provided with input from the potential users of the protocol and the political decision-making framework within which the protocol must be applied. Unless steps are taken to ensure that these external entities are aware of and prepared to use the scientific protocol being developed by the project, the entire effort could come to essentially nothing. Therefore it is recommended that the protocol development group interact with and even include (1) representatives from appropriate state and federal regulatory agencies, (2) industry (and their consultants) which would be the eventual users of the protocol, (3) the general public and (4) environmentalists (who will find far less to object to in the protocol if they have been involved in its development).

C. Forcing Functions

The above discussion deals mostly with a structural framework for project organization and characteristics of important structural components. The motive forces which will cause that structure to function effectively in bringing about project goals is equally important. The following is a brief discussion of some "forcing functions" which were considered.

1. Project Management - Certainly project management is one of the driving forces which needs to be considered. One critical problem identified by the group is an apparent current lack of scheduled information exchanges. It is assumed that a number of investigatory tasks are best performed only with input from separate investigation teams. It is important then, that project management initiate and monitor procedures whereby the necessary information exchanges are identified and will occur on a timely basis. For the above-defined organization structure the scenario might be something like:
   a. Management and integration group undertakes a total project overview, identifying important information exchanges,
   b. Management generates a matrix of information needs and interactions which must occur (to whom?, from whom?),
   c. Matrix is communicated to grantees who are asked, "Given that you need to include information from these groups to complete your part of the project, specifically what information do you need, in what format, and in what time frame?" (There may be several iterations of this step),

d. Management puts together a final critical path schedule for required information exchanges to be sent to principal investigators (could call this an interaction user's document or IUD - for the prevention of failures to communicate). Somewhere in this process, agreement needs to be established on the data format for communication, to facilitate the use of the data by others as well as to insure that they get what they need,

e. Management establishes feedback mechanisms by which any change in schedule is communicated to management, which in turn evaluates how it will affect the schedules of others and communicates this to them. Although this is a management function, much of it can be delegated to the "interaction group."

Another identified problem is that annual reports are too outdated if they are to serve the function of communicating "where we are now" to project participants and other interested parties. It is suggested that some group, possibly under supervision of the Technical Coordinator, undertake to streamline this process. For example, formats should be established and given to investigators before they write their portions of the report. Guidelines should include ways to save space better organizing tables, etc.

2. Integration group - Considerable motive force toward project objectives will result from a project overview and the creation of simulation models by the integration group. It is through this group that the necessary feedback loops between management

and investigators are assumed to function. This need is critical and must be instituted before next field season.

3. Grant Proposals - One of the most effective ways of "arranging for" necessary information exchanges will be to ask for their inclusion in the new proposals which, if approved, will become the new contractual agreements. Thus, all parties agree to such interactions at the outset and make specific arrangements to see that they occur.

4. Policy Advisory Group - A side benefit to participative management, in addition to obvious benefits to the technical quality of the work, will be a kind of group commitment (and if need be - peer pressure) to see that all parties hold up their end of the project so that the overall outcome is of maximum benefit to all.

5. United we stand, divided ... It is critical that all project participants understand and believe that their own self-interest is best served, not by attainment of their goals alone, but by achievement of the overall project goals. A common sense of mission is a critical element in achieving this.

THE MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP 76

PROJECT PLANNING WORK GROUP

Most of the initial discussion centered around the overall project mission, the development of the protocol and its implications for proposed users. It was felt essential that the relative importance of siting criteria and monitoring criteria must be pegged down and understood.

It was suggested that socio-economic impacts may overpower biological concerns. Thus we, as biologists, have to develop a position that not only relates to human needs and perceptions but also is ecologically sound. Decisions about energy development must optimize the balance between these two points of view.

The best approach for us to take is to see that our research is absolutely sound (i.e., high quality research) and that it relates to the concerns of the people who are involved with energy development.

This puts a great deal of importance on the OVERALL CONCEPTUAL FRAMEWORK of the project (q.v.). It is essential that we identify the interrelationships of contributing processes, especially cause-and-effect and threshold indicators. It also is essential that we follow through to subsequent economically important impacts. Obviously important (to laymen) factors must be stressed throughout. For example, lichen damage, although very interesting from a scientific viewpoint, is not likely to greatly disturb a country planning committee. But, if lichen damage is a reliable precursor of decreased grassland productivity, then it is a relevant input to decision-making.

One of the project goals should be a mix of basic ecological and physiological studies to explain why things are happening, with related practical, demonstrative studies showing what is happening, and why it is significant to local biological and ecological systems. The optimum mix will be developed only by concentrating on project goals in terms of the overall conceptual framework. It is critical that we put bounds on the system and identify critical elements, including those we have not yet addressed. A system of assigning priorities to research is crucial. Decisions must take into account things which have worked and things which have not. Also, there should be a balance between administrative criteria and scientific criteria in project direction with scientific predominating.

We feel strongly that the protocol development should be under way immediately. This should be growing as fast as the supporting data base will allow. We recognize that it will take much input from many people to do this properly. We recommend that a new subproject be considered which is specifically directed at protocol development. Further, there should be "strike teams" or miniconferences among certain principal investigators as the need arises. This should be programmed into future project budgets. Also, we need to meet with representatives of state and local governments, industry, and environmental groups to find out what questions they are asking or will ask as future energy developments are proposed.

We recognize that there will be three main products of the Montana CFPP project: The siting protocol, the ZAPS technique, and a set of baseline data for the Colstrip development. Each of these is important, but in some ways they will have to be considered separately.

The protocol is the most sophisticated, and ostensibly the most broadly applicable of the products. It will require validation on a fairly broad scale before its allowable degree of extrapolation will be known. To expand its utility it should include forest and cropland ecosystems; hence these should be added to the CFPP data base.

The ZAPS may become a standard approach to pilot studies of air pollution in natural systems. Thus, it must be very carefully documented throughout. Details of its construction and operation probably will be ready for the technical literature before those of any other program element. This should be a high priority activity.

The baseline data for the Colstrip development will be generated by this project as a fringe benefit of the protocol development. There are other data gathering activities in the area, and it is important that the CFPP data be compatible with them. Further, CFPP data must be available to interested planning personnel. Perhaps the most important aspect of this information is how well it is communicated to potential users.

The remainder of our discussion was devoted to outlining the elements of the biological components of the project which might enter the simulation model. We attempted to identify important system components, and then make some comments about the status of each.

The framework we proposed, while not complete, is shown below. It is a structure of system elements rather than experimental approaches, and includes both existing and proposed areas of study.

I. The Abiota

temperature, air and soil
humidity
wind
sulfur dioxide concentration
NOx
HCO
O_3
particulates
nuclei
solar radiation
precipitation
soil moisture

These data are being gathered by several groups, including a number outside of the project. There is no overall coordination, and there are some overlaps and some gaps. We must use vegetation indicators as much as possible, recognizing that independent variables become filtered in becoming response variables. In particular, we need to know; (a) what is ambient, (b) what is taken up by the system, (c) what are the effects.

II. A. Autotrophs Biota

1. Structure

Population dynamics
  interseasonal changes at individual and organismic levels
Diversity
Phenology
Live vs. dead roots

2. Function

Productivity
Pathology
Phenology
Physiology
 respiration
 metabolic status
 chemical analyses
 photosynthesis
 uptake and translocation of sulfur

We need some more work in these areas, especially in the physiology of pollution. Research topics which would probably be fruitful include photosynthesis, respiration, water relations, carbon budgets, nutrient uptake, changes in protein pools and consequent changes in resistance to stresses (drought, SO_2, winter) and production.

III. Heterotrophs

Small mammals
- population studies
  - diversity
  - dispersion
  - density
  - age structure
- physiology
- endocrinology
- reproductive biology
- anatomy
- histology
- pathology
- diets

Birds

same as above

Livestock

diets
- digestibility of nutrients
- forage availability and utilization
- forage palatability and preference

Native ruminants

histology and pathology

We need more emphasis on large herbivores, especially livestock, since these are the important economic organisms of the area.

Arthropods

Above-ground
- bees
  - population dynamics
  - distribution
  - physiology
  - pathology

other "beneficial" and "detrimental" forms

difficult to study, but of lay interest

ground beetles

numbers, kinds, changes, physiology

Below-ground (soil) macro- and microarthropods

It would be interesting to study microflora and microfauna in relation to decomposition cycles.

Nematodes

characterization of roles; changes due to pollution.

Summary

In reviewing our proposals for additional research it is clear that physiological studies are of high priority. Insect investigations probably should be beefed up, but there are problems in doing so (population diversities, taxonomic difficulties, sampling procedures, etc.). Perhaps caged insects for feeding and pathology studies would work out. Another serious problem is the selection of the species to be studied. It may be difficult to interpret data from artificially maintained, non-mobile animals. One or two species are about all that could be handled. Also, tissue banks should be maintained.

THE MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP '76

PUBLIC EDUCATION AND INFORMATION WORK GROUP

OBJECTIVE

To define the public education and information philosophy, identify tasks, and recommend procedures for implementing a public information component of CERL's Montana Coal-Fired Power Plant Project (CFPP). That component will reflect the need for a two-way information flow and will be consistent with the present information policies of the U.S. Environmental Protection Agnecy and the Coryallis Environmental Research Laboratory.

Goals

To inform and prepare state and local governments, utilities, other identified groups, and the general public of the need to develop a siting protocol for coal-fired power plants on western grasslands, and

To ensure that the protocol development proceeds fully cognizant of the perceived needs of the above noted groups.

PURPOSE OF TASK GROUP

To prepare an information plan for the CFPP that meets the needs of the project team on several desired levels. Although prepared specifically for the CFPP, the plan should provide a protocol which, with appropriate modifications, would have application in similar situations where coal-fired power plant siting decisions must be made.

The plan should reflect the reality that the flow of information must be a two-way process, i.e., not just from the organization or agency to the various publics, but also from the public back to the organization. To achieve this, it is necessary to build an adequate confidence level on the part of the public. They must feel confident that their concerns are being given adequate consideration in the siting process. In any siting protocol, this confidence building and information providing process must begin early enough to ensure that the various publics understand the process and the issues involved.

All members of the CFPP team need to understand and be able to communicate the overall project "message" (objectives, components, procedures for reaching the objective) and the interrelationships among the various components. Also, it must be recognized that there are "personal messages" which relate to the individual's goals and needs. These valid personal messages should be complementary to the project message and not in conflict with the project goals.

PHILOSOPHY

An effective public education and information program for the CFPP must be based on the need to communicate accurate, timely information about the project to various clearly identified groups and individuals who have an interest or concern about the purpose and the progress of the project.

The communication goals must be well defined by determining answers to the questions: Who are we trying to reach? Why are we trying to reach them? What is our message. What are the obstacles or constraints we must deal with in trying to reach the audience? What specific outcomes or products do we need to reach the desired audience?

The success of the information component is dependent upon the effective performance of all principals. Professional standards must be of the highest quality. A detrimental effect will result if faulty or inadequate data are communicated.

IDENTIFIED GROUPS WHO MAY HAVE A NEED FOR CFPP INFORMATION
(list not intended to be all-inclusive)

Universities (selected departments)
Regulatory agencies, state and federal--especially in the western energy development areas
Consulting firms and agencies
Environmental groups
Power industries
Science teachers
Country Commissioners, land use planning committees
Special interest groups--League of Women Voters, Cattleman's associations, etc.
General public

There is a need to build a mailing list of individuals and groups who wish to be informed of events and progress of the CFPP. A suggested mechanism to establish this list would be to send out a general information announcement summarizing the present status of the CFPP and provide a return card so interested recipients could be included on a standard mailing list.

When providing information to a specific group, it should be tailored to meet the needs and interests of that group. The information must contain adequate details and be high quality. In the case of some specialists and consultants the information must be the best technical, most current information available. Frequently these individuals are making recommedations or giving advice related to energy development projects and their information base may be limited.

The CFPP is expanding that data base and project leadership needs to make sure the findings are disseminated to those who need it.

