A MANAGEMENT MODEL FOR VEGETATION PEST MANAGEMENT ON ELECTRICAL UTILITY HIGH VOLTAGE AND EXTRA HIGH VOLTAGE TRANSMISSION RIGHTS-OF-WAY

BY

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ABSTRACT

A complete management model, that addresses the conflict between tall-growing woody plants on electrical utility rights-of-way in North America and the aerial transmission of electricity, is developed and discussed in the context of expanding demands for reliable electricity while minimizing environmental impacts.

The present land area alienated by rights-of-way is documented and the projected growth of electrical systems examined with possible right-of-way acreages calculated from now until the last decade of the century. The increasing difficulty utilities are experiencing in obtaining rights-of-way is noted and it is concluded that public awareness has, in recent years, been directed toward both the aesthetic and technical aspects of transmission line maintenance. This problem is most pronounced near urban centres, but is now extending to electrical transmission systems in all localities.

The problems of underground transmission of electricity are reviewed and likelihood of dramatic technical advances in the near future discounted.

The design and maintenance criteria for rights-of-way that ensure uninterrupted transmission of electrical energy are examined in order to provide a benchmark for a later discussion of vegetation management objectives and methods.

Techniques and implications of selective retention of woody plants on rights-of-way to improve appearance and reduce maintenance cost are discussed. The clearing of new rights-of-way using similar practices is also examined. The rationale for vegetation management on rights-of-way is stated and the important continuum of planning, from time of initial route location through construction to eventual maintenance is recognized. It is concluded

that recent statutory requirements for environmental impact analysis in the United States and Canada will improve the present uncoordinated process.

Attempts by various agencies to outline vegetation management practices are suggested as largely inadequate and the importance of comprehensive management offered as a more suitable alternative.

A simplified management model summarizes the components and concerns of an advanced integrated right-of-way vegetation management program. Strengths of the model include logical analysis of program components, facile planning aids, and ready comprehension by those not directly concerned with vegetation management. Five detailed appendices provide the vegetation manager with the working procedures for a complete vegetation management scheme.

In appendix A, various theories that have been developed to explain plant succession on disturbed lands are reviewed and their implications for long term vegetation management discussed. The incautious use of herbicides as a common practice in attempting to obtain stable plant communities is documented from the literature. The benefits which evolve from biologically sound vegetation management are discussed and it is concluded that a wide variety of opportunities and benefits exists.

In appendix B, the support services included in a vegetation management program are examined in detail. The importance of accurate up-to-date information is stressed and a system of historic profile preparation and automated field data collection developed. A specialized image track and information recording system is given. Advanced photogrammetric systems are examined and the results of a test using signature enhancement of right-of-way vegetation with a scanning photodensitometer presented. It is concluded that low-level high resolution photography holds considerable potential for automated vegetation detection and analysis.

In appendix C, the importance of inventories, workload analysis, work records and costing, reports, support services and documents, and support listings, in a complete vegetation management program is examined.

In appendix D, the role of communications in successfully accomplishing the basic objectives of a utility vegetation management program is expanded from an initial discussion of public acceptance of vegetation management and of human abilities to be objective, retain information, and discern accurate information sources. The responsibility incumbent on utilities to provide accurate information as to their operating practices is suggested as a public right.

The avenues of information presentation for the public, for various levels of government, and for internal company relations are outlined.

The actual steps involved in determining and executing the tasks which constitute each project in a vegetation management program are described.

In appendix E, the research and development needs for a large utility are addressed in the light of current knowledge and possible areas for continuing study are indicated.

It is generally concluded that electrical system expansion will continue for the foreseeable future and that the conflict between aerial transmission of electricity and tall growing woody plants will remain of concern at least until the turn of the century. Biological principles have been elucidated for ecologically sensitive vegetation management, yet many utilities still do not apply the most prudent practices. A correlation exists between poor record keeping coupled with the long term nature of ecological phenomena and the common, yet inappropriate, short-term management policies endorsed by many senior utility managers. Nevertheless, it appears possible to prepare a comprehensive plan for vegetation management which is ecologically sound, socially acceptable, and economically feasible.

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Page

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF PLATES

LIST OF PLATES (Cont.)

INTRODUCTION

The purpose of this thesis is to outline, in a conceptual sense, the complex vegetation management considerations that form the basis for planning and administering high voltage (HV) and extra high voltage (EHV) rights-of-way in North American electrical utilities.

As such, concerns of socio-legal importance or of civil, mechanical, and electrical engineering are not addressed except where these requirements or responsibilities impinge upon or overlap with the objectives of vegetation management.

It has been recently noted by Odum (1977) that the way to deal with large-scale complexity is to search for overriding simplicity. It is therefore an intent of the present study to provide, in tabular form, a simple outline and summary of those key components that must form the cornerstones of a vegetation management program for all electrical transmission rights-of-way.

An attempt will be made to knit the text and tables into a single entity. However, it is intended that the tabular summaries will be self-supporting without the explanatory discussion, and may suffice as a checklist for planning and review at the working level in utility organizations. In particular, it is hoped that this format may serve as a procedural document for establishment and support by senior corporate managers of an identifiable vegetation management and presence in those utilities not presently harnessing this expertise, or provide a more adequate determination of purpose and administrative method for those with limited resources yet experiencing continued system growth.

Without a full understanding of, and support by, senior management, a vegetation management section cannot expect the necessary recognition which will allow appropriate rapport with other groups within the corporate entity. In turn, this manifestly complicates the process of communication with resource agencies and the general public. Further, these latter groups are often poorly appraised of the functioning of an electrical utility and of the objectives and constraints of a utility vegetation management program in particular. Nevertheless, the vegetation management staff may, particularly at the field level, have more interaction with the general public, both for routine administration of the vegetation management program and in the public hearing process now commonplace for approval of new transmission facilities, than almost all other segments of a utility structure.

It is important then, that the diverse nature, complex technology, social and environmental costs, and supporting rationale be fully understood by all who participate in, or interact with, a utility vegetation management program. Within the utility, this includes the vegetation management group itself, as already mentioned, senior corporate management, the environmental and transmission planning group, and the corporate section responsible for community and public relations.

External to most utilities there is also a clear need for a fuller realization of the necessity for vegetation management programs. Three groups: the general public, the government agencies responsible for overall environmental protection and individual resource agencies can benefit from the presentation of a complete cohesive, yet simple, model of the catenary parts of a scientific utility vegetation management scheme.

In 1945, Novikoff observed that essential for the purpose of scientific analysis are both the isolation of parts of a whole and their integration into the structure of the whole, and the consideration of one to the exclusion of the other acts to retard the development of biological and sociological sciences. There is no doubt that this is true. For example, chemical 'brush' control on rights-of-way has been simplistically substituted for integrated vegetation management in many utilities, to the detriment of both environmental quality and public confidence in utility land managers.

As the major element of concern here is that of complete vegetation management, a holistic approach must by necessity view, and attempt to place, this single component in the context of the broader scope of utility operations. Moreover, it is necessary to examine the interactions between vegetation management and other issues. For example, the moral responsibilities that attend the use of herbicides on easement and public lands, the maximization of right-of-way uses in response to societal objectives, and the execution of a safe, economic and aesthetically sound program must be built on a foundation of good forward planning and justifiable rationale. This rationale must be understood by both political and civil government and the public at large, if the narrower objectives underlying vegetation management are to be attained without social and environmental disruption.

Although the central theme is that of vegetation management and in particular the management techniques appropriate to control of tall growing woody plants which become an unwanted intrusion on rights-of-way, a number of other Tasks impinge upon, or relate to, this primary objective. Collectively these tasks may be viewed as 'environmental maintenance' and should not be divorced from the basic responsibilities assigned to those forces that undertake transmission right-of-way vegetation management.

Staff training, experience, stability of employment, and pride of workmanship should be seen as investments that can be protected with job variety and mutual respect in either "in-house", contractor, or mixed operations. This broader range of tasks on transmission rights-of-way are outlined in Appendix F and the relationship between transmission line work and other utility Elements is discussed in the thesis.

This work then, examines the recent history of growth in electrical systems and discusses expected expansion up to the final decade of this century. The intimate relationship between transmission lines and rights-of-way is described here and the factors that constrain the design and development of rights-of-way, documented. The objectives implicit in a utility vegetation management program are reviewed in the context of underlying rationale. The attempts by various agencies to establish guidelines for right-of-way maintenance are briefly examined and the planning stages prior to construction of transmission lines and their application for later vegetation management are discussed.

A detailed alliterated management model is developed to simplify the principles of a utility vegetation management program. The model is supported by a number of synopses which outline the basic components or considerations which attend such a program.

As the aim of this dissertation is to provide a broadscope view of utility vegetation management, the merits of any particular method of controlling vegetation will not be evaluated. Instead a conceptual framework will be provided within which it is possible to examine the needs and emphasis of any particular Program or Tasks and objectively weigh the Task Method Alternatives.

As will have been noted already, certain terms are "underlined" and it will be seen later that these terms are each used here with a particular context and definition in mind. These terms form the fundamental working words for the management model. Descriptions of these terms as used in this work are given in the Glossary of Terms.

In order to provide the vegetation manager with an extension of the model components, five detailed appendixes have been compiled to address the specific ideas embodied in the more general outline.

Vegetation management programs of the past relied heavily on blanket spraying of phenoxy herbicides since their development in 1942. A few ecologists have argued for more reasoned and biologically sound practices based on practical knowledge, research, and experience of plant succession on disturbed lands. The concepts which should predicate vegetation management programs, the impact of herbicides on plant succession, and the benefits from ecologically sound vegetation control on rights-of-way are discussed.

To function effectively, a utility vegetation program on rights-of-way must embrace a variety of support services. These are examined in detail and supported by examples. Some new concepts for maintenance of historical data and collection of field information are offered.

The criticality of communications is addressed for all facets of an effective program from a concept of human perceptions to a particularized account of communication systems.

The execution of tasks arising from the determination of program needs is demarcated in a practical sense. The logistics of organization, project and job communication, and hazard assessment are examined in detail.

Research and development, the cornerstone of innovative management, is addressed in the final section as a review of needs that are, as yet unfulfilled, but which require elucidation if we are to move into the 21st century with the confidence and conviction that our vegetation management practices are responsive to the natural resources and social structure of our future global community.