IDENTIFIED INFORMATION NEEDS

There is a need to:

- nurture/stimulate the scientist to scientist exchange. It is important to interpret the data and get the information out to others in the project.

- gain understanding that action and implementation does not happen at the state or federal level. The local scene is where decisions are implemented. Project personnel need to understand the decision-making process at the local level and try to use the mechanism of working from the grass roots up through state agencies.

- ensure that the study objectives, progress and findings are communicated to state agencies on a regular basis in a manner that is clearly understood. Personal contact is effective but should be backed up with well-written progress (or other types) reports. It's a tough interface between state, federal, and local levels on a project such as the CFPP; however, it must not be neglected.

- consider the fact that quarterly reports required from team personnel do not coincide with the working situation. Reports must be current to be useful. Several work group members recommended semi-annual reports due in January and June. They felt these reports would be more meaningful since there would be more time to prepare them. The January report would indicate results of data analysis from the past season and plans for the coming season of field work.

- find out specific data needs of special groups and fill the communication gap where possible. Find out what studies have been done and relate the studies to each other.

- be prepared to follow up public demands for more information. When information is disseminated to various groups and/or the general public, additional questions and requests for specifics will result. Project leadership must be prepared to meet these demands.

SPECIFIC RECOMMENDATIONS
(no priority has been established for the following items)

- Work group members felt the need for a formal communication network among team members, not too structured but one that functions efficiently and holds official status. A newsletter is suggested as one possible method; others should be developed.

  Newsletter suggestions

  Some newsletter should have a single theme; others could cover several topics. These newsletters should be prepared in a language that can be easily understood by persons of all disciplines.

  Include notes of personnel (human interest--who's doing what, personalize newsletter.)

- Regular distribution of abstracts of each investigator's work separate from the newsletter. These must be current and distributed rapidly.

- More meetings that include all project personnel.

- Prepare a looseleaf notebook for each team member that can be updated easily. Inserts can be sent out to keep project personnel current--schedule of events, dates, status of various projects, series of fact sheets. All pertinent information provided to project leaders should be synthesized and made available to other team members. All project personnel should have the same level of understanding of the CFPP that the leaders have.

- A clipping file should be maintained and circulated among team members.

- Project investigators and team members need to develop a working relationship with organizations that have an established communication network with specific groups, i.e., county extension services, soil and water conservation boards, regional planning agencies, etc.

- An important contribution would be for EPA, in cooperation with project personnel, to compile a list of related projects under way in the CFPP area, with names of contact persons, project goals, etc.

- Divise some way to explain the overall picture of the related activities in the area and relate the CFPP to the total picture. Develop attractive maps, overlays, juxtapose data so it can be interpreted within a meaningful framework. Show resources, trends, interrelationships. Provide hard data to people who need it.

- Prepare a short, attractive lay level publication that explains the CFPP and shows the interrelationships of what is going on in the area (in terms of energy-related activities).

- Develop a media and information sharing exchange. Team members could provide a list (perhaps samples) of information tools they have available to share, loan, copy, etc.

- Prepare news releases on research activities and/or events of "key actors". Project personnel need to be alert to "news" in their fields and let the project leadership know so appropriate information can be developed and released. Also, sometimes it is appropriate to filter news through existing organizations. This can help legitimize the project in the eyes of local people and develop cooperation where needed.

- Project personnel should prepare lists of newspapers, key persons, organizations, etc. to whom CFPP information should be made available.

- Update a slide set for use of principal investigators and team members. Individuals should contribute slides and narrative from their specific areas to be combined into a concise presentation which can be used as the core of specialized presentations.

- There was no consensus on the value of exhibits. Work group members expressed concern on the maintenance, distribution, scheduling, etc., of managing exhibits. However, existing signs should be examined to make sure they communicate the desired message effectively. Also, further study should be given to the need for small, portable, low-maintenance displays.

Preparation of the "road show" was recommended. This would be a presentation on the CFPP which could tie in with meetings or workshops of existing groups. For example, a program with exhibits and handouts could be developed to use for county and regional extension meetings, Montana Energy Advisory Council meetings, etc. It would be important to identify contact persons and present balanced, objective information. Use these opportunities to "humanize" the project and let local people become acquainted with workers operating in the area.

FOLLOW-UP

Members of the Public Education and Information Work Group recommended that project leadership review the needs and recommendations presented in this summary and determine priorities and specific actions to be taken in terms of the available resources and expertise.

THE COLSTRIP, MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP '76

FIELD EXPERIMENTS WORK GROUP

This group was requested to review the field experimental system with respect to performance of the physical system and design and conduct of the field experiments.

The single most important problem identified by the work group is the turn-around time for ZAPS SO_2 data. This should be reduced to about a week, and a data summary should be disseminated to all PI's and other interested persons. A proposed format includes:

Daily: Maximum 1 hr and 3 hr peaks and times of day; geometric and arithmetic means.

Weekly: G.M. Vs. time of day; cumulative G.M. and S.G.D. for 8 min, 1 hr, and 3 hr averages.

Biweekly: same as weekly

Monthly: G.M. and S.G.D. for 8 min, 1 hr, and 3 hr averages.

One suggested solution to the turn-around time problem is to use data loggers which might be made available to the project. If two data loggers are available, and if they can be operated reliably under field conditions, this would provide the shortest turn-around time. A second suggestion is to have the SO_2 data manually reduced and recorded on a daily basis. It is also recommended that the met-data be summarized and disseminated on a weekly basis.

Additional mapping of SO_2 concentrations was recommended, especially near the delivery lines and outside the plots. It is recommended strongly that a SO_2 analyzer and time-share unit be dedicated to this task next season. This analyzer would also serve as a back-up instrument. Inclusion of ZAPS in the quality assurance round-robin is necessary.

The group generally agreed that the SO_2 concentrations on the plots should be kept at the present levels and that no modifications ought to be made because 1) up to two years data has been taken with the present configuration; 2) some biological effects have already been noted, such as color differences between plots, differences in respiration, damage to lichens, and shifts in mammal, insect and nematode populations; 3) the existing browned-out areas under the pipes are not extensive enough to invalidate existing experiments. In fact the SO_2 gradients implied by these areas offer valuable research opportunities; 4) information on the responses of vegetation to somewhat higher concentrations could be obtained by other means, such as chamber studies.

Lack of grazing on the ZAPS plots was not considered a serious problem, at least on the time scale of this experiment, since the area had not been overgrazed. It was suggested, however, that comparisons be made with areas outside the exclosure.

Determination of the cause of the observed differences in plot colors and in color-infrared signatures was identified as an important experimental objective. Suggested hypotheses and research approaches include:

1. Changes in chlorophyll content--chlorophyll extractions, optical measurements on leaves.

2. Differences in water stress, perhaps caused by SO_2 - stomate interactions - plant water potential measurements; leaf respiration and transpiration measurements.

3. Differences in litter quality or quantity--chemical analysis of litter; optical measurements on litter; continuation of measurement of litter standing crop.

4. Merging of browned-out areas--considered unlikely by most, but determinable by microdensitometric measurements on photographs, and other techniques.

5. Differences in SO_2 reflectivity--considered unlikely since effects were observed when no SO_2 was present.

6. Sulfur fertilization by SO_2 - considered unlikely since the soil contains large amounts of gypsum.

Expansion or initiation of studies of various inter-specific interactions was recommended. These included (1) characterization of phytophagous insect populations; (2) initiation of Peromyscus and Microtus feeding trials; (3) expansion of nematode studies to study more closely the relation between changes in root exudate and observed changes in phytophagous nematode populations; (4) initiation of research on the important topics of mychorrizal interactions and symbiotic N-fixation, especially as affected by changes in root exudate.

It was suggested that more use could be made of areas outside the ZAPS plots but inside the exclosures, especially areas which are frequently exposed to SO_2. This might include small area exposures, irrigation of small areas between plots, and extension of a line (i.e., teflon tubing) to the vicinity of the beehives.

It was generally agreed that ZAPS III would be a very valuable addition if the site or exposures are not like those of ZAPS I or II. Suggested differences included (1) a different type of grassland community; (2) a different climatic regime (i.e., moisture, temperature); (3) an additional pollutant, such as NO_2; (4) different exposures of SO_2. These differences would increase the generality of the ZAPS data. For example, the current sites are relatively low in warm weather grasses, even though these are important over a large areas of the Northern Great Plains. The question of SO_2 - NO_2 synergisms is quite important, as these might greatly alter the pattern of stress response. The addition of NO_2 would require some redevelopment of the system, and would require the longest lead time.

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP 76

MODELING WORK GROUP

The modeling work group was asked to produce:

a. a statement of the values and role of modeling activities within the CFPP project.

b. a list of questions that should be answered by project output.

c. recommendations for numbers, kind and gross structure of model to address questions and the subsets of questions that which each is to address.

d. plans for implementing effective modeling with the project.

Five of the six participants in this work group had no formal association with the CFPP project. While this precluded project related preconceptions of the role modeling should play in the project, it hindered progress in identifying specific project needs. The material presented here is limited to an overview of the role modeling could play as seen by individuals with substantial experience either as modelers or from association with other large research projects.

Two important roles for modeling were identified and discussed. First, it may be used to organize hypotheses into a coherent conceptual framework that will serve to focus research activities and establish research priorities. Secondly, predictive models will probably be important to the power plant siting protocol to be produced by this project.

No list of specific questions to be addressed by project output was produced. We agreed that such a list would have to be produced through the interaction of modelers and potential model users--presumably environmental policy makers. Though models likely to come from present research efforts will provide output in terms of ecological impact (effects on primary and secondary production, temporal dynamics of system's functions, etc.), these outputs must ultimately be expressed in socioeconomic terms (esthetics economic impact, cultural impact, etc.) in order to be useful to policy makers. In order to gain wide use assumptions incorporated in models should be readily apparent, their consequences clearly understandable, and predictions should have clearly stated confidence limits.

Statistically based models are likely to gain wide usage because they often satisfy the above criteria. However, such models are likely to be site specific because no rigorous understanding of underlying mechanisms is incorporated. Mechanistic models would be more transferable from site to site, but would be more complex, would usually require large data inputs to generate prediction, would be difficult to validate, and would probably require a lengthy period to elaborate.

It was recommended that an individual or core of individuals be given the specific responsibility for providing modeling support to the CFPP project and to project components. This (these) individual(s) should be given sufficient funding for travel to permit regular direct interaction with principal investigators and would be responsible for maintaining an integrated modeling effort.

It was suggested that a mini-workshop be convened in the near future for principal investigators and modelers to define specific needs of the CFPP project and of project components. Activities at the workshop might include:

a. identification of specific sets of questions that lend themselves to analysis and solution through modeling.

b. discussion of alternative forms that models addressing these questions might take (Box and arrow conceptualizations).

c. development of a conceptual model of the sulfur cycle in the grassland ecosystem.

THE COLSTRIP, MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP 76

ECOSYSTEM STRUCTURE & DIVERSITY

This group was requested to:

1. define relationships between grassland diversity measures biomass and/or productivity (gross and net) at primary and higher trophic levels.

2. define relationships between diversity within other taxa and/or within other trophic units and productivity of the range resource.

   a. how is range productivity related to that of primary consumer diversity?

   b. how is range productivity in the Colstrip area related to avian diveristy?

3. resolve the 3 grassland phenology codes now in use into one code acceptable to all. If this is not possible, justify maintenance of more than one code and suggest ways to integrate the phenology data in these different codes.

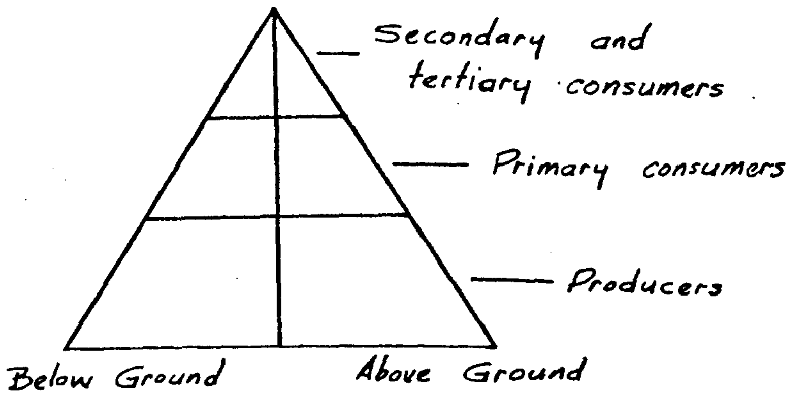
4. discuss the effects of SO_2 fumigation on the relationships defined in 1 & 2 above.

5. discuss the effects of SO_2 fumigation on plant phenological development and its relationship to measures employed in 1, 2, 3 above.

6. discuss links in ecosystem energy flow, nutrient cycles, and carbon cycle that are likely to be particularly sensitive to air pollution.

Initial efforts were directed to describing functional attributes of ecological systems, both intra- and inter-trophic level. This was necessary because of the confusion with which structural and functional aspects of ecosystems have been discussed by project participants in the past. We identified the following as the most obvious structural attributes:

1. Trophic pyramids of both numbers of organisms and biomass (including height and depth stratification)



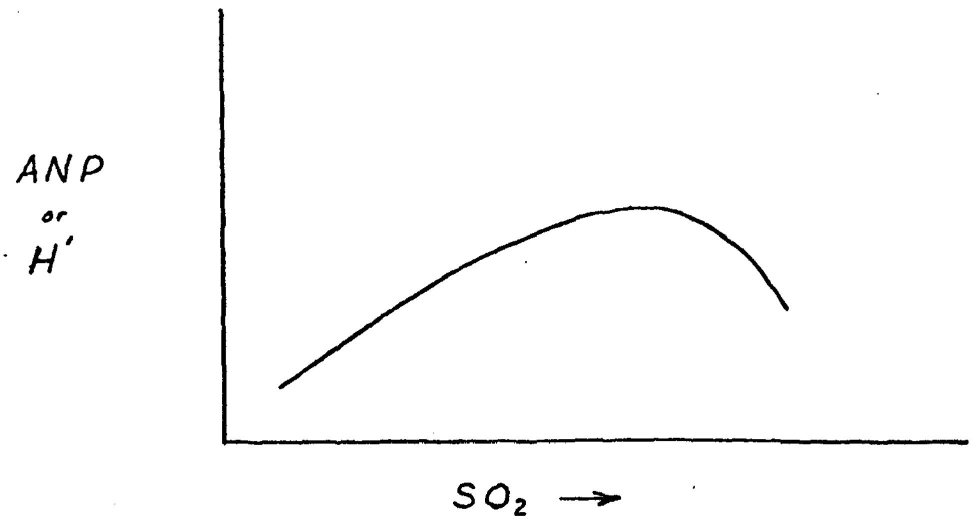
2. Inter- and intra-trophic level composition based upon:
   a. Taxonomic groups
   b. Functional groups (guilds)
3. Inter- and intra-trophic level diversity based upon:
   a. Taxonomic groups
   b. Functional groups (guilds)
4. Standing crops and locations of mineral nutrients (i.e., nitrogen, phosphorus, sulfur, etc.)

Throughout this discussion it became evident that most of the group members were interested in ecosystem structure, primarily for the insights it may provide into functional relationships. This precipitated a brief discussion of ecosystem function which resulted in the following list of important functional attributes of ecosystems:

1. Energy flow
2. Nutrient cycling
3. Information flow (including controls)

We next addressed ourselves to the specific problems relating to the project . An idea that was expressed early was that it was important now to pull together all of the information currently available from the project into a picture of ecosystem structure. This was generally agreed upon by the group members and will be discussed later with respect to a data analysis workshop to be held at Colorado State University.

A discussion of the relationship between diversity (H') and productivity (ANP) yielded no conclusive results. The following general relation was extracted from the biomass data from ZAPS I in 1975.



A similar relationship was found with the biomass diversity data for both ZAPS I and II in 1976 but the productivity data are not yet available. Relationships between diversity based upon density and canopy coverage and biomass and productivity were discussed and although most members felt they were definitely related, no theoretical relationship was proposed.

Provisional objective three was resolved by proposing that the three investigators consult and decide upon a general phenological classification: this was acceptable to the three groups involved and will be agreed upon and reported to the project director before 1 April, 1977 field session.

Committee Recommendations

Committee members were in agreement that a major effort should be stated immediately to assemble all of the current information on the structure of our grassland ecosystem. A data analysis workshop was proposed to be held at Colorado State University in December to begin work on the primary producer data. The expected output of this workshop in addition to defining the structure of primary producers includes detailed examination of the utility of various diversity measurements as indicators of changes in ecosystem function. A new diversity measurement that was dicusssed involves assessing color diversity from infra-red aerial photographs with a densitometer. The remote sensing group indicated that those data would be available for the workshop.

THE COLSTRIP, MONTANA COAL-FIRED
POWER PLANT PROJECT

WORKSHOP 76

BIOLOGICAL ESTIMATORS OF IMPACT WORK GROUP

Provisional Objectives

1. Identify methods for qualitative evaluation of pollution effects.

2. Identify suitable criteria for damage to the environment.

3. Propose criteria necessary for the establishment of a biological effects monitoring system. Identify problems and propose an operational scheme for establishing such a network.

4. On the basis of field and experimental evidence, including what is known regarding the responses of grasslands to stress, what are the specific (direct) effects of AP which might be expected in SE Montana.

5. If it is possible at this time, specify the (grassland) ecosystem components which have differing risks of pollution susceptibility? What kinds of further information are needed?

6. Identify appropriate methods and systems for detecting low levels of pollution from CFPP in SE Montana.

7. Define an approach to obtaining quantitative relationships between SO_2 exposure and lichen condition.

Product

1. Methods for qualitative evaluation of pollution effects.
   a. Visual effects would include chlorosis and necrosis on plant tissues, and internal structure changes.
   b. On a larger scale, aerial photography may be able to document changes community species composition.
2. Suitable criteria for damage to environment.
   a. Long-range criteria include productivity changes and diversity changes (in percentage cover or species richness) because of chronic, low-level, non-lethal, accumulative effects of SO_2 stress.
   b. Shorter-term damage effects may be best observed in physiological, anatomical, and histological studies of individual species, e.g., lichens and Ponderosa pine needles.
   c. The effect on accumulators, e.g., honeybees, is not yet known.
3. Criteria necessary for biological effects monitoring system.
   a. Susceptibility and sensitivity to SO_2 must be identified, apparently on a process level, since population and community changes are more suitable.
   b. The effects must be identifiable: e.g., material change (protein to cellulose change that reduces value to consumer), or leaf damage tht would lower resistance to pathogenic insects, or tissue and cellular changes (leaking of nutrients).
   c. The effects must be transferable; if a process is reduced measurably and dramatically in key species at low stress level in a short period of time, will it occur eventually in economically important species in the area.

4. Effects of pollution in southeast Montana
    a. One of the purposes of the ZAPS experiments is to discover which processes need intensive study.
    b. Chronic sulfur stress on individuals may lead to less resistance to water stress, grazing, trampling, and pathogens.
5. The ZAPS results indicate that lichens are susceptible organisms and 1976 observations indicate that Ponderosa pine needles are sensitive. Perhaps more organisms are susceptible, but this has not yet shown up on an organismal, population, or community level. Native grasses appear to be fairly resistant, but more information is needed at the sub-organismal level.

    Further information is needed concerning soil microbes, water relations, and micrometeorological conditions.
6. It is important to collect baseline population and community information, but the anatomy, histology, and physiological processes of the organisms must be examined also. Short-range effects are more likely to be discovered at low organizational levels.

THE MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP 76

REMOTE SENSING WORK GROUP

The projected role of remote sensing in the project protocol is essentially threefold: a) Remote sensing can aid in the fast survey of large areas so that representative samples can be selected for consideration as study of development sites; b) RS can aid in gathering pre-treatment data aginst which to measure any changes resulting from energy development activities; and c) RS can (should) be an integral part of the long-term monitoring program after power plant construction. Each of these functions requires a little different approach in terms of photographic processes, image types, scales, frequency of coverage, and interpretation of the results. The project protocol arising from the CFPP Project must recognize these differences, which should be carefully spelled out in the final report.

In discussions conducted among various groups and individuals at the workshop it was clear that there is a general recognition among project workers that remote sensing offers many important advantages in this research. In some cases this probably is an intuitive feeling rather than a judgement based on experience. Nevertheless, it seems that this is a high priority activity and it needs to be made more available and intelligible to all program elements.

The ability of aerial photography to distinguish ground level treatment differences, particularly those associated with the levels of sulfur dioxide fumigation on the ZAPS plots, has been shown repeatedly. The fact that concurrent ground samples of biomass and diversity have not shown high correlation with these visual indications suggests that the organism/population/ community levels of integration are not sufficiently sensitive to show relatively slight treatment responses. It appears that the ground studies should be expanded to include studies at the cellular and tissue levels, since these levels are likely to first reveal changes in factors affecting plant reflectance. Some of the studies suggested in this connection are:

plant tissue observations, esp. pathological signs
photosynthetic activity
soils moisture studies related to water potential
of plant tissues
yields over long time periods
diversity over long time periods

The visual indications from remote sensing need to be quantified so that a reliable combination of aerial and ground monitoring can be developed. This will require more sophisticated photographic analysis than has been used previously. Such procedures as density analysis, color enhancement, and reflectance ratioing should be evaluated. The project should obtain a color densitometer for first-line photoanalysis. Further, the contract studies being conducted by Calspan Corporation must be followed closely. An emissivity meter might also prove useful.

Improved color control on the photographic images must also be obtained. A density step-wedge should be exposed onto all film before processing. This will allow calibration of gray-scale and color differences which may result from factors not associated with pollution stresses.

EPA Las Vegas is working on a plant fluorescence technique which might be applicable to our work. This is an airborne system that uses very narrow spectral ranges to detect slight metabolic anomalies. It is hoped that this system might be used over the ZAPS sites next summer.

There was some discussion of non-photographic and specialized photographic systems such as multispectral scanners, thermal scanners, radar, microwave, etc. With the exception of the fluoresence system mentioned above it was our consensus that none of these techniques would offer large advantages over conventional photographic systems, especially in view of the proposed users of the protocol. Therefore, we will continue to emphasize photographic approaches.

The remote sensing activities of the project are vested in two related but separate operations. The first is EPA's Environemtal Photographic Interpretation Center (EPIC) in Warrenton, Virginia. This group has acquired and duplicated much existing photography originally obtained by various federal agencies. EPIC also has contracted with NASA and other sources for original imagery of the study areas. All of this photography is in standard 9 x 9-inch format, mostly color infrared, flown at high elevations and at fairly small scales. EPIC has used this photography to prepare various secondary products such as land use maps, display materials, and copies of prints and transparencies for various program needs. EPIC also has contracted with Calspan Corporation for a study of that company's patented image reflectance ratio process. In addition, EPIC has provided film, processing, copying, and photointerpretations assistance to the Montana State University project.

The second part of the remote sensing research is included in Montana State University's plant community monitoring project. This is relatively low-level photography, using small aircraft and 6 x 6 cm camera systems. Photographic scales are larger, but coverages are restricted by the smaller angles of view and smaller negative sizes. This kind of imagery is used for more detailed analysis of species and population-level stress responses.

If EPA Las Vegas becomes involved next summer, there will be three remote sensing elements in the project. Even with the two current participants there are some problems in coordination, planning, scheduling, etc. This should be tightened up. It was proposed that one individual should be made responsible for the coordination of all remote sensing activities, including flight planning, processing, distribution of products, analysis, interpretation, and any other aspects of handling film exposed as part of the overall project. It is assumed that much of the routine decision-making would be delegated to the appropriate group, but overall coordination would be improved by identifying a responsible individual.