HISTORICAL PERSPECTIVE FOR OVERHEAD TRANSMISSION RIGHTS-OF-WAY

Introduction

The science of electricity has its roots in the observation known to Thales of Mioetus in 600 B.C., that a rubbed piece of amber will attract bits of straw (Halliday 1967). The study of magnetism goes back to early observations in Asia Minor that naturally occurring magnetite stones attracted iron particles. These two observations evolved into two simple sciences which developed separately until 1820 when Hans Christian Oersted observed that a current in a wire could also cause magnetic effects, namely, that it could change the orientation of a compass needle. This, and the previous work by Stephen Gray in 1729 which demonstrated the existance of electrical conductors, laid the foundation for a new science of electromagnetism.

It fell to a Scot, James Clerk Maxwell, to put the laws of electromagnetism into the mathematical form known today. The scope of Maxwell's equation was remarkable, including the fundamental principles for all present day large-scale electromagnetic and optical devices, such as electric motors, cyclotrons, radio and television, computers and optical or radar telescopes.

Michael Faraday, born in the same year as Maxwell, had been, in the meantime (1831), experimenting with electromagnetic induction at the Cavendish Laboratory, Cambridge University, laying the way for development of the electric generator. In 1887 Heinrich Hertz experimentally demonstrated the existence of radio or "Maxwellian" waves. Now electromagnetic developments branched into two separate fields not always mutually confident of the validity of the other.

In 1837 Samuel Morse had demonstrated the use of electricity for telegraphy. This work was furthered by a disciple of Faraday's, Sir William Hendry Preece, Chief Engineer of the British Post Office. He, in turn, strongly encouraged Guglielmo Marconi. Preece, a learned and able engineer, responsible for introduction of the telephone into Great Britain, was somewhat less than enthusiastic about the work by the American, Thomas Edison. Sir William soundly declared that "subdivision of the electric light is an absolute _ignes fatuus_". Fortunately, Edison did not feel it such a delusive idea and had perfected his incandescent lamp by 1878.

Almost overnight, the damand for electricity began. The first generating plant went into operation in New York in 1882 (Britannica 1976) and the first electricity in Ontario was generated near St. Catharines in 1898 (Gardner 1971). By 1906 public sentiment had been aroused sufficiently for the Ontario Legislature to pass an "Act to Provide for the Transmission of Electric Power to the Municipalities".

In 1910 a ceremony in the city of Berlin (now Kitchener, Ontario) brought about the "Illumination of the Streets and Buildings by Electricity" - electricity produced and purchased in Niagara Falls, ninety miles away, and transmitted on a 110 kV line. A humble start to the first of many transmission lines and rights-of-way which would eventually form a grid across North America.

Contrary to the assertions of those who could not foresee the growth of power systems, expansion and better service became pressing needs - and with expansion came problems. Interruptions caused by vegetation were frequent: a frequency which neither the customers would tolerate nor the utilities reduce without concerted effort. And thus were lain the foundations for utility vegetation management.

Description of Electrical Utilities and Energy Demand

Spoehr (1956) in contrasting the counter currents which pervade our present society, observed that Darwin and Faraday well exemplify those currents. It is noted that Darwin opened our eyes to the functioning of organic matter, and dealt with man's place in nature as part of a huge dynamic biocoenose of which he was only a small part, actually not very different from the other parts. Faraday, it is suggested, introduced us to inanimate forces which could be made to serve man's needs and wants. He stimulated the invention of new devices and the formation of a new technology based on the use of natural forces. Faraday had brought the excitement attending the accomplishments and application of the physical sciences.

It is concluded that in the modern world where men are dedicated to exploiting to the utmost the natural resources of the planet - a dedication that is stimulated by the very numbers of men on earth - the view exemplified by Faraday is necessarily uppermost. It could hardly be otherwise.

Thus, man wishes to exploit every advantage available from the forces harnessed by Faraday and the other early workers in electromagnatism, and so has grown the demand for electricity - grown to the stage where sudden loss of power can jeopardize the very fabric of civilization that man has laboured to develop over so many centuries.

Aubrey Wager, Chairman of the Board of Directors of the Tennessee Valley Authority, records the view that we must solve our present energy problems quickly or face economic, social, and political consequences that will threaten our survival (Wagner 1977). This view is more bluntly stated by Robert Taylor, Chairman of Ontario Hydro; "Electrical energy made the 20th century possible. Its loss would make it impossible" (Taylor 1975 p.11). The Tennessee Valley Authority and Ontario Hydro are the two largest individual utilities in North America. Wagner further suggests that electrical energy is vital to the quality of life that we all expect. It ranks closely behind air, food and water as essential elements of life today.

By the end of this century there will be a population of an additional 50 million in North America bringing the total in excess of 275 million (Electrical World 1975). All of these people will need, want, and deserve warm homes, food and jobs. As we face the energy future, Kahn (1976) predicts that electricity will have to provide an ever increasing share of future energy needs. Virtually all our basic energy, after we use up our oil and gas, are best used in the form of electricity. Nuclear power can essentially be used only as electricity. Coal's best use as energy is for generating electricity. Fusion and geothermal power, pyrolysis of waste, windpower, the energy of the tides, ocean currents and thermal gradients, as well as the direct energy of the sun - all will find their ultimate use, if any, as electricity, ~~if at all~~.

Historically, the use of electric power has been doubling about every ten years. If current trends persist in the next two decades, the demands for electric power will triple or quadruple. While population growth is responsible for part of this expanding need, the per capita consumption of electric power has been increasing roughly five times as fast as population growth in the United States (Federal Power Commission 1971). McCloskey (1971) estimates that we consume 15 times the energy we did 100 years ago, although our population has only tripled in that time. Stanley (1971) calculates that the proportion of energy required in the form of electricity is currently about 25%, and that present projections indicate an increase to 43% in 1990 and possibly up to 50% by 2000 (Wagner 1977). Electrical energy consumption is thus expected to increase by 284% during the period 1970 to 1990.

Power generation is usually in relatively isolated or wilderness areas near the source of power. Hydro electric plants are on or near bodies of water. Fossil fuel plants are often near the source of fuel. One of the advantages of nuclear power plants is their relative freedom from finite geographical locations. However, in highly populated areas, citizen rejection of local nuclear power plants has happened with some regularity (Robinette 1973).

Transmission lines are the vital links between generating plants and the distribution systems that deliver electricity to the consumer. A strong transmission grid is vital for reliable economic electric service (Energy Policy Staff 1970). Thus, the phenomenal increase in electric power requirements, the necessity for greatly enlarged, reliable and economical electrical systems, and the complex considerations bearing on the location and servicing of power plants and rights-of-way are compounding the problems of the past and creating new and more difficult problems for the future (Bagge 1968).

The reliable use of higher transmission voltages has increased greatly the carrying capacity of transmission lines and made possible the economical transmission of large blocks of power over long distances. The electrical industry is continuing to endorse a move to EHV, with expenditures on transmission systems alone estimated at $2·564 billion in 1975 (Electrical World 1975). Historically, as higher voltage transmission facilities were developed and as larger amounts of power were transmitted without excessive losses, new generation sites were developed to satisfy continuing load growth and the distances between these locations and the market centres of electrical load becomes greater. The growth of high voltage (HV) electric and extra high voltage (EHV) electric power transmission has also made it feasible to transmit large amounts of electric power among several utility systems (Bagge 1968). These systems are thus able to realize considerable financial savings in generating capacity because of time zone and seasonal diversity among their respective peak loads. Also the availability of low cost EHV transmission has made it possible for several utilities to combine resources and construct larger nuclear and fossil fuel generating units, thus realizing the benefits of the economies of scale.

That electrical load growth will continue is without doubt. The challenge is in supplying the growing consumer demand for that energy, to minimize the impact of the necessary generation and transmission facilities on land use, on the environment, and on other aspects of the social structure, while making minimum demands on limited available capital resources (Foster 1975). It is to this end that the following discourse of this thesis is directed.

Description of Electrical Utility Rights-of-Way

Among the various components of the electrical utility industry, the transmission lines and rights-of-way of various sizes are the most pervasive, obvious and ubiquitous item of the infrastructure associated with the industry.

Transmission lines and their linear corridors intrude, or are at least evident, in all types of landscape throughout most civilized nations. The height and size of the structures, the fact that the lines and rights-of-way pervade all qualities and levels of landscape, and that in the past little concern or few guidelines existed for the optimal location and minimum destruction of environmental values by the function of utility operations, all are reasons for the general feeling that they are destructive of the quality of the environment (Robinette 1973).

To Robinette's suggestion that optimal location has sparked the concern about transmission systems could be added the observation that the clearing and maintenance practices of many utilities have also contributed to public awareness. To understand that awareness, and how it is manifest, is to understand the inseparable nature of transmission lines, rights-of-way, and the often outspoken public condemnation of their construction and maintenance.

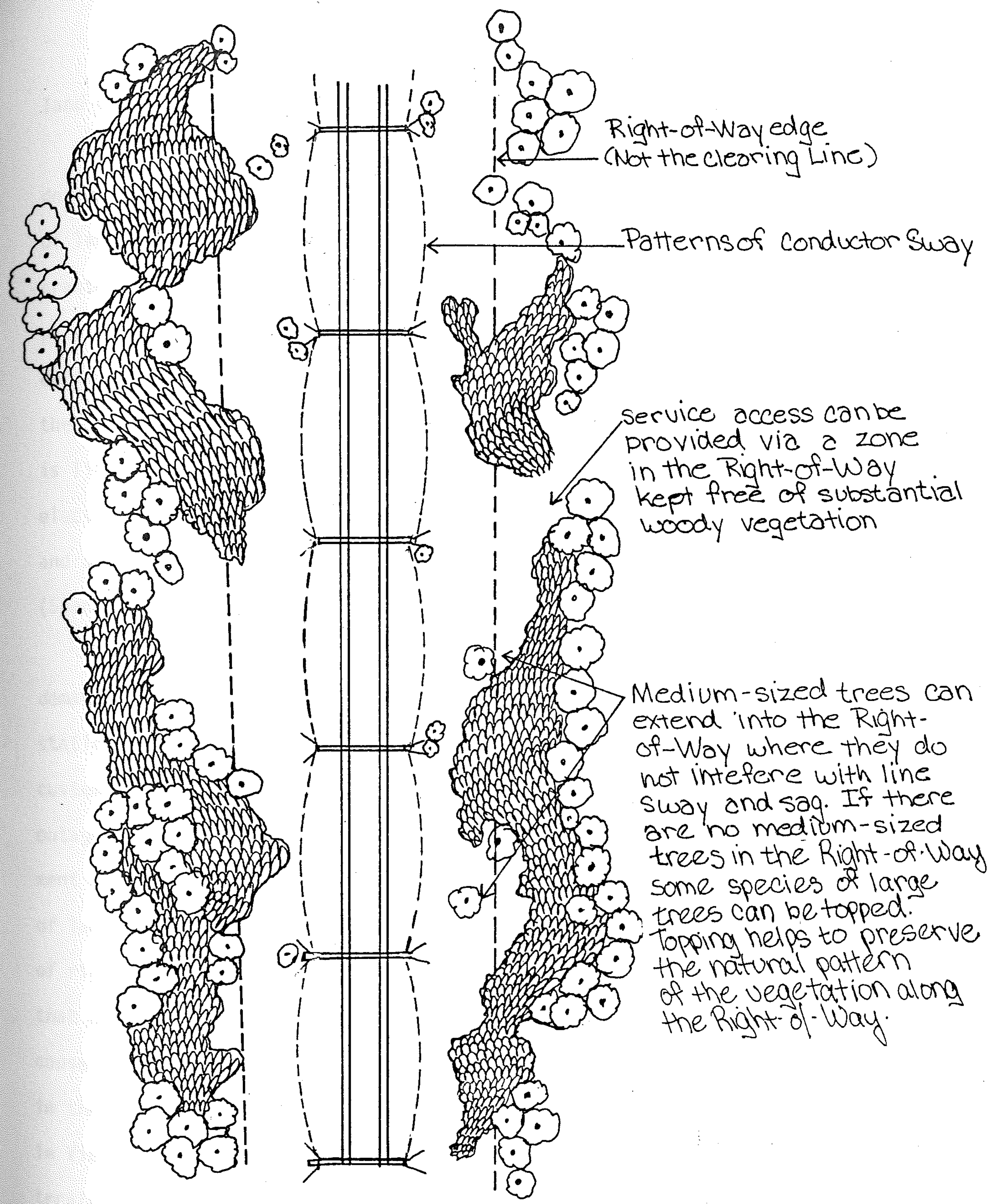
Over 35% of continental North America is considered forested lands (Urban Renewal Administration 1963). With few exceptions, almost all land, left to nature, will support the growth of vegetation. In all but those places where vegetation will not grow, or is restricted in growth through intensive land use or climatic extreme, there is the potential for tall growing plants.

The aerial transmission of electricity depends on its passage through a conductor hung between structures and insulated from earth by air. Because there is an inherent weight in the conductor which in turn is subject to heating and cooling, it will sag in a characteristic catenary between structures. At times of high loading and high ambient temperature, the sag will increase to a maximum reached at mid point in a span. If a wind force is then applied at right angles, the conductor will bulge downwind. As electricity can arc to the ground, especially in moist weather, a minimum acceptable clearance must be established within which no conductive object must approach when all of these factors are in force.

As even a single circuit consists of three conductors not only separated from other conducting materials but separated between phases, a theoretical band, broader at mid point and narrower at a structure, delineates the safe limits of approach for a transmission line (Figure 1).

To secure control over structure sites and the airspace surrounding the transmission conductor, a utility company must negotiate with each

Figure 1 Plan View of a Transmission Line Showing Patterns of Potential Conductor Sway and Retention of Right-of-Way Vegetation


Right-of-Way edge
(Not the clearing Line)
Patterns of Conductor Sway
service access can be provided via a zone in the Right-of-Way kept free of substantial woody vegetation
Medium-sized trees can extend into the Right-of-Way where they do not intefere with line sway and sag. If there are no medium-sized trees in the Right-of-Way some species of large trees can be topped. Topping helps to preserve the natural pattern of the vegetation along the Right-of-Way.

land owner for each parcel of land over which the line may pass.

A right-of-way then, is an accurately located strip of land with defined width, point of beginning, and point of ending. Within this strip of land the user has authority to conduct the operations approved or granted by the land owner in an authorizing legal instrument such as a permit, easement, lease, license or memorandum of agreement. To this definition must also be added those properties actually in ownership of the utility where the land title also confers the right of operation. It is little recognized by the public, however, that the great majority of electric transmission rights-of-way are just that - the right to install and service the line on property that is not purchased from the owner (Spencer 1975).

The conflict which arises is, on the one hand, the ever-increasing demand for electricity and with it the vital links between generating stations and the distribution system which delivers electricity to the customer, and, on the other hand, the need to protect that supply from outages caused by vegetation growth on land often not under direct management of the utility. Further complicating this picture are the pressures of land use especially near urban centres, the demands for multiple use of rights-of-way and the trend toward higher voltage transmission lines that necessitates larger towers and larger rights-of-way. This in turn, causes pronounced aesthetic impact. Finally there is a false association in the public mind between the abuse of vegetation management practices in Vietnam, past contamination of phenoxy herbicides with a powerful teratogen, and vegetation management on utility rights-of-way (Colwell 1971, Wilson 1972, Clement 1973).

Underground Transmission as an Alternative

The mistaken assumption exists that underground transmission of electricity is currently available as a substitute to overhead transmission.

The late President Johnson expressed the growing public concern for the protection of aesthetic, historic, and recreational values before the American congress (Johnson 1965). He proposed that efforts be made toward the achievement of this objective by placing electrical power transmission facilities underground. At a later Whitehouse Conference on National Beauty, the Panel on Underground Installation of Utilities recommended that - "...a greater endeavor in the field of research and development to the end that systems and equipment be developed for the efficient and economic transmission of electrical energy at high voltages underground over long distances".

In 1968, however, the Working Committee on Utilities had concluded that: "Today it is not technologically or economically feasible to place high voltage electric transmission lines underground for long distances."

The technical problems associated with underground transmission are substantial. Electric conductors must be properly insulated. Overhead lines employ air as an insulator except when they are suspended from towers where porcelain or glass insulator strings are used. With underground cables the insulation must be sufficient to withstand the high voltage and prevent leakage to ground, yet be thin enough to offer minimum resistance to the escape of heat. This heat is caused by the passage of electricity in the central core of the cable exciting the molecules of the conductive metal. The electrical insulation of a cable (oil impregnated paper, lead or aluminum sheath and plastic outercoat) also has a low increases and voltage decreases. In order to ensure system stability, shunt reactors (reactive absorption equipment) and synchronous compensators (absorption or production of reactive current) are required on transmission systems.

With a cable system there is spontaneous production of 30 to 40 times the production of reactive current than in an overhead system. A 400 kV cable 40 miles in length, for example, without reactive compensation, will reduce its carrying voltage to zero. Construction of capacitor stations are therefore required along the length of high voltage cables substantially increasing their cost.

Costs apart, a number of further considerations largely nullify the apparent advantages of underground transmission of electricity. Buried cables are operationally about as reliable as overhead lines. However the outage time for repair of cables is far longer and when taken into account, the reliability of equivalent voltage overhead transmission is found to be about 70 times greater (Central Electricity Generating Board 1972). Construction disruption and time is considerably longer than for overhead systems and Howlett (1973) has noted that a right-of-way free of trees and with restricted multiple use capabilities and high potential for erosion problems can in fact produce a higher environmental impact potential than comparable overhead facilities. The U.S. Forest Service (1975) recognizes the difficulty of splicing, the demands for transformation and similar facility sites, the difficulties of construction in rocky terrain, and the requirement for special substructures for river crossings, and makes allowances for these constraints in its underground policy guidelines.

Dr. Solandt in a Royal Commission on the Ontario Hydro proposal for a

Nanticoke, Pickering link in Ontario (Solandt 1974 p.19) concluded that: "Underground transmission by 500 kV cable, while theoretically possible, is still in the developmental design stage. There are no 500 kV cables in operation anywhere in the world, and it is too early to consider the incorporation of sections of a high capacity 500 kV prototype cable into operating power systems."

"A right-of-way for three 500 kV underground circuits would be approximately 160 feet wide. The land would have to be cleared <u>of all trees</u> due to the risk of cable damage from roots and to avoid overheating because of reduction of soil moisture."

"The availability of air as an electric insulator and heat exchanger makes overhead transmission much less demanding of technology than underground."

"The estimated capital outlay for one mile of 500 kV single circuit overhead line is $180,000. For comparison purposes, without regard for the present technical limitations of high voltage cables, the estimated cost of one mile of underground cable is $4.5 million, or 25 times greater."

"Ontario Hydro presented a convincing case that the technology of underground transmission was not yet adequately developed to use it even for a relatively short distance on such an important link on their network as the Nanticoke to Pickering line. Direct current transmission was similarly dismissed as impractical because of the short length of the line and the large number of conversions from AC to DC and from DC to AC that would be required."

The U.S. Federal Power Commission noted in the National Power Survey (Federal Power Commission 1971 p.1-12-9) that in 1970 "there were about

2,000 miles of underground transmission lines in the United States, mostly in densely populated areas where overhead rights-of-ways are not available or are prohibitively expensive. These high voltage underground lines represent less than 1% of the nation's total transmission system."

"From an aesthetic point of view, the underground construction of transmission facilities might seem to be desirable. In wooded areas, however, undergrounding would require a completely cleared swath. Moreover, the earth disruption of burial could heighten erosion, and under certain soil and moisture conditions the heat dissipated into the earth by underground conductors could adversely affect vegetative growth. In such areas, the visual impact of undergrounding could be as pronounced as for overhead installations."

"Another aesthetic consideration in undergrounding alternating current transmission lines is the bulky equipment required to compensate for charging current. Providing such equipment along the underground transmission lines creates siting problems comparable to those involved in locating and designing substations."

The technical limitations notwithstanding, it appears that cost alone is the most powerful deterrent to extensive underground transmission systems. The C.E.G.B. experience suggests that a comparable cost ratio (without allowance for cable reactive compensation) for one mile of underground 132 kV to overhead is some 12 times, for 275 kV some 16 times, and for 400 kV 15 times (Central Electricity Generating Board 1973).

A similar analysis in the U.S. (Bagge 1968) suggests that for 138 kV in a rural situation the ratio is 14:1 and at 345 kV 26:1, without assuring any costs for underground right-of-way compensation or for terminal pothead or ancillary equipment sites.