As holdings of photographic imagery proliferates, the problems of access and reproduction increase. A list of photographs should be available to interested researchers. Principal investigators should have access to copies pf photography acquired as normal project coverage, although costs and accessing procedures need to be worked out. Principal investigators should be able to obtain "custom" coverage on their areas of particular interest. This will necessitate a more highly structured consultation service.

If the remote sensing activity is really to constitute a program element, and not just be viewed as a supporting service, a feeling of mutual cooperation and support will have to be developed among the principal investigators. This exists in a casual sense, but it needs to be nurtured and reinforced. The remote sensing project work should receive ground support as well as providing support to ground elements.

In discussing changes in aerial monitoring for 1977, it was suggested that it may be important to do some daily sampling and/or diurnal sampling next year. There is some indication that morning/afternoon periodicity in plant activity may be important in explaining treatment responses. This might be shown adequately by ground photography, but aerial coverage, at least during periods of rapid plant growth, would be desirable.

THE MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP 76

ABIOTIC FUNCTIONS WORK GROUP

This group was:

1. To evaluate and summarize present knowledge of aerosols, air quality, and meteorology in the Colstrip area.

2. To evaluate air quality and micrometeorology needs of CFPP and suggest a sampling regime to satisfy them.

3. To elucidate quality assurance requirements and develop a data acquisition and management plan.

Information on climate and surface meteorology is available for the state of Montana. Data in the Fort Union Basin (Colstrip area) for climate and meteorological conditions appears to be available. The base line characterization of aerosols and air quality is proceeding. An adequate data base for base-line conditions will be provided through the efforts of Battelle Pacific Northwest Laboratories, the State of Montana, EPA, NOAA, and other investigators.

The Pacific Northwest Laboratories of Battelle is collecting and analyzing particulates in air samples for elemental constituents. The scientists at Battelle have generated and are actively participating in round robin quality control program involving exchanges of standard reference materials and particulate type samples. The round robin exercise will provide the necessary confidence in the elemental characterization of air samples.

The NOAA scientists continue to conduct research on measurement of aerosols, radiation and meteorological conditions.

The characterization of particulates in air samples seems to be adequate with good data quality assurance.

The measurement and analysis of gases, sulfur dioxide, (SO_2), carbon monoxide, methane and hydrocarbons, nitrogen dioxide, NO_x, and ozone is being accomplished instrumentally at two sites, (Hay Coulee and a state of Montana site),. Sulfur dioxide measurements using a bubbler are being made by BPNWL at a number of sites. Total particulates using the reference method for determination of suspended particulates in the atmosphere (high volume) is being done by EPA (Hay Coulee), State of Montana and Montana Power. There is a need to generate a round robin program for intercalibration of gases, an audit of particulates (weighing) and an intercalibration of high volumes. It would be desirable to invite the Montana Power Co. group into this quality assurance program.

The mechanism for institution and coordination of such a program will be the responsibility of the principal investigator (R. Lewis) with assistance from LASS-CERL, and EMSL-RTP.

The abiotic functions work group has recommended that the instrumental trailer now located at Hay Coulee be kept operational. The consensus of the group indicates that the measurements made by the instrumental trailer are necessary and that steps should be taken to assure the project leader that the data are valid from a quality assurance standpoint. The group further recommended that the methane and total hydrocarbon analyzer be discontinued but that the equipment be kept on site in a standby condition. It was the collective opinion of the group that if a more appropriate or convenient site for the trailer can be found which will better suit the purposes of the majority of investigators, then the trailer should be moved. If the trailer is kept at Hay Coulee, steps should be taken to stabilize power, repair computer, automate operation through computer control and evaluate data.

The group recommended that all data collected on aerosals, air quality and meteorology after appropriate quality assurance determination made by the responsible investigator be placed into a data bank (computer stored).

With the present state of the art of instruments, the work group does not see any merit in acquisition of new unmanned instruments and their siting in new, unattended locations. The group did endorse the careful siting of systems to collect data. The movement of the trailer from one location to another would provide more stability in instrumental conditions than a number of unattended sites. The word came across with definition and clarity that if an instrument is out there making chemical measurements an individual has to be standing by.

In summary, aerosols are being characterized with a good quality assurance program. Air quality measurements are being made and a quality assurance program will be carried out. Data acquisition requires inspection of data by project leader before data inclusion into central data bank. An integral part of the data collection must be based on quality assurance principles.

Follow up Summary

Since the November workshop we have drafted an interagency agreement with ERDA to modify the present air quality monitoring operations at Colstrip. The plan is designed to meet the specific research needs of EPA but will also complement the ERDA and State of Montana Programs. The agreement involves expansion from the present Hay Coulee sites to include air quality monitoring at EPA research sites Kluver North, Kluver West, and Kluver East. The three new sites will be provided with a portable source of power for operating real time analytical and sampling equipment. There are also micrometeorological facilities at each site which we will continue to operate cooperatively.

ERDA will be responsible for field operations and maintenance. Overall management, the quality assurance program, and data processing will be the responsibility of EPA/Corvallis.

Major emphasis will be placed on assuring the quality of the data, that all the measurements are defensible, and that errors associated with the laboratory analyses are within known and acceptable limits.

EPA/Corvallis is in the process of elaborating the quality assurance program and ERDA will implement it. Independent audits of performance of the air monitoring network will be carried out semi-annually by representatives of EPA/RTP. Any deficiencies found will be reported to EPA/Corvallis and ERDA who will share the responsibility for undertaking appropriate corrective action.

The Hay Coulee site is now provided with most of the necessary equipment as well as a power supply and protected laboratory space. At the new sites there is no electric power and we intend to provide it as follows.

At each new site, we will place two small trailers. One will house a 5 KW natural gas-powered electric generator. The natural gas will pass through a charcoal filter to remove sulphur compounds that could cause local pollution. The electric power generated at the power trailer will be transmitted through a heavy-duty extension cord to the equipment to maintain reasonably constant temperatures.

The equipment trailer will have the following instruments:

1. A continuous SO_2 monitor (Meloy Model 285)
2. Cloud condenser nuclei counter (Model Rich-100)
3. Two-stage aerosol particle size fractionator

The data from the continuous SO_2 monitor, will be stored on a magnetic tape cartridge and also on a strip chart recorder. The strip charts will be kept for possible future reference, while the magnetic tape cartridges will be used to transfer the data for computer analysis at the Corvallis computer center.

At the Hay Coulee site, NO_x and O_3 will also be monitored.

Cloud condensation nuclei (CCN) are a sensitive indicator of air pollution. Therefore, we plan to operate a CCN analyzer at the Hay Coulee site and at each of the three additional sites. These analyses should give us the first, and by far the most sensitive, indication of the influence of the Colstrip plant power plant plumes at the monitoring stations. We believe that the next most sensitive indicator may be an SO_2 analysis. Plume movement and diffusion is controlled by the local meteorology such that only low pollutant concentrations are generally anticipated at the sites and actual fumigating may occur rarely, or not at all. It is thus essential to operate an SO_2 bubbler which would integrate the total SO_2 bubbler which would integrate the total SO_2 exposure at each site. This will provide a far more useful indication of the total exposure than the real-time SO_2 analysis. Operation of real-time SO_2 analyzers will also be carried out since this permits transient fumigations to be sensed.

Sulphate reaching the monitoring sites may be of major importance and we will measure this on the air filters employed for the collection of particles. We will use a two-stage particle separator that separates aerosols into size ranges of less than and greater than 2 μ. We anticipate that all of the sulphate will be associated with the smaller size fraction. Both of these fractions will be analyzed for some 20 to 40 trace elements, including most of those considered to be important in environmental pollution.

We feel that implementation of the cooperative agreement between EPA/ERDA will meet the needs of the CFPPP for defensible Air Quality data and insure smooth operation of this task in the future.

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

ANIMAL WORK GROUP

Animals, like plants, respond to unusual or abnormal changes within their environment. Changes mediated by a variety of toxic gaseous emissions from coal-fired power plants may affect animals directly resulting in detectable behavioral changes or perhaps even death, or indirectly such as gradual decimation of a food supply with consequent withdrawal of an affected species from the area, or contamination of a food resource with consequent bioaccumulation of potentially toxic trace elements or compounds. It is a fundamental objective of the CFPP project to determine which animals common to a grassland ecosystem can serve as bioindicators of pollution stress or damage. Selected species of arthropods, passerine birds, and small mammals have received the greatest attention. Both qualitative and quantitative information regarding their behavior, seasonal cycles, and population dynamics relative to natural variation in other biotic and abiotic components of their respective habitats must be obtained to evaluate the effects of chronic pollution.

The study of chronic pollution effects on animals (or plants, for that matter) is not a coherent, well-defined discipline. Nor is it rooted in a general theory that helps in organizing the work or identifying disciplines that can in fact, contribute most importantly to assessment, predict in control. Nevertheless, we are trying to improve this process of definition by the elaboration of hypothetical framework and by recognizing that an assemblage of disciplines perspectives and foci may be required to successfully address the mission. We must include not only generalists (e.g., wildlife ecologists) who are concerned with the interdisciplinary approach, but we also require disciplined, quantitative specialists, if we are to idenfity the subtle but pervasive effects (probably often indirect) of chronic pollution stress. Interactions among vertebrate/ invertebrate biologists and among ecologists, physiologists, behaviorists, histologists, etc. are crucial. Clearly this is only possible through effective cooperation among grantees and EPA scientists and managers.

The current status of major aspects of the animal program are summarized here and suggestions for future efforts are presented. This is a consensus report.

I. INVERTEBRATES.

Both ZAP sites have been intensively sampled for relative changes in arthropod numbers. Preliminary 1976 data from below-ground microarthropod sampling at ZAPS 1 show decreases in numbers of nematodes correlated with increases SO_2 concentrations. At ZAPS 2, however, the converse was found, perhaps reflecting a stimulatory effect of SO_2 on the productivity of a previously unfumigated area. Such increases in arthropod numbers are correlated with increased oxygen consumption of Prairie Junegrass and Western Wheatgrass on all plots in August. Data analyzed from 1975 also suggest that some mite populations or groups respond to SO_2. This work should be intensified employing more taxon-specific sampling procedures. Samples should also be taken at other sites, to provide additional "control" data.

The 1976 data for above-ground sampling of macroarthropods are not yet available. The inadequate and highly variable numbers as well as high diversity of macroarthropods within study plots on ZAPS 1 in 1975 suggest that little new information may be gained by continuing above-ground sampling. In the future, we intend to focus on two or more abundant "key species" whose susceptibility to SO_2 is suspected from previous work. This is essential if process or mechanism-oriented experiments are to be conducted. For example, the distribution changes in beetle populations across ZAPS plots may result from a behavioral avoidance of SO_2, a direct toxic effect upon beetle function, indirect effects such as alterations in nutrient availability or rate of decomposition, or perhaps some combination of these. Experiments that were suggested included feeding and nutrient tests within ZAPS plots, either by retaining caged insects on a given plot or by feeding fumigated vegetation to caged insects not on the plots. Also suggested was a study of decomposition cycles to include macroinvertebrates, microflora, and microfauna. Ongoing analyses of total soil respiration would support these kinds of experimental approaches. We all acknowledged that a study of soil structure and chemistry should be initiated.

Honeybees exhibit considerable potential as bioindicators of air pollution. A beehive was placed on ZAPS 1 in 1976, but no change in bee foraging behavior was noted. However, since no certainty exists that the bees were subjected to SO_2, an extension of one SO_2 carrying pipe to the colony was recommended to insure fumigation of the hive. Behavioral observations will then be continued in 1977.

Fluoride analyses of bees have been productive and should continue as in the past. A few samples of bees collected from sites near Colstrip in 1976 show about a 60% increase in fluoride compared with levels found before the operation of Colstrip Unit #1. Bees near Rosebud, MT, show a fluoride level about 10 times greater than that found elsewhere. The contaminated source appeared to be the water supply near the beeyard.

Other work that should be continued includes the extent of Ponderosa Pine needle damage owing to scale insects. This work is closely allied to our research on the effect of air pollution on Ponderosa Pine needle damage. Because of the heavy workload during the field season, another full-time assistant or graduate student is needed to assist in the collection and analysis of large arthropods, especially bees and beetles.