The Central Electricity Generating Board (1972) concluded in their analysis of underground overhead cost ratios, that these are unlikely to be materially reduced in the foreseeable future. This stance was later reaffirmed in testimony before the Solandt Enquiry in Ontario (Solandt 1974).

Despite a concerted effort on the part of Government, the utility industry, and cable manufacturers, the feasibility of long distance underground remains an elusive possibility for the future (Bagge 1968).

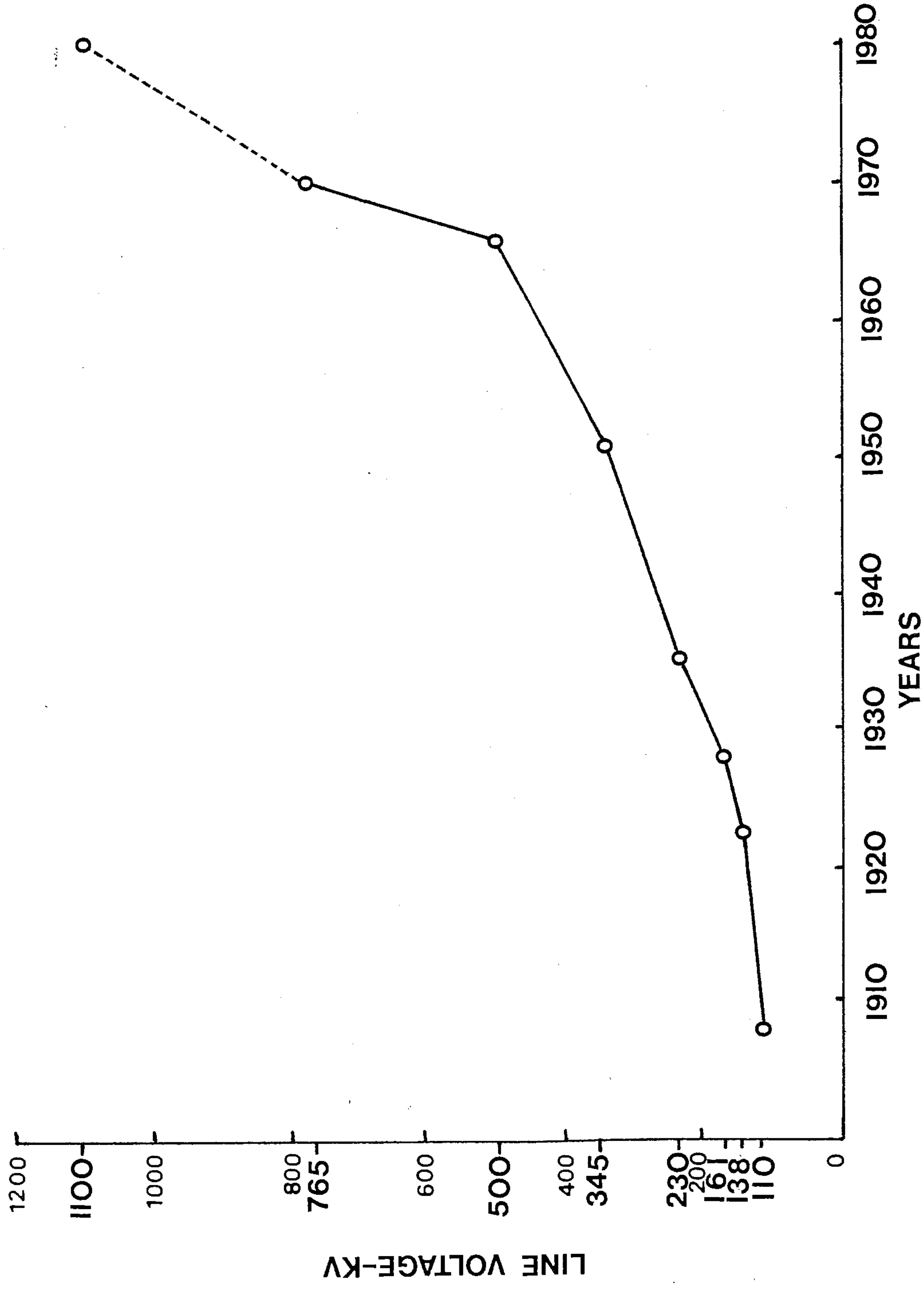
Overhead Transmission and Rights-of-Way at Present

Before examining existing transmission systems serving the United States and Canada, it is useful to examine the historical growth of transmission voltages which have allowed expansion of such systems and the economic advantages which underlie increased high voltage and extra high voltage transmission.

Figure 2 traces the increased maximum transmission voltage as a function of time. From the introduction of 110,000 V. alternating current transmission in 1908 to about 1950, there was a steady increase in voltage levels (Energy Policy Staff 1968). In the past decade progress has accelerated through the introduction of 500 kV in 1965 to the point when Quebec Hydro in Canada and a number of utilities in the United States are operating 765 kV systems and an experimental 1100 kV has been tested by the General Electric Company.

The advantages of HV and, especially, EHV transmission may be summarized: (a) as design load limitations exist for a given kV rating

Figure 2 Increases in Alternating Current (AC) Transmission Line Operating Voltage as a Function of Time (Adapted From Energy Policy Staff 1968 p.66)


LINE VOLTAGE-KV
1200
1100
1000
800
765
600
500
400
345
230
200
161
138
110
0
1910
1920
1930
1940
1950
1960
1970
1980
YEARS

over distance, there are advantages to higher voltages for transmission of energy from generation sites remote from load centres (Figure 3), and (b) higher voltage require fewer conductors to carry the same amount of power (although with a penalty in requiring more massive or structurally stronger towers), fewer structures per mile, greater efficiency in megawatts per acre and therefore lower right-of-way costs despite increased width requirements, Figure 4. Variations in design, conductor materials and configuration, basic insulation levels and operating conditions, render it difficult to present a simple comparison of transmission line costs and capabilities. The figures prepared here represent average values.

The transmission system as of 1970 for the United States is shown in Figure 5. The map represents 40,600 line miles of 230 kV, 1,020 miles of 287 kV, 15,180 miles of 345 kV, 7,220 miles of 500 kV, and 500 miles of 765 kV for a grand total of 64,520 miles. This figure compares favourably with a 1968 total line mileage estimate by the Working Committee on Utilities (1968) of 65,000 miles. By comparison, there were only 2,974 miles of transmission at any voltage above 230 kV in 1940 and only 8,174 in 1950. By 1960 transmission line mileage had grown to 22,379 miles (Federal Power Commission 1971).

There are an estimated 4.4 million acreas occupied by transmission lines in the United States, approximately 2,843,500 acres for the 235,000 miles of line in the classes 69 kV to 200 kV, and 1,573,000 acres for the 65,000 miles in the HV and EHV classes from 230 kV to 765 kV.

In Canada, miles of line by voltage are, however, reported (to Statistics Canada, Energy and Minerals Section) by circuit miles and not by line miles which represented an approximate 10% increase over actual line miles in 1975. In the class 200 to 300 kV there were a reported 16,685 miles, from 300 to 400 kV 4,116 miles, from 400 to 500 kV 2,909 miles, and above 600 kV 3,044

Figure 3 Cost Advantages of Electrical Energy Transmission Over 200 Miles for Four Voltages (Based on Estimates from the Federal Power Commission 1971 p. I - 13-9)

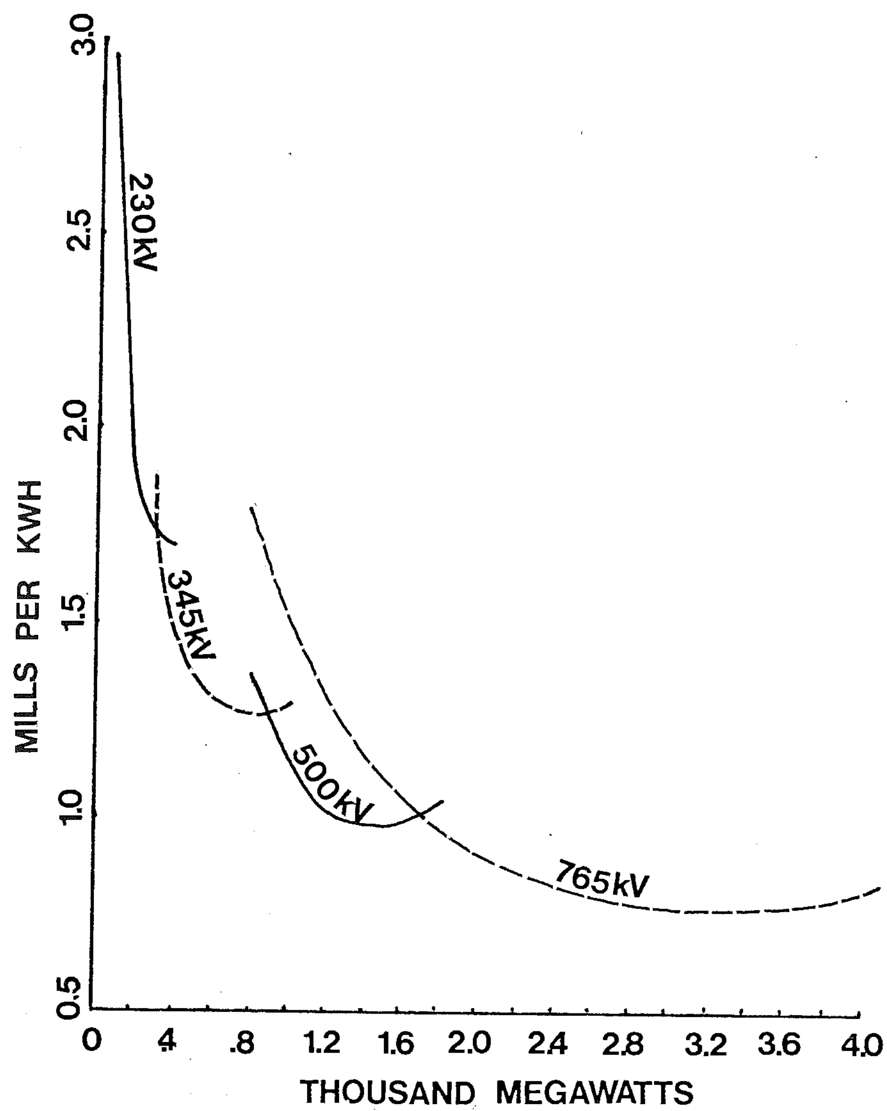

MILLS PER KWH
3.0
2.5
2.0
1.5
1.0
0.5
230kV
345kV
500kV
765kV
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
THOUSAND MEGAWATTS

Figure 4 Increased Land Utilization and Megawatt Capacity and Decreasing Number of Structures with Increasing Voltage. (Calculated from values given by Bagge 1968, and Shah 1975.)