Owing to a number of technical and biological constraints the vertebrate program has not and will not address the original objective pertaining to the examination of those functions that contribute to population regulation of birds or mammals. All other aspects of the avian program will continue though collections will be temporarily curtailed, and this work will be replaced by needed innovations as described below.

Current extramural research operations for the vertebrate animal program include detailed histological analyses of avian and mammalian organs deemed most likely to be affected, directly or indirectly, by pollution stress, lipid extraction from several hundred avian carcasses necessary for component analysis of body structure (water, fat, lean-dry mass, and ash), and enzymatic assay of a blood enzyme (acetylcholinesterase) of small mammals that may be altered by exposure of the animal to sulfur dioxide.

In-house (EPA) staff and facilities do not exist and therefore analyses of these critical aspects of animal function must be performed by qualified specialists in their respective laboratories. Each piece of research is essential to any statements regarding the effects of Colstrip-originating air pollution upon animal systems and their functions.

Current in-house research involves both execution and coordination. Coordination involves overall project design, and management. Including longer range planning and task integration. Personnel restrictions and the scope of work in relation to the complexities of the research necessary to support the mission, have made it impossible for the senior EPA animal scientists to accomplish these tasks without the help of appropriate basic scientists and laboratories not available in-house. A two-year population study of grassland birds (to be extended for at least 1 year) will produce pre- and post-operational data on dispersion and changes in relative abundance of resident and non-resident species relative to proximity to a pollution source. A two-year study of small mammal populations near Colstrip has been completed, and the first of at least a 2-year study of small mammal population structure and subsequent dispersion as a function of sulfur dioxide is being conducted at the ZAPS site in Southeast Montana. On a limited scale, the breeding phenology of the Western Meadowlark was initiated in 1976 and will be extended another season. This study will provide baseline information related to clutch size, hatching success, fledging mortaility, and predation, all of which must be quantified if changes in any of them are observed in future serial studies. Related to this study is a proposed, sensitive experimental method designed to assess the presence and extent of stress in grassland birds by measuring quantitatively the adrenal hormone corticosterone. Because hormonal imbalances in stressed birds can interfere with normal reproductive activities, one successful outcome of this projected work would be to correlate changes in a readily-detectable hormone with persistant environmental insult to air quality and food quality and availability. Performance of this task is external to current EPA capabilities. The technique itself can be performed by only one laboratory in the Western United States, and thus the need to enlist the research skills of appropriate basic scientists outside EPA is readily apparent.

Beyond 1977, these studies will be further integrated by studying the distribution of birds along environmental gradients established by a pollution point-source. This will require cooperative efforts between the EPA team and the appropriate grantees. Gradient analysis as now conceived will involve population assessments of grasslands birds along the gradient followed by successive and alternating collection and population analysis until the end of the season nears, at which time birds will be collected for further intensive component and physiological analysis and evaluation.

Completion of these tasks will require maintenance of adequate laboratory staff (1 programmer, 2 full-time technicians) and facilities until the completion of the program as well as close interaction with the appropriate grantees.

B. Mammals. The reduction of population studies of rodents in the Colstrip area from 5 plots to 1 plot (Hay Coulee retained) permitted extensive monthly capture, mark, and release operations at ZAPS 1 and 2. Over a 6-month period, 112 and 142 mice and voles were trapped at ZAPS 1 and 2, respectively, providing data comparable to that obtained from rodents trapped near Colstrip as well as establishing an experimental base from which SO_2 effect on population dynamics could be observed.

Preliminiary data analyzed for prairie voles indicate that the non-uniform distribution of voles within study plots and their erratic appearance during live-trapping suggests that voles are either unaffected by SO_2 levels occurring where they are trapped or are not suitable indicators where they are found in low numbers. The highly erratic distribution and trappability of voles in the Colstrip area supports this conjecture. Deer mice, on the other hand, are widespread and normally trappable year-round. Although a few marked mice could be retrapped 3 to 5 months later at both ZAPS sites, most mice trapped (52-60%) were those that made a brief appearance on the sites during a single monthly trapping period. Furthermore, a few mice that were residents within gassed plots appeared to move out, even in those areas of high SO_2 concentration. However, population turnover in gased areas has not been determined. A fuller understanding of rodent dispersion requires co-ordination with teams preparing vegetation maps as well as additional trapping areas outside the fumigated zones. Additional behavioral and biochemical experiments to determine direct or indirect effects of SO_2 on small mammals are feasible. For example, acetylcholinesterase assays of blood from mice and voles trapped at Hay Coulee and ZAPS during 1976 will be performed within the ensuing quarter and may provide clues of pollution stress. Studies of specific enzymes (e.g., mixed-function oxidases) in liver of mice subjected to fumigation offer another potential signal of small mammal biochemical responses to air pollution.

Extensive data on the cycles of body weight, body length, sex and age structure in deer mice and to a lesser extent in voles and pocket mice will permit the population studies at Hay Coulee to cease, at least for 1977. Weekly or biweekly trapline work will continue as traplines are a means by which to monitor natural variation and cyclic processes, such as reproduction and body weight, in commonly trapped species. Much of the histological work will be reduced, pending the completion and fulfillment of existing contracts.

III. REVIEW OF OBJECTIVES AND COORDINATION EFFORTS

In view of altered objectives of the vertebrate program, the following revised objectives are proposed as realistic and attainable within the time course of the CFPP project.

Revised Provisional Objectives for the Vertebrate Program.

1. Measure and predict changes in population structure and/or dynamics of grassland birds and small mammals as a function of annual, seasonal and life cycles as well as other environmental information including biotic interactions and physical factors that influence such structural or dynamic processes under study.

2. Assess the specific effects of air pollution, if possible, upon avian and mammalian population structure and dynamics as well as upon specific organ systems.

3. Evaluate certain physiological, biochemical, and behavioral functions that may have potential for sensitive assay of pollution challenge. We hope to identify low levels of pollution stress before serious or irreversible effects occur.

A greater degree of coordination among the various teams involved in animal research will be exerted by CERL to facilitate the flow of ideas and information where they serve the best interest of principal investigators. By virtue of the trophic structure within grassland ecosystems, the results of any one team may likely supplement those of another. Hence, greater information exchange is highly desirable.

IV. SUMMARY

Several kinds of evidence now exist that indicate changes in population density and composition in vertebrates and invertebrates as a function of air pollution stress. Problems are complicated and require interdiciplinary and cooperative/collaborative studies. All members of the group agree that increased communication, cooperation and collaboration are essential to success. Although studies so far have not indicated alterations in physiological state, they do suggest that chronic low level exposure to SO_2 or other gaseous effluents modifies the original biotic organization or results in bioaccumulation of toxic compounds. Hence new and refined approaches and disciplines mentioned above seek to elucidate current results in fulfillment of project goals or refining pollution-caused or related environmental changes that affect, modify or eliminate some or portions of animal populations that are either critical in maintaining the integrity of a grassland ecosystem or are economically invaluable to man's growing agricultural demands and needs.

THE MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP 76

LICHEN WORK GROUP

Provisional Objectives

1. To evaluate progress if lichen work toward stated objectives:

   a. To establish baseline information on 2 species of lichens so that effects of chronic SO_2 challenge may be determined.

   b. To compare relative sensitivities of lichens, native grasses, and ponderosa pine.

   c. To assess population level changes in lichens that result from power plant emissions.

2. To define the role that the lichen work is likely to play in our impact assessment protocol.

3. To evaluate present objectives in the light of 2 above, and suggest modifications likely to increase the effectiveness of this task.

4. To develop mechanisms of interaction with other project components that will facilitate realization of revised objectives from 3.

1. Progress of lichen work was evaluated in relation to stated objectives.

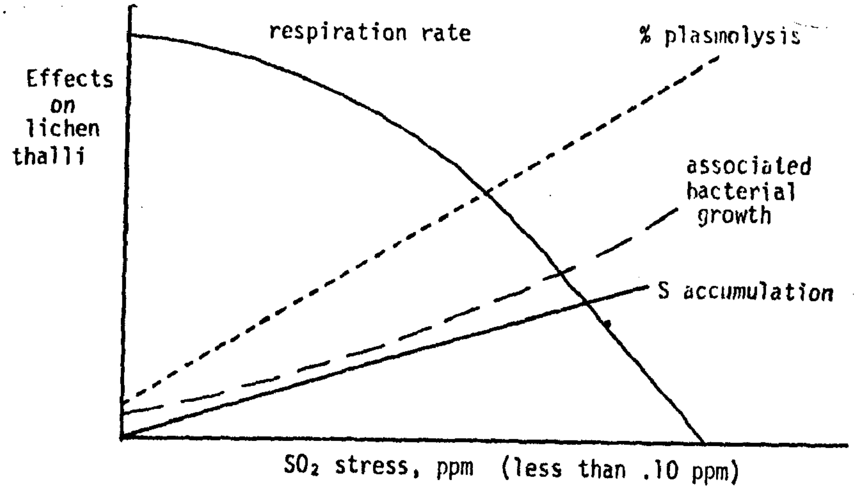
a. Baseline information on Usnea hirta and Parmelia chlorochroa include: respiration rates, anatomical condition, total sulfur and nitrogen contents--from 20 Ponderosa pine and grassland sites in the Colstrip-Fort Howes areas, and for two summers from the ZAP sites. However, the total sulfur content percentages have been questioned by Larry Gough, USGS, Denver, who feels that my results, obtained from the MSU Soils Testing Lab, are much too high. I am now corresponding with him concerning the possibility of having their laboratory replicate the sulfur tests.

b. According to respiration rate determinations, Usnea hirta is affected by SO_2 stress more than Western Wheatgrass (Agropyron smithi) and Prairie junegrass (Koeleria cristata); i.e., there is a definite decrease in gross respiration rate within 34 days in Usnea samples from ZAP sites B, C, and D. whereas the two grasses show a possible effect, and increase in respiration rate after more than 100 days of fumigation on plots C and D. Parmelia chlorochroa exhibits pronounced respiration rate decreases when placed on the fenceposts with Usnea hirta, but shows no respiration rate differences when left on the soil, its natural habitat, on ZAP plots B, C, and D. Ponderosa pines, not really testable on the ZAP sites, seem to be showing leaf tip burn when collected from sites close to Colstrip, according to C.C. Gordon, but I cannot yet detect any visible anatomical damage in Usnea hirta collected from the same or similar sites. The respiration rate of lichen samples from these areas is not significantly changed from baseline rates, and total sulfur content assays for 1976 are not yet completed.

c. No population level changes in lichens, either on the Ponderosa pines or on the soil, have been observed. No changes were expected at this point.

2. Lichens are considered to be an indicator organism; an indicator organism should be sensitive at very low levels of stress -- an "early warning system." It should exhibit effects from stress that are expected to be found in other organisms, but in less time and at lower levels of stress. If the pathological effects of SO_2 are identified in the indicator organism, then other ecosystem components can be observed for signs of similar chronic insidious reactions, and warning can be sounded before acute damage is economically and ecologically more important organisms occurs.

My goal is to get a documented graph from the ZAP site results that would look something like this:



3. Increased effectiveness of the lichen work will result from quantifying the intensity of reactions to the SO_2 stress on the ZAP sites and observing specific structural and physiological processes that occur in other plants so information can be transferred to and effects can be anticipated in other vegetation.

4. Although lichen work is the primary raison d'etre of this project component, comparable data on plants associated with the lichens is also being gathered, the importance of lichen indicator properties can be assessed in context. We hope to scale susceptibilities and sensitivities of ecosystem components.

Revised Objectives

Gross observations of respiration rates, plasmolysis, bleaching, loss of thallus integrity, conductivity of water around soaked thalli, and increased bacterial growth on *Parmelia* from the ZAP sites have led me to "think small." My objectives remain similar, but methods are somewhat revised, and refined.

1) To document changes in lichen communities. I see this as a long-range sampling problem; this should result in a good survey of a Ponderosa pine epiphyte community.