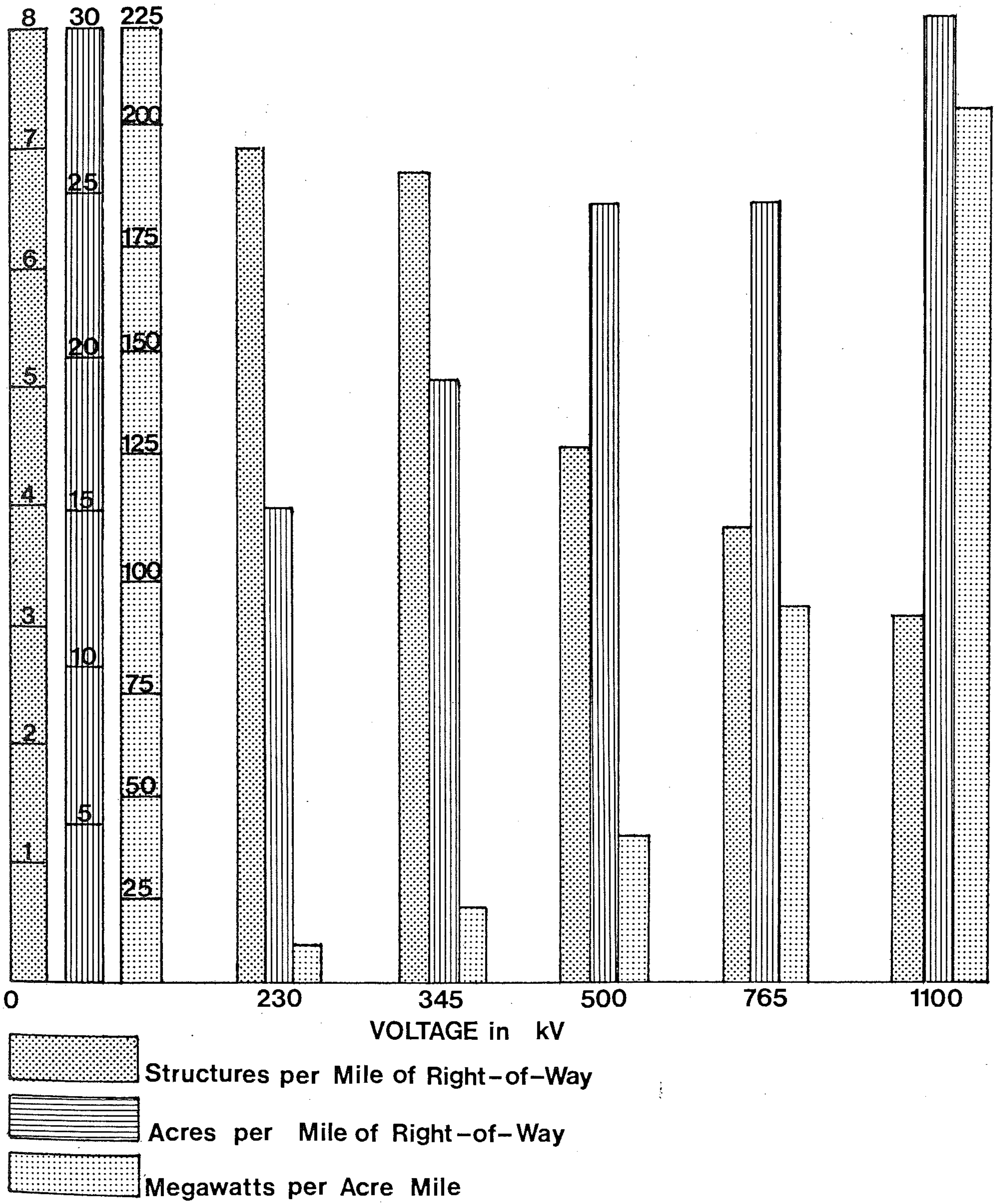

8
7
6
5
4
3
2
1
30
25
20
15
10
5
225
200
175
150
125
100
75
50
25
0
230
345
500
765
1100
VOLTAGE in kV
Structures per Mile of Right-of-Way
Acres per Mile of Right-of-Way
Megawatts per Acre Mile

Figure 5 Existing United States HV and EHV Transmission System in 1970 (From Federal Power Commission 1971 p. 1-18-14)


Legend
230 KV AC
345 KV AC
500 KV AC
765 KV AC
± 400 KV DC
NUMBER OF CIRCUITS
Bangor
Boston
Providence
Hartford
New York
Concord
Burlington
Albany
Trenton
Wilmington
Baltimore
District of Columbia
Richmond
Buffalo
Pittsburgh
Charleston
Charlotte
Columbia
Savannah
Jacksonville
St Petersburg Tampa
Atlanta
Cleveland
Detroit
Louisville
Nashville
Birmingham
Montgomery
Indianapolis
Chicago
Milwaukee
Memphis
Jackson
New Orleans
Peoria
St. Louis
Shreveport
Little Rock
Kansas City
Minneapolis
Des Moines
Omaha
Tulsa
Dallas
Houston
San Antonio
Wichita
Oklahoma City
Pierre
Bismarck
Cheyenne
Denver
Albuquerque
Great Falls
Billings
Salt Lake City
Boise
Las Vegas
Phoenix
Seattle
Portland
287 KV
Reno
San Francisco
Los Angeles
San Diego

miles (Cavanagh 1977). This circuit mileage totals 26,754 miles or approximately 24,000 line miles. This is an increase from approximately 11,000 miles in 1966. No figures are available for present acres occupied by transmission lines in Canada. If a conservative average right-of-way width of 150 feet is used, a calculated acreage of 434,000 acres are probably occupied by HV and EHV transmission facilities in Canada, an increase from around 132,000 acres in the same ten-year period assuming somewhat narrower rights-of-way at the voltages predominant a decade ago.

A combined summary of right-of-way acreage for North America, excluding Mexico, on transmission systems operating at or above 230 kV would appear to be in excess of 2,000,000 acres as of 1970.

Overhead Transmission and Right-of-Way Trends of Growth

A comparison between Figure 5 for 1970 and the projected system in Figure 6 demonstrates the phenomenal rate of growth expected in transmission facilities in the United States between now and 1990. Growth projections determined by the Federal Power Commission indicate an increase to 158,670 line HV and EHV miles excluding direct current facilities (Federal Power Commission 1971). This compares with 165,000 miles suggested, on the same basis, by the Working Committee on Utilities in 1968. This growth rate and a suggested attendant rise from 4.4 million right-of-way acres for all voltage classes (69 kV to 765 kV) to 7.1 million acres is shown in Figure 7.

The impact of technological change is not expected to influence these growth rates significantly. As discussed already, underground transmission

Figure 6 Projected United States HV and EHV Transmission System in 1990 (From Federal Power Commission 1971 p. 1-18-15)

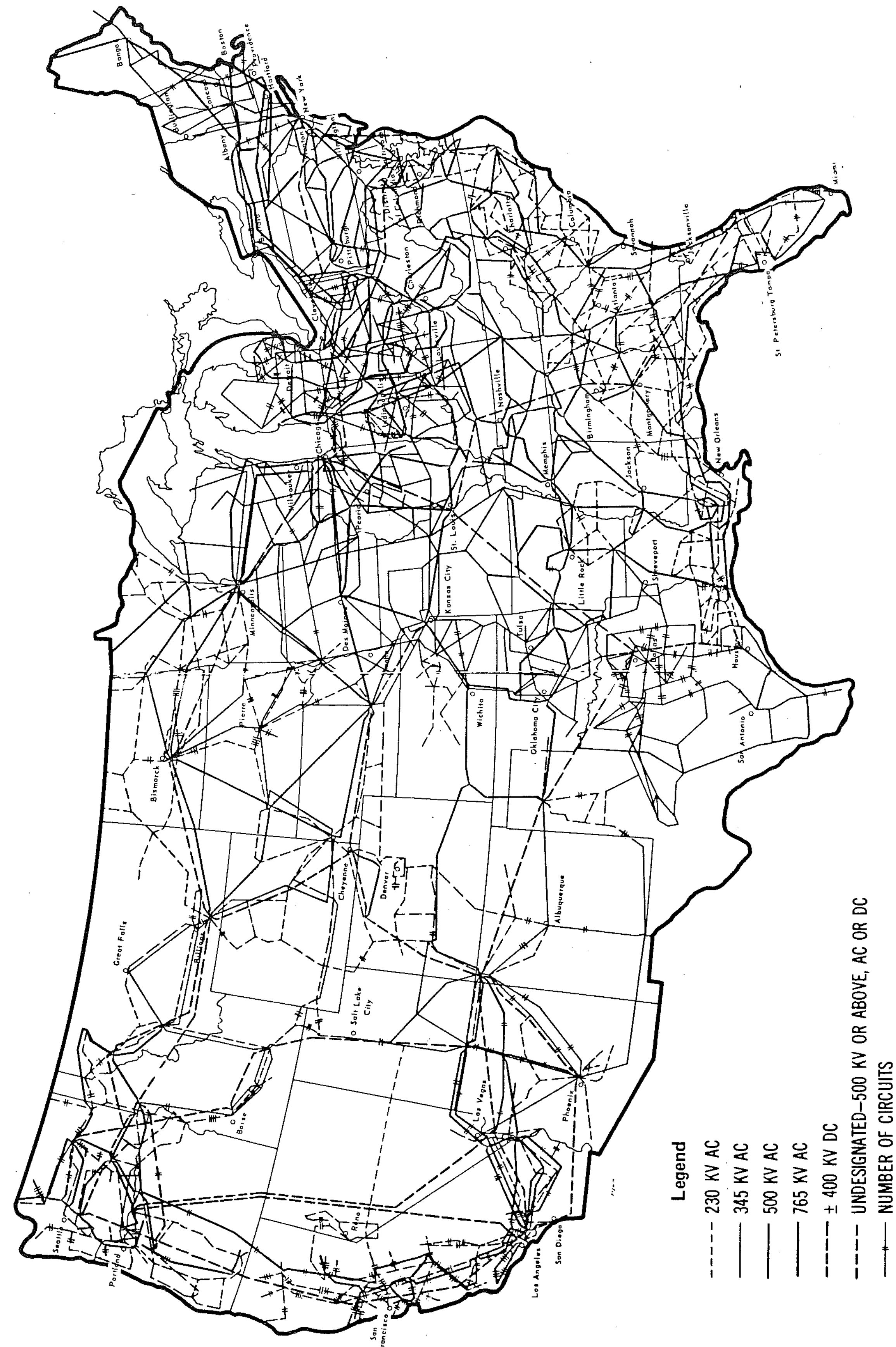
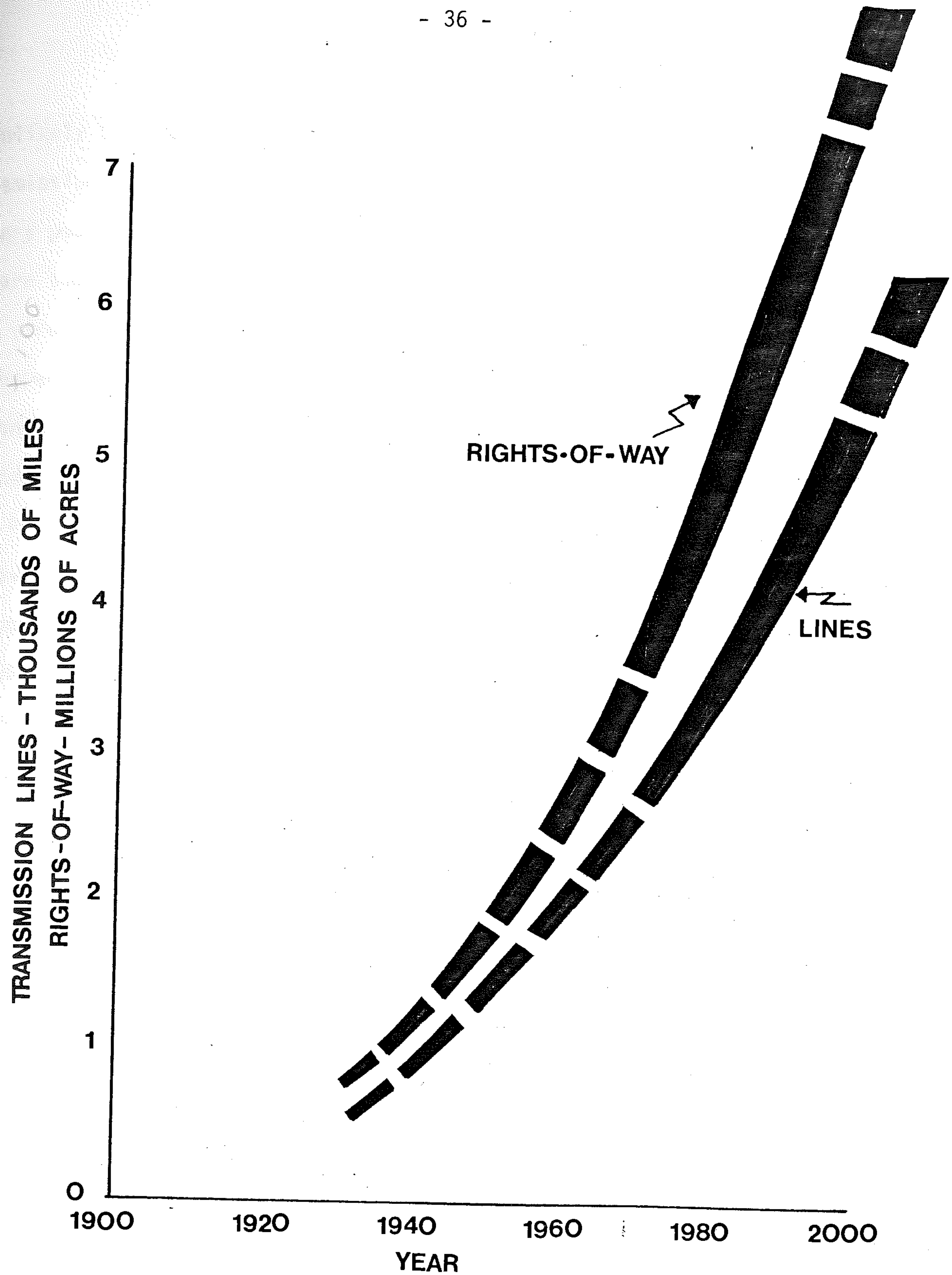

Legend
230 KV AC
345 KV AC
500 KV AC
765 KV AC
± 400 KV DC
UNDESIGNATED—500 KV OR ABOVE, AC OR DC
NUMBER OF CIRCUITS
Seattle
Portland
San Francisco
Los Angeles
San Diego
Reno
Boise
Las Vegas
Phoenix
Salt Lake City
Great Falls
Billings
Cheyenne
Denver
Albuquerque
Bismarck
Pierre
Des Moines
Wichita
Kansas City
Tulsa
Houston
San Antonio
Shreveport
Little Rock
St. Louis
Peoria
Chicago
Detroit
Nashville
Memphis
Jackson
Birmingham
New Orleans
Atlanta
Savannah
Jacksonville
St Petersburg Tampa
Miami
Charleston
Pittsburgh
Buffalo
Albany
New York
Boston
Providence
Hartford
Bangor

Figure 7 Projected Growth of Transmission Lines and Associated Rights-of-Way in the United States of America at all transmission voltages above 69 kV. (working Committee on Utilities 1968 p. 51)



TRANSMISSION LINES - THOUSANDS OF MILES
RIGHTS-OF-WAY- MILLIONS OF ACRES
0
1
2
3
4
5
6
7
1900
1920
1940
1960
1980
2000
YEAR
RIGHTS-OF-WAY
LINES

is unlikely to have significant effect in the next 20 years. Overhead transmission rights-of-way corridors over 600 feet wide have been suggested as very possible (Anon. 1975). More compact towers and narrower rights-of-way are suggested, however, by Howlett (1973), Paris (1969) and Scott (1972). They strongly endorse the continuing trend toward EHV. This movement may be tempered by public concern over noise, radio interference, ozone production, electromagnetic radiation field effects, and increasing problems of induced current (Morgan 1974).

Projected increases for line mileage and right-of-way alienation are not available for Canada but are likely to mirror the rate of expansion projected for the United States. This would suggest line mileage approaching 60,000 miles encompassing some 1,452,000 acres of right-of-way by 1990.

This 250% increase in line miles and their concomitant rights-of-way will place a considerable burden on the right-of-way manager for well reasoned, innovative, socially acceptable, environmentally sound, and cost effective practices in the decades which will close the 20th century.

DESIGN CRITERIA FOR OVERHEAD TRANSMISSION RIGHTS-OF-WAY

Introduction

Four components govern the design of transmission line rights-of-way. Engineering requirements will dictate the width of right-of-way and the clearances required for vegetation. There has been continued pressure on the utility industry to improve the appearance of transmission lines and, by the same token, protection of environmental values has also become a factor for concern in the design, construct, and maintenance phases of right-of-way development. Further, the standards applied for initial clearing and restoration of the right-of-way significantly influence long term management practices. This chapter examines these four factors in detail.

Engineering Considerations

As air is the insulator used to prevent flashovers of the electrical current in aerial transmission systems, a number of minimum design criteria exist for each line voltage. Phase to phase and phase to ground separation are critical values. Safe clearance constraints are normally developed by each utility but no less (in Canada) than Canadian Standards Association, C 22.3, No. 1 (1970). A typical calculation for high wind locations would consider a 20 p.s.f. wind value with conductor at 60°F final sag and include free conductor swing up to 30° to 40° plus 60 Hz peak withstand values to allow for switching surge plus a 1' or 2' buffer. Such calculations have important implications in determining right-of-way width.

Other important factors in design are type of structure, width and pattern, conductor design, number of circuits, radio interference control, electrostatic induction potential, audible noise suppression requirements, galloping space, and construction and maintenance requirements. A typical double circuit lattice type tower is shown in Figure 8. More recent "aesthetic" towers, designed by Dreyfuss (1968) and the Electrical Research Council (1967), are narrower than a conventional tower. In urban areas appearance and land cost constraints may support use of these more expensive structures.