2) To determine relative sensitivities of lichens, grasses, and Ponderosa pines.

3) To document some subcellular changes in *Usnea hirta* and *Parmelia chlorochroa* when exposed to SO_2 stresses.

Research Plan

Usnea hirta thalli were soaked in distilled deionized water for up to 4 hours, then the water was tested for conductivity. It increased when it had contained SO_2--stressed Usnea. This indicated membrane damage and electrolytes leaking out of the cells into the water; therefore, I am attempting electron microscope studies of the Usnea cells hoping to photograph subcellular changes. It is taking a great deal of time to determine the infiltrating and embedding procedures for the damaged thalli, but I feel this effort will accomplish good things. It would also be interesting to examine grass leaves and pine needles for comparative studies.

Parmelia chlorochroa samples collected from ZAP sites B, C and D have consistently showed increased bacterial populations clustered around the fungal hyphae. This indicates exudates, probably nutritional, are leaking out of the cells. A project to identify nutritional groups of these bacteria is about to be undertaken with the help of a MSU soil microbiologist. The implications of this are exciting, and the procedure can be extended to examining roots from the ZAP sites and perhaps also to stressed pine needles.

I am continually collecting data on several organizational levels: tree and ground lichen communities; and gross organismal conditions such as thallus color and integrity, respiration rate, and sulfur accumulation. My next steps must include: 1) subcellular effects, e.g., electron micrographs; 2) interactions with other organisms (the bacterial communities); and 3) comparisons on these suborganismal levels with grass roots and leaves and Ponderosa pine needles.

THE COLSTRIP, MONTANA COAL-FIRED

POWER PLANT PROJECT

WORKSHOP 76

PRODUCTIVITY AND BIOMASS SAMPLING WORK GROUP

This group was asked to:

1. evaluate this work to determine how it might more effectively to satisfy overall project goals.
2. identify other tasks with which this task might interact more effectively.
3. define relationships between the biomass sampling techniques of CSU and the Daubenmire technique of MSU.
4. consider developing a non-destructive method of biomass estimation. Explore the use of a double or multiple sampling program which might reduce the need for destructive sampling.

The group initially directed itself to the question of the utility of the presently available biomass data. There was general agreement that the sensitivity of the currently used technique was not sufficient to answer all of the potential questions about the effects of SO_2 fumigation on primary production but that the most important questions from an economic point of view were being satisfactorily addressed. Given the precision of assessment of livestock carrying capacity and livestock production, primary production estimates with standard errors of 15 percent are sufficient. Since large scale changes in net primary production calculated from harvest data have not occurred, the committee felt it was important now to place a large effort into assessment of the quality of the plant material and various physiological measurements of plant performance. Many of the discussions of a wide variety of potential effects of SO_2 fumigation on primary producers converged upon the subjects of the quality of plant material for herbivores (both ruminants and non-ruminants) and plant physiological alterations. A considerable amount of time was spent speculating upon explorations for the lack of differences in net primary productivity among treatments in the field experiments. An hypothesis that emerged from those discussions was that carbon fixation and herbivory were both depressed by SO_2 fumigation. Initial (but scanty) support of this hypothesis is found in some of the invertebrate data and the initial dry-matter digestibility data.

In discussion of the future needs for biomass data, there was general agreement that while it represented a basic resource for many projects, several other aspects of primary producer functions were more important at this point in the project. Indirect measurements of plant biomass were discussed and the general recommendation was that harvesting be limited to perhaps one date per year and indirect methods be utilized to their maximum benefit. Many techniques are presently available for indirect assessment of aboveground biomass and while all have shortcomings, a suitable one can probably be found to meet our needs.

THE MONTANA COAL-FIRED POWER PLANT PROJECT

WORKSHOP 76

PLANT PHYSIOLOGY WORK GROUP

This group was asked:

1. To review the present role of the plant physiology task of the CFPP project.

2. To define the role this work is likely to play in the development of an impact assessment protocol.

3. To revise the present role of the plant physiology task if necessary, in the light of 2. To increase the effectiveness of this project component.

4. To develop new mechanisms of interaction with other project components that will facilitate the realization of revised objectives from 3.

The following tasks are ongoing or completed:

a) The determination of acute injury thresholds of Western Wheatgrass Bluegrass, Prairie Junegrass, Needle & Thread Grass, and Fringed Sagewort to either; SO_2, NO_2, O_3, SO_2 + NO_2, or SO_2 + O_3. This study is completed.

b). Determination of the metabolic status of plants subjected to various SO_2 levels on the ZAP site. The levels of organic N, total available carbohydrates, P, K, Mg and are determined in various plant parts at several times during the summer.

c). Measurements of deposition rates of SO_2 into plant canopies, and the movement of S within the plant.

The following new projects are suggested:
These proposed studies, generally relate to the field-experimental study.
a). Plant water relations. Determine the effect of the SO_2 treatments on plant water use. There is a need to measure both the soil water content and plant water status.

b). Effect of plant water status on plant responses to various SO_2 levels. Determine if and to what extent plant water potential may alter the plant response to SO_2.

c). Effect of SO_2 on plant carbon exchange. Measure the effects of SO_2 on photosynthesis, photorespiration and respiration. Determine if the S content of the air or the leaf is the factor that controls photosynthesis.

d). Plant pigments. Study the pigment types and levels in vegetation to see if the pigments changes can explain color differences seen on film (remote sensing).

3). Plant sensitivity. Extend the species sensitivity list to new species. Also include the effects of night fumigations on injury thresholds.

THE COLSTRIP, MONTANA COAL-FIRED POWER PLANT PROJECT

PONDEROSA PINE STUDY GROUP

This group was requested to produce:

I. Revised Objectives for the Ponderosa Pine Plant Disease Work

II. Research Plan Addressing Revised Objectives

III. Plan for Interaction with Other Project Components

Introduction

Currently there are fifteen growth/health functions being investigated for ponderosa pines growing at permanent sites located 5 to 83 kilometers from Colstrip, Montana. Based on two years of study on these parameters, thirteen of the growth functions appear to be excellent indices of air pollution impact upon ponderosa pine, while two parameters are clearly poor indices. These latter two are (1) chlorophyll a and b concentrations in pine foliage and (2) internodal lengths of ponderosa pine stems from the upper or lower crowns.

The two baseline chemical assays of ponderosa pine foliage are total sulfur and fluoride concentration of whole needles exposed for five years to three months to the atmosphere of the Colstrip study sites. Both of these elements already appear to be excellent measures of potential air pollution damage to ponderosa pines.

I. Revised Objectives

We propose to conduct two new studies of the growth/health parameters of ponderosa pine this coming year. These two studies are:

1. Pollen viability

2. Tannin concentrations in ponderosa pine foliage growing on abiotic stressed and non-stressed trees.

The objectives of these studies are:

1. To ascertain the potential damage of SO_2 and HF to ponderosa pine pollen viability and pollen tube elongation.
2. To assess reduction of tannin concentrations, if any, in ponderosa pine foliage that is stressed by chronic or acute concentrations of phytotoxic emissions of coal-fired power plants or by other environmental stressors.

II. Research Plan

Pollen viability

The techniques to be utilized have been adapted from those of O'Kelley (AIB, March, 1955) and Facteau (Amer. Soc. for Hort. Sci., 1973).

Pollen collections will be made at (or near the vicinity of) our sites on Kluver's and McRae's properties as well as the Morning Star site located on the Northern Cheyenne Reservation. Collection of ponderosa pine pollen from a polluted area will be carried out either at Billings, Montana (800 meters from the 180 MW Corette plant) or at Sydney, Montana, where a 140 MW coal-fired power plant is located.

Since pollen production of individual ponderosa pine trees is intermittent and of irregular occurrence, we will not necessarily sample from our ten permanently marked trees on the Kluver and McRae properties, but will select those closest in proximity to these sites as possible.

The importance of this objective lies in the fact that the perpetuation of ponderosa pine forests depends upon successful sexual reproduction.

Tannin Studies

Tannin studies will be carried out on ponderosa pine foliage and selected destructive insects feeding upon this important timber species. The methods employed will be a modification of those perfected by Feeny (1968) for his oak studies and again modified by Dr. Gordon Orians (1976) from the University of Washington as discussed with him at the workshop at Corvallis in November.

This study has real potential for answering the questions that arise in areas where trees experience chronic air pollution. Numerous investigators (Evenden, Carlson, and Gorden) have noted that a high incidence of insect infestation occurs in a pattern around stationary sources of of air pollution which corresponds to the pattern of air pollution damage to the trees.

Feeny and Prians have shown in their studies that when vegetation comes under stress from abiotic causal agents (i.e., drought), tannin concentrations are reduced in the foliage. The foliage thus becomes more palatable to chewing insects (spruce budworm, tent caterpillar). These studies have demonstrated that due to tannin reduction of stressed foliage, the protein of the foliage is more digestable to insect larvae and thus the reason for the beginning of the epizootic infestation.

Justification: As the ponderosa pine trees of the Colstrip area are stressed by chronic levels of SO_2, NO_x, and HF, it is more than likely that they will be predisposed to insect infestations, as was found by Evenden for stressed ponderosa pine in a 35-mile area south of the Trial, B.C., lead smelter in the 1930's. While this phenomenon of epizootic infestation has been observed and repeated in other air pollution areas since that time (i.e., Kittimat, B.C., 1960; The Dalles, Oregon, 1963-75; Columbia Falls, 1970-74), no one working in these areas has applied the studies of Feeny and Orians to the study of the etiology of insect infestation associated with air pollution stress.

Colstrip is an excellent area to incorporate the findings of Feeny and Orians into our past two years of baseline insect and chemical studies on ponderosa pine. We propose to start slowly on this project during the coming year and have been offered guidance and help from Dr. Gordon Orians (University of Washington) and Dr. Fred Shafizadeh (a tree and wood biochemist here at the University of Montana Chemistry Department). We believe that this proposed study has tremendous potential not only because of the prevalence of ponderosa pine in the study area but also because most plant species (especially the shrubs) of the Fort Union Basin have substantial quantities of tannins which potentially could also be reduced by air pollution stresses. We intended to present a much more thorough write-up on this objective and justification in our upcoming three-year proposal in December of this year.

III. Interaction Plan

From the November Corvallis workshop, it became apparent that much more interaction between our field and laboratory studies could be accomplished than in the past. Consequently we gave verbal (now written) commitments to the following principal investigators:

1. Sharon Eversman: To periodically collect lichens for her during the winter months at the ponderosa pine sites where she collected samples last summer for her field-experiments.

2. Jack Taylor: To have photographer (Don Dodge) train under Taylor in the use of the USFS density slicer so that Don can spend a month with Taylor's aerial pictures here in Missoula in an attempt to obtain as much data as possible from these photographs.