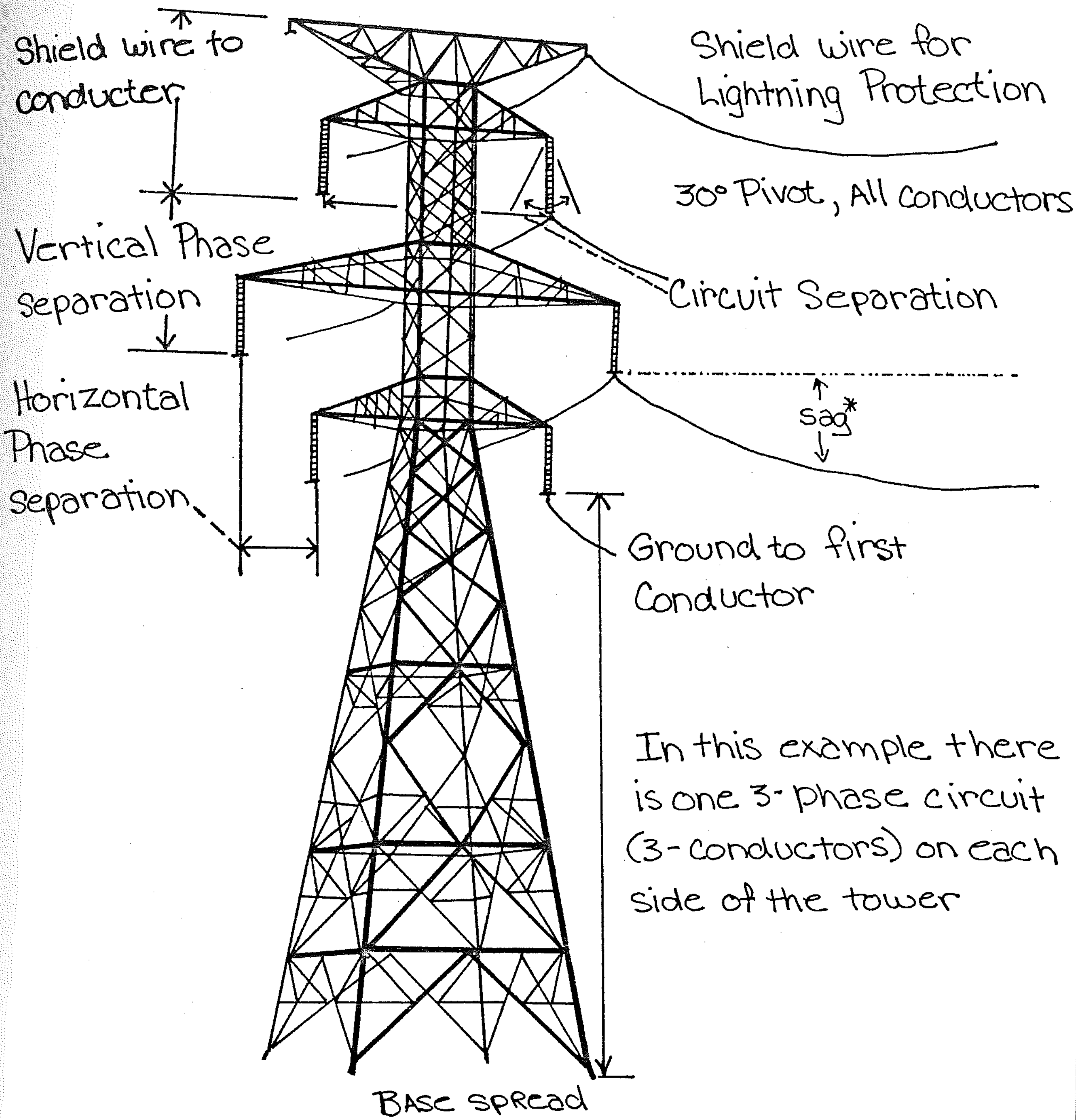
Voltage and loading capability (megawatts) will influence conductor size and bundle configuration which in turn affect the ratio of conductor span to sag. This will assist in determining structure size, number, and spacing. Size is further determined according to the line angle imposed upon a tower with the weight, and often complexity, increasing with the degree of line angle. Attempts at tower compaction also influences size and spacing as well as multiple lining on the same right-of-way.

Radio interference suppression, electrostatic induction control, and audible noise requirements, though important in line design, do not materially affect right-of-way width criteria.

Conductor blow out from high winds and galloping space can affect lateral clearance especially at centre span. Line construction needs rarely exceed the minimum operating safe width limits given in Figure 9. Maintenance requirements for helicopter patrol space may, however, influence right-of-way width.

In some exposed areas an additional allowance is made for tower collapse. Terrain contours will also affect tower spacing, height and conductor apparent and maximum loading sag. This in turn directly influences right-of-way width or danger tree clearance. From the factors given

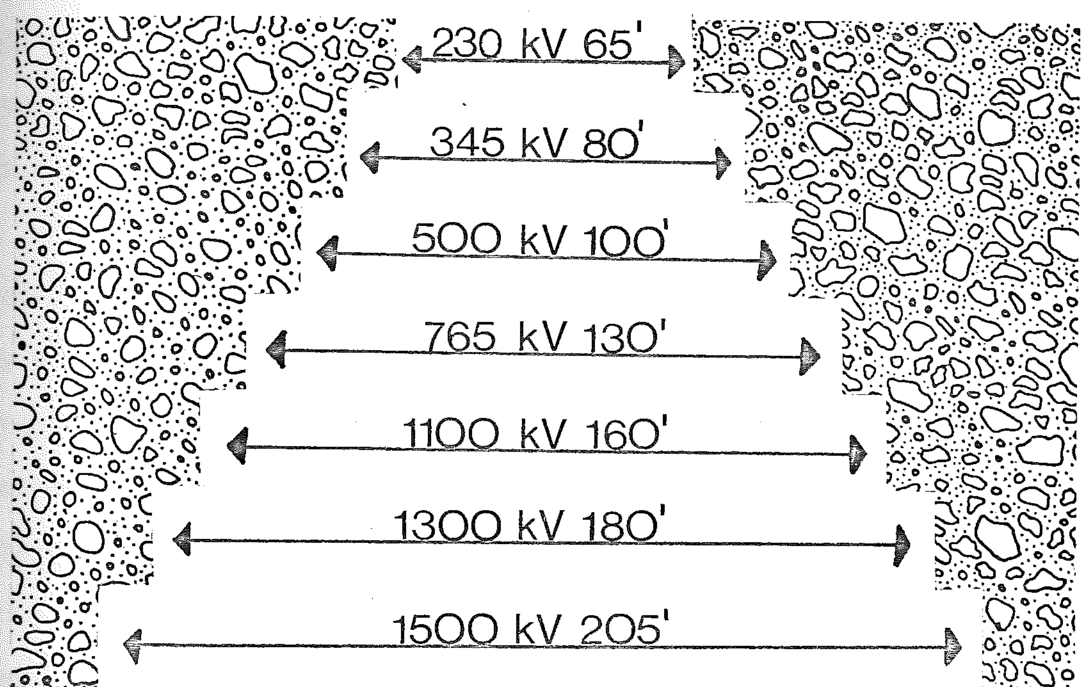
Figure 8 Elements of a Typical Double-Circuit Lattice Transmission Tower



*Conductor Sag varies with:

- Conductor type and size
- Conductor tension and span
- Air temperature
- Loading

Figure 9 Projection of Minimum Right-of-Way Clearing Widths at Centre Span for Horizontal Configuration of Alternating Current Transmission Lines of Different Voltage (after Shaw 1975)


230 kV 65'
345 kV 80'
500 kV 100'
765 kV 130'
1100 kV 160'
1300 kV 180'
1500 kV 205'

here, a Policy of Clearance should be prepared and individually tailored for each transmission line or section of line. This will then provide underlying criteria for subsequent management practices.

The trend toward higher transmission voltages, shown in Figure 2, p.24, the increasing dependence on EHV feeding conurbations from remote generation sites, the complex interconnected pool system (e.g. Western Systems Co-ordinating Council), the reduction in system peaking capacity in many utilities from environmentally based delays in generation construction, and cost constraints reducing past practices of 'overbuilding,' have led to a high degree of dependence on secure transmission systems.

Despite protestations to the contrary and incorporation of sophisticated circuit breakers and protective relay devices, system outages caused by transmission failures do occur. Such system failures can unmask the fragility of our civilized life. On an individual scale, inconvenience, extremes in temperature, and loss of frozen food can occur with failure of electrical supply. At the institutional, commercial and industrial levels, loss of production, income, and disruption of emergency services can result. For example, in November 1965, the Western Seaboard of the United States and Canada was affected by loss of power for 13 hours after a transmission failure snowballed into system collapse. On July 13, 1977, New York City experienced a major system collapse which triggered arson, rioting and looting, 2,700 looting arrests, 800,000 people trapped in the subway systems, and losses in the millions (Edmonton Journal 1977). Return of dumped generation to the city system took twenty-five hours resulting in a lost work day for most companies.

Protection against the eventuality of vegetation caused outages is a prime responsibility of the vegetation manager. After construction and commissioning each line should be assigned a priority for protection from outages of any origin. Factors which will influence assigned priority will include voltage, security of supply, and consumer demand for continuity of service, alternative supply options, and trade-off costs. This should result in formulation of an individual Protection Policy for each line.

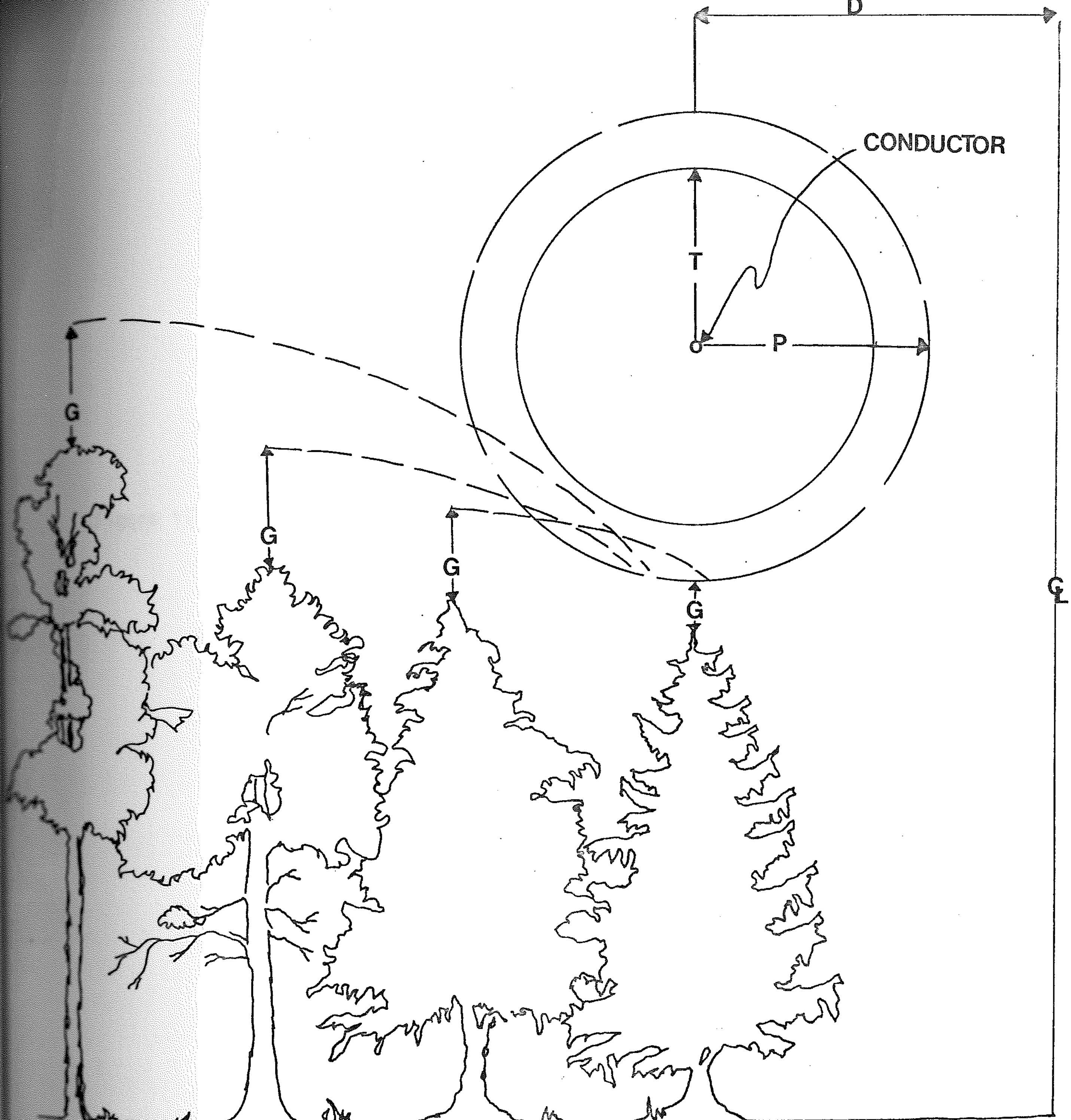
As line priority increases, the Protection Policy will demand removal or topping of danger trees (Figures 10, 11, 12) and adequate clearance for any vegetation which grows sufficiently tall below the conductor to enter the limits of approach, Figure 13. These removal or topping criteria must take into account designed sag at maximum loading, conductor blow out under high wind conditions, right-of-way access and site conditions, and rate of growth of incompatible woody plants. Condition and age of individual trees is also important.