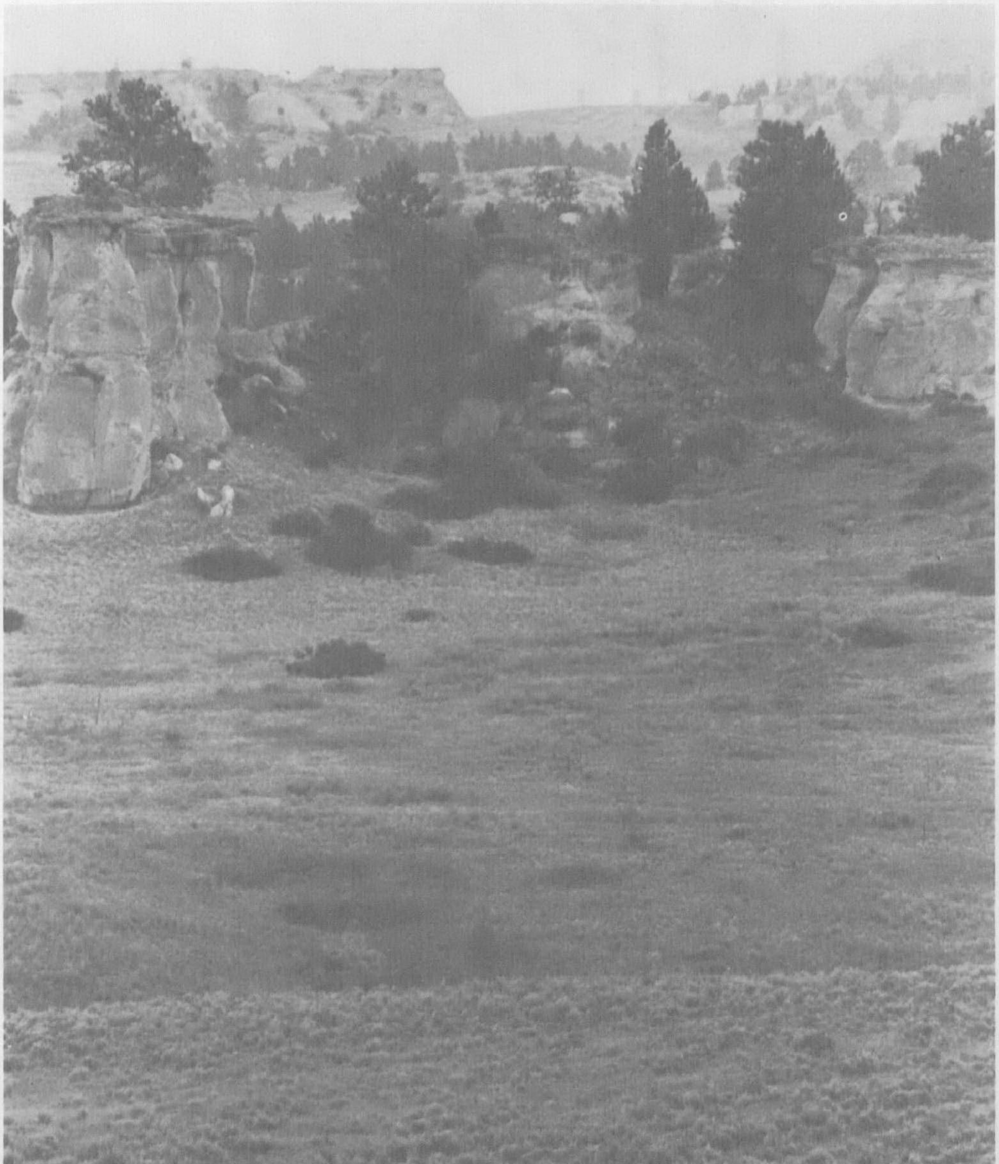
3. Bill Laurenroth and Jerry Dodd: To help their laboratory technician set up sulfur analysis procedures for vegetation samples from the ZAP sites.

4. John Leetham: To help design field experiments concerned with feeding-responses of insects on SO_2-stressed vegetation.

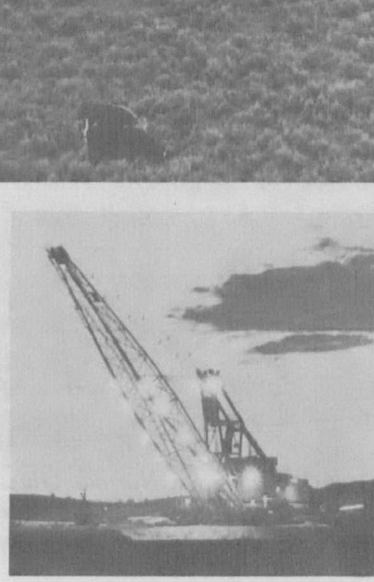
5. To present all participating principal investigators with our current field study data rapidly and prior to the next year's study.

RESEARCH ON THE PLAINS

By Charles Pierce



Barely visible in the center of the horizon line in this Montana plains scene are the tips of the twin stacks of a new power plant several miles away from where cattle are grazing in the foreground.



This dragline works through the night to strip the earth from rich coal seams near Colstrip, Mont.

Standing on a butte in southeast Montana you could see a herd of cattle grazing on the bronze-colored grasses of late summer. A whinnying sound floated in from the distance where the tiny figure of first one horse and then several could be seen galloping down a slope toward a ranch for their evening feed.

All around was a countryside bathed in shadow and sun under the cloud-streaked big sky. To the south was the Rosebud Creek Valley where Custer camped on his way to doom at the nearby site of Little Big Horn.

Now, however, even the memory of this old battle could not disturb the peace of this scene where the only noise was a breeze ruffling the branches of the butte-top ponderosa pines.

Then you noticed on the far horizon the electronic aircraft warning lights pulsing rhythmically every few seconds on the barely discernable tops of the twin towers of a huge power plant seven miles away at Colstrip.

And you were reminded of a new and often bitter struggle in the plains country over the issue of whether the grasslands should be stripped for coal to help fuel power plants not only in Montana but for energy-hungry cities elsewhere in the Nation as well.

Immediately below was another reminder: a fenced-in acre of grassland and a mobile air quality monitoring trailer, part of a major project being conducted by EPA's Environmental Research Laboratory headquartered at Corvallis, Ore.

EPA is attempting to learn how this beautiful countryside can be protected from coal fumes discharged at the Colstrip power plant, some 100 miles east of Billings, Mont.

Dr. A. F. Bartsch, Director of the EPA laboratory at Corvallis, explained that "this project has national significance because we are attempting to develop information which can be used to minimize the environmental impact of all coal-burning plants.

"Recognizing that the United States is moving toward the use of coal as the primary fossil fuel, EPA is seeking to reconcile the Nation's energy needs and our obligation to protect the environment.

"The study, which is being carried out by EPA scientists with the aid of researchers from three State universities, is attempting to determine the effect of the power plan

Charles Pierce is Editor of EPA Journal

Reprinted from EPA Journal, November/December, 1976

fumes on the grassland's animals, insects and plants. An important objective is to determine which forms of life are the most sensitive and reliable measures of air pollution.

"Once the information is obtained, it can be developed into a protocol or guidebook on how to site power plants so that they will do the least damage to the environment. Information accumulated in this research project, which is also expected to prove enormously valuable in developing improved air quality standards for the future, is being analyzed at the Corvallis laboratory."

The setting for the Colstrip power project is spectacular.

Towering draglines work day and night seven days a week to remove the earth covering the huge coal seams 30 to 160 feet below the surface. The coal is then loosened with dynamite and loaded by enormous shovels which can bite off 15 tons of coal with one sweep of their buckets. After being loaded onto heavy duty motor carriers the coal is taken to conveyor belts. The belts take the coal either to the nearby power plant or to a site where it is loaded into 100-car trains. Autos back up on the highway at the main rail crossing outside Colstrip as rail cars roll by carrying the fuel which will light homes and power factories in the Middle West. An estimated 11 million tons of low-sulfur coal will be mined in the Colstrip area this year.

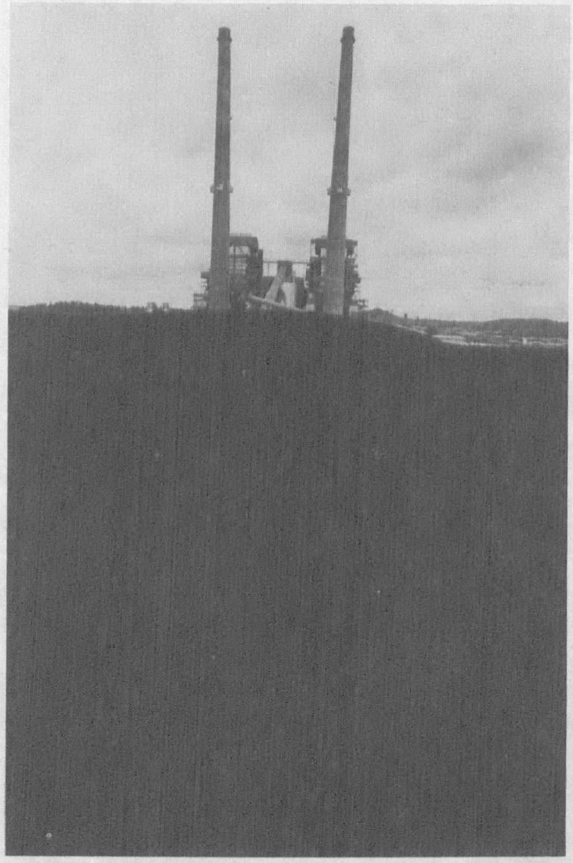
Nearby are enormous earthen furrows largely barren of vegetation which were left after strip mining started in this area 50 years ago to provide coal for steam locomotives.

The new power plant rises like a giant battleship riding the prairie sea. At night, with its hundreds of lights, it sparkles like a great beacon. From outside voices can be heard booming over the plant's internal loudspeaker system.

A short distance away is the company town of Colstrip with its scattering of permanent homes, trailer camps and new recreation building and park still in the process of being built.

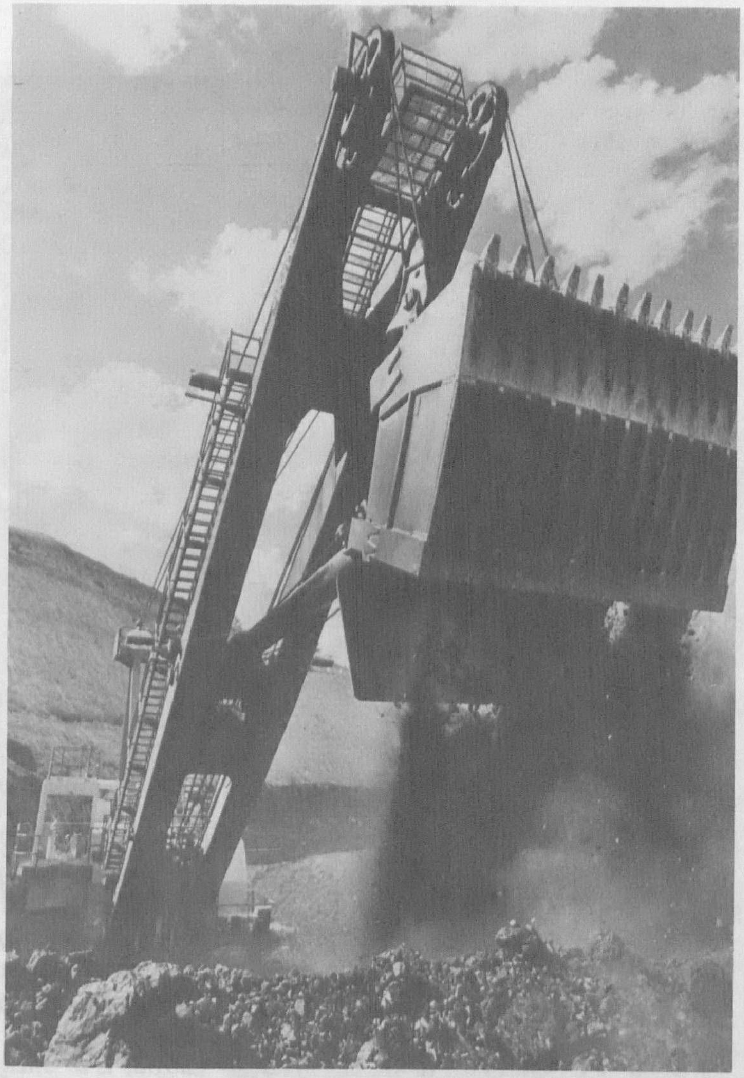
The surrounding silent prairie seems to stretch forever under the star-drenched night.

"A raw, vast, lonesome land, too big, too empty," wrote A. B. Guthrie about Mon-



Coal is stockpiled in front of towering power plant.

Dr. Eric Preston (left) and Dr. Norman Glass, two EPA scientists, review data from a meteorological station at a "ZAPS" site. In the background are the pipes used to stress the area with sulfur dioxide fumes.



Shovel takes huge bite of coal.

tana in his novel, *The Big Sky*. "It made the mind small and the heart tight and the belly drawn, lying wild and lost under such a reach of sky as put a man in fear of heaven."

At night the plains are alive with deer mice, voles and other nocturnal creatures, some of which are caught in traps set as part of the EPA research project. They are released the next day after being weighed, measured and thoroughly checked for indications of pollution injury.

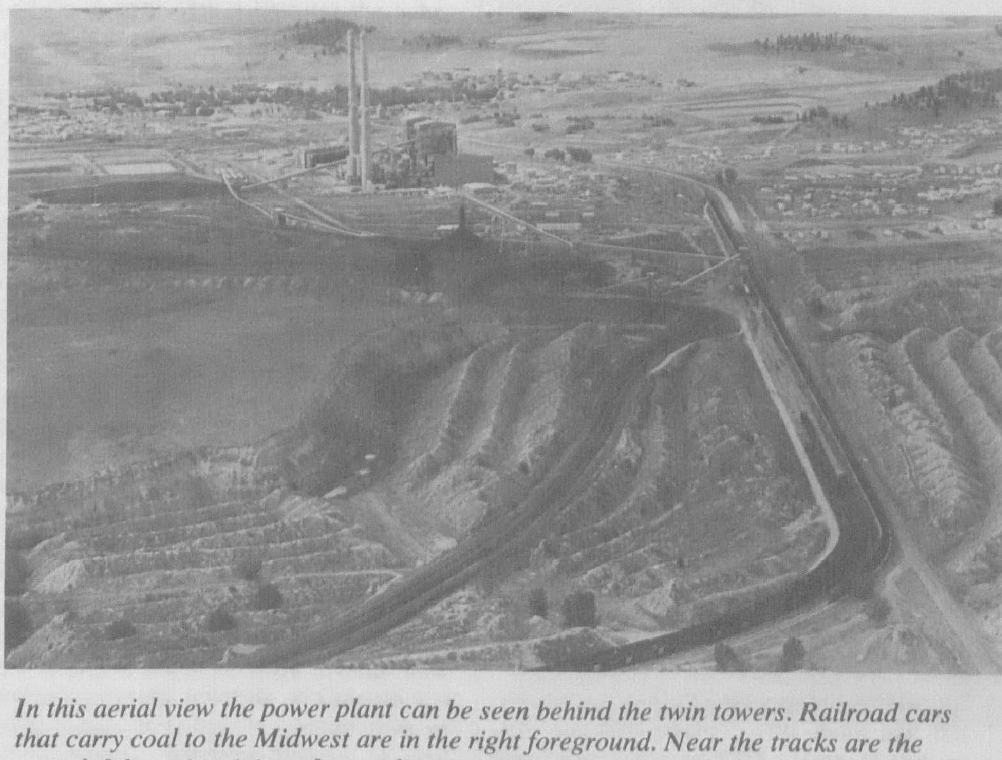
In the daytime as one walks across the plains, jillions of grasshoppers explode under foot, flying off like so many tiny firecrackers.

Driving along the bumpy prairie roads frequently crossed with metal cattle guards, you pass fields studded with hay stacks and occasional lofty buttes. Flocks of mourning doves and meadow larks burst into the air sporadically as the car goes by.

While the grasslands in this semi-arid region are fragile, they teem with life. And all forms of this life are being screened by the project scientists for possible duty as early warning sentries of sulfur dioxide pollution.

One of the humbler forms of life, the mosslike lichen, promises to be one of the more effective in detecting the presence of the pollutant.

The two main research areas are at Hay Coulee, about nine miles southeast of the power plant, and at Ft. Howes, a site



In this aerial view the power plant can be seen behind the twin towers. Railroad cars that carry coal to the Midwest are in the right foreground. Near the tracks are the scars left by strip mining of an earlier era.

Giant shovel dumps coal from huge seam into waiting carrier.

about 65 miles further southeast in the Custer National Forest.

At the coulee (a dry gulch or ravine) site, an air quality monitoring trailer records the amount of sulfur dioxide and other pollutants as well as wind speed, humidity, rainfall and solar radiation to collect complete data.

Intensive studies are conducted on such plants as bluejoint, needle and thread, crested wheat and blue grama—all grasses eaten by cattle and sheep on these rangelands.

As part of the study Dr. Eric Preston, EPA field project manager, conducts a periodic bird census in the area. Beginning a half hour before dawn he stops at stations every half mile along a 30-mile route around the plant to record either by sight or song the number and variety of birds present.

So far no significant impact on the grasses or other forms of life has been detected at the Hay Coulee site. However, the project scientists report that so far the power plant has not been in full operation.

Dr. Norman Glass, Director of the Corvallis Laboratory's Ecological Effects Research Division, explains that the study is "the first major attempt to develop methods that can predict bioenvironmental effects of air pollution before damage is sustained."

The project was started in 1973 to obtain useful "before" and "after" data on the impact of fumes from a coal-burning plant. The first 350-megawatt unit of the Colstrip power plant began operation spasmodically in 1975 and the second unit started intermittent operation last summer. The two 500-foot power plant stacks are equipped with "scrubber" devices, pollution control mechanisms designed to reduce the amount of sulfur in the emissions from the plant. Construction of two additional larger generating units at Colstrip has been proposed by Montana Power and four other utilities from the Pacific Northwest.

In the past air pollution field research has concentrated on the direct impact of air pollution on vegetation after the damage has occurred. Also little information has been available on the effect of relatively long-term low-level pollutants.

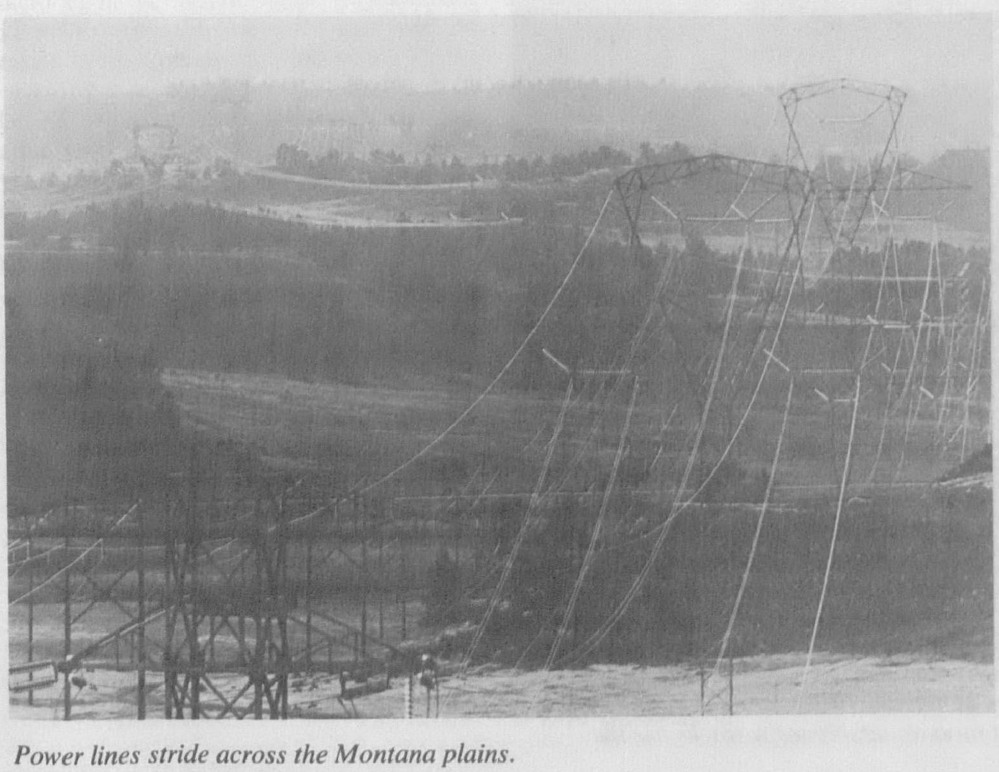
The Colstrip area was picked for the study for many reasons, including the fact that it is representative of a relatively large portion of the North Central Great Plains. It is a rangeland where the vegetation and the non-migratory animals have had to endure such environmental problems as drought, freezing temperatures, and scorching heat but never the added stress of air pollutants.

At a remote grassland area in the Custer National Forest, near the Ft. Howes site, experimental stressing of two four-acre sites, known as "ZAPS" (zonal air pollution systems) tracts, is under way.

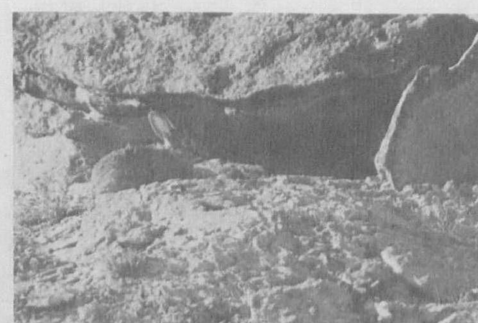
Each tract is criss-crossed with what appear to be metal irrigation pipes. However, instead of water the pipes are releasing the fumes from tanks of sulfur dioxide

Continued on page 14

The large net is dropped from its boom to collect insects for EPA's study of the impact of sulfur dioxide fumes. Resting on the pipes used to distribute the sulfur dioxide is a "sticky cup," a trap used to catch flying insects.



Power lines stride across the Montana plains.



Rabbit outside his lair at the base of a Montana butte.

at carefully controlled concentrations.

Progressively greater amounts of this pollutant are released on the plots in each tract.

Dr. Glass remarked on an inspection tour of the site that the "sulfur dioxide pollution here is equivalent to that on an average summer day in Philadelphia. We tried to get the pollution up to the Chicago level, but we didn't quite make it."

Dr. Glass explained that EPA is fumigating two four-acre sites and may start a third one if funding can be found because "we don't want to put all our eggs in one or even two baskets."

At the ZAPS sites various types of traps are used to collect insects and small animals, and detailed studies are made of all plant forms.

Dr. Sharon Eversman, a lichenologist and biology instructor at Montana State University at Bozeman, reports that at the ZAPS location, as in other areas around the world, lichens show great sensitivity to the sulfur dioxide fumes.

"After no more than 30 to 60 days of exposure to the sulfur dioxide, the lichen respiration rate goes down and the algal cells begin to bleach," Dr. Eversman reports. "The whole appearance of the lichen which is normally a greenish gray becomes yellowish.

"While the grasses don't appear to show much difference between the progressively more polluted ZAPS sites, the lichen certainly do. I think this is because the lichen get all their water and nutrients through the air. They have no roots and so there is no filtering by the soil before the water and nutrients are received."

Universities and their team leaders working on the research project under contract with EPA are:

Colorado State University, Jerry Dodd; Montana State University, John Taylor, and the University of Montana, Clancy Gordon.

Strip mining of the enormous coal supply available in seams averaging 25 feet in thickness was started by the Northern Pacific Railway at Colstrip in 1924. At that time the coal was used to fuel steam locomotive boilers. However, the railroad discontinued its mining in 1958 when its steam engines were replaced by diesel locomotives.

In 1959 the Montana Power Company acquired the Northern Pacific's large mining machinery, the townsite of Colstrip and mining leases covering 75 million tons of coal resources. Western Energy, a coal mining subsidiary of Montana Power, later obtained additional leases in the Colstrip area to bring the total to about 850 million tons of coal resources.

Cattle browse on plains grass.

Some of this coal is shipped to midwestern utility companies in Illinois, Wisconsin and Minnesota and much of it is used by Montana Power Co. plants, including the two new generating units in the coal mining area known as Colstrip 1 and 2.

Dr. Glass estimates that EPA is spending approximately $900,000 a year on the Colstrip research project, with about half this sum being spent by EPA scientists and the remainder being used to finance work by State universities and other Federal agencies cooperating on this project.

"We hope to complete the project in another year to two," said Dr. Glass "and be in a position then to provide advice on optional siting of power plants with the least amount of environmental damage.

"Also, we hope to develop a protocol or method for determining potential environmental impact of power plant emissions before the power plant is constructed, which could be used by public and private utilities and State and Federal Government agencies in assessing power plant sites before energy development occurs." ■