Knowledge of these factors, the original engineering assumptions and sound experience mark the vegetation manager well able to implement a corporation's policies for continuity of service.

Aesthetic Considerations

"The cause of the environmental uprising (against utility rights-of-way) essentially has been the conventional utility rights-of-way policy of clear cutting or removing all woody material from the entire length and width of the proposed right-of-way. This approach created a 'corridor' look when viewed from road crossings. It was the aesthetic aspect, not

Figure 10 Potential Danger Trees with Ten Year Clearance



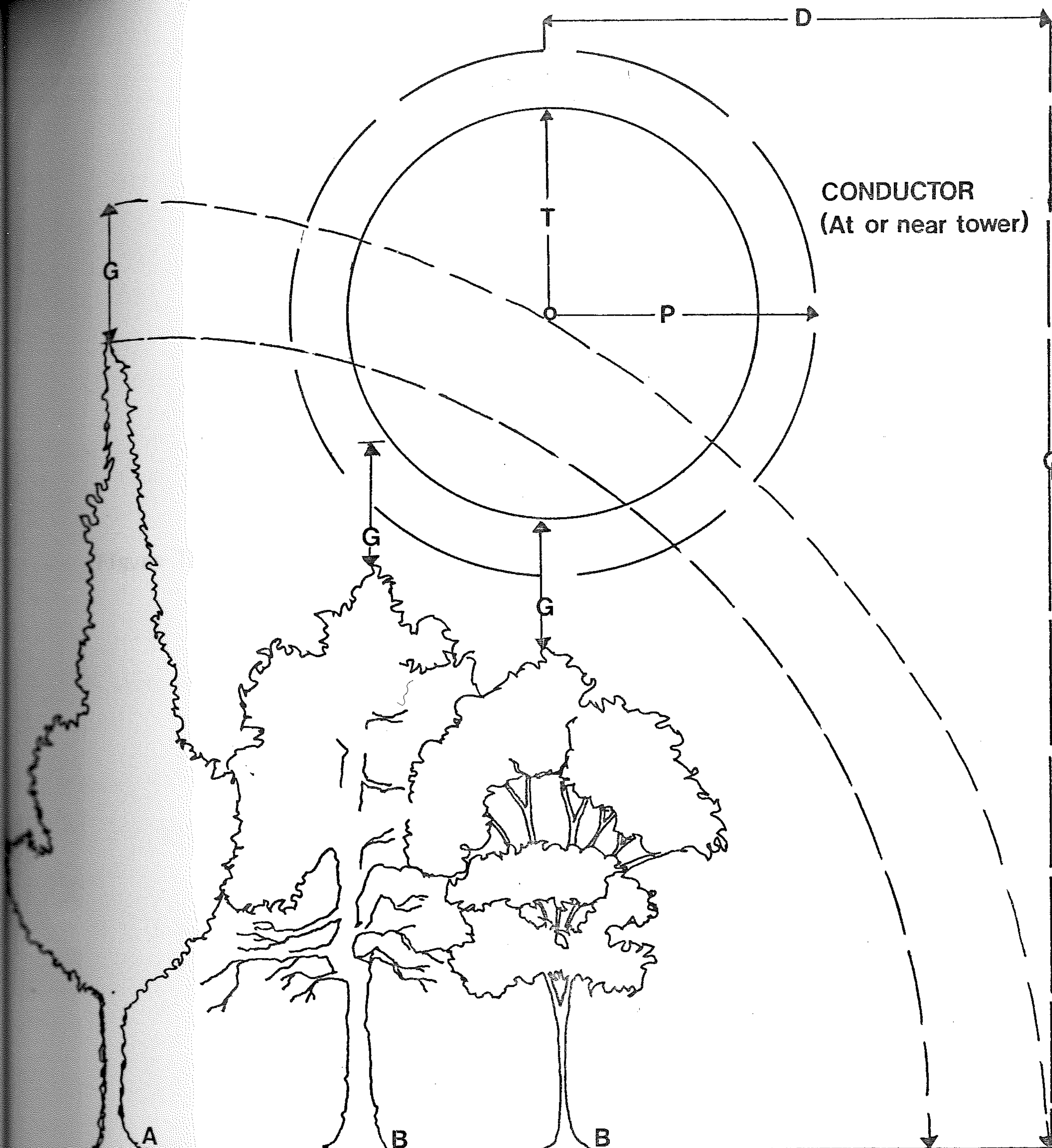
G GROWTH FACTOR (10 year Tree Growth)

P ELECTRICAL CLEARANCE FOR PROLONGED EXPOSURE

T ELECTRICAL CLEARANCE FOR TEMPORARY EXPOSURE

D DISTANCE OF CONDUCTOR FROM ℄

Figure 11 Danger and Potential Danger Trees Near a Tower



G GROWTH FACTOR (10 year Tree Growth)

P ELECTRICAL CLEARANCE FOR PROLONGED EXPOSURE

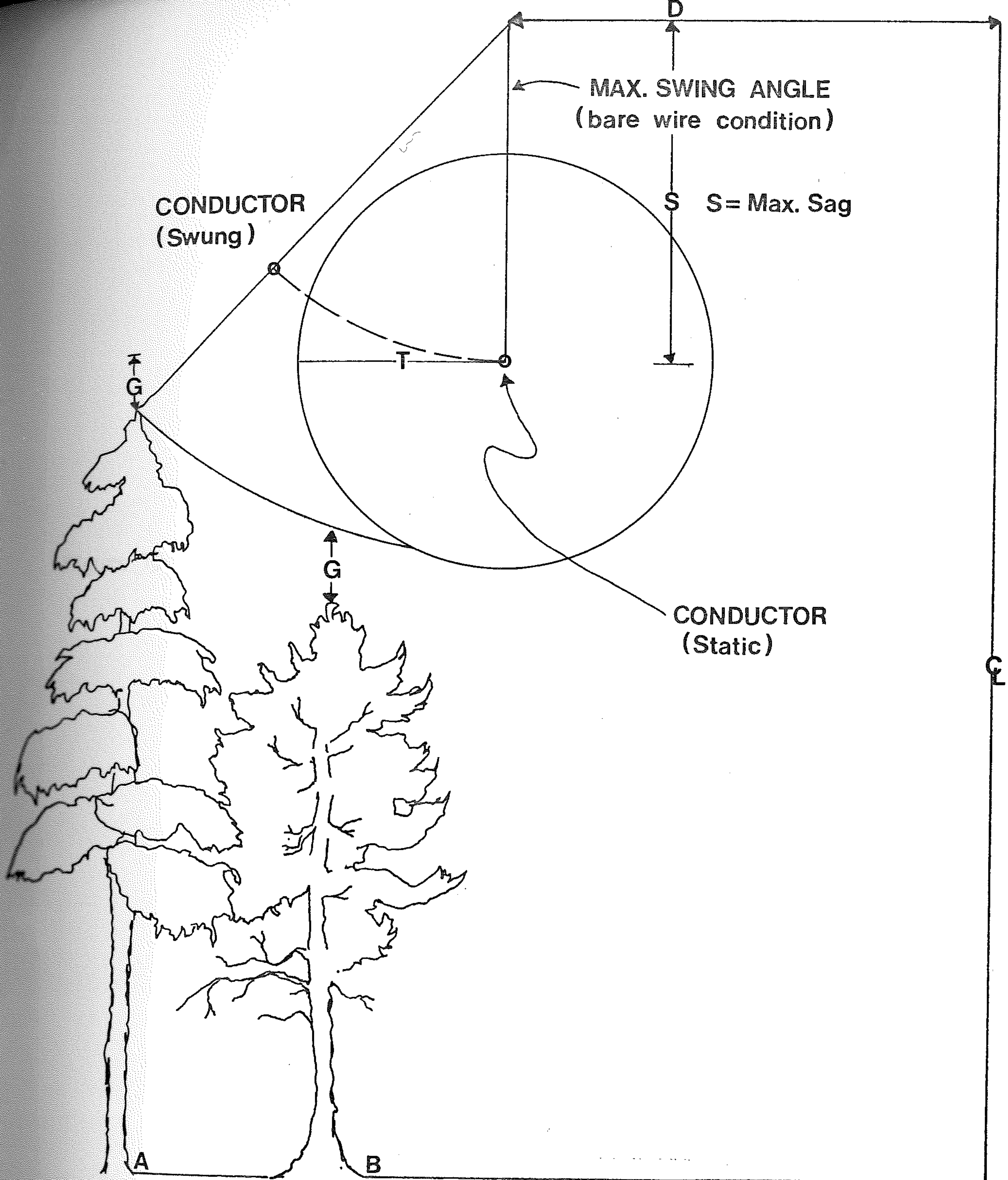
T ELECTRICAL CLEARANCE FOR TEMPORARY EXPOSURE

D DISTANCE OF CONDUCTOR FROM ℄

A PRESENT DANGER TREE

B POTENTIAL DANGER TREE

Figure 12 Danger and Potential Danger Trees Near Centre Span



G GROWTH FACTOR(10 year Tree Growth)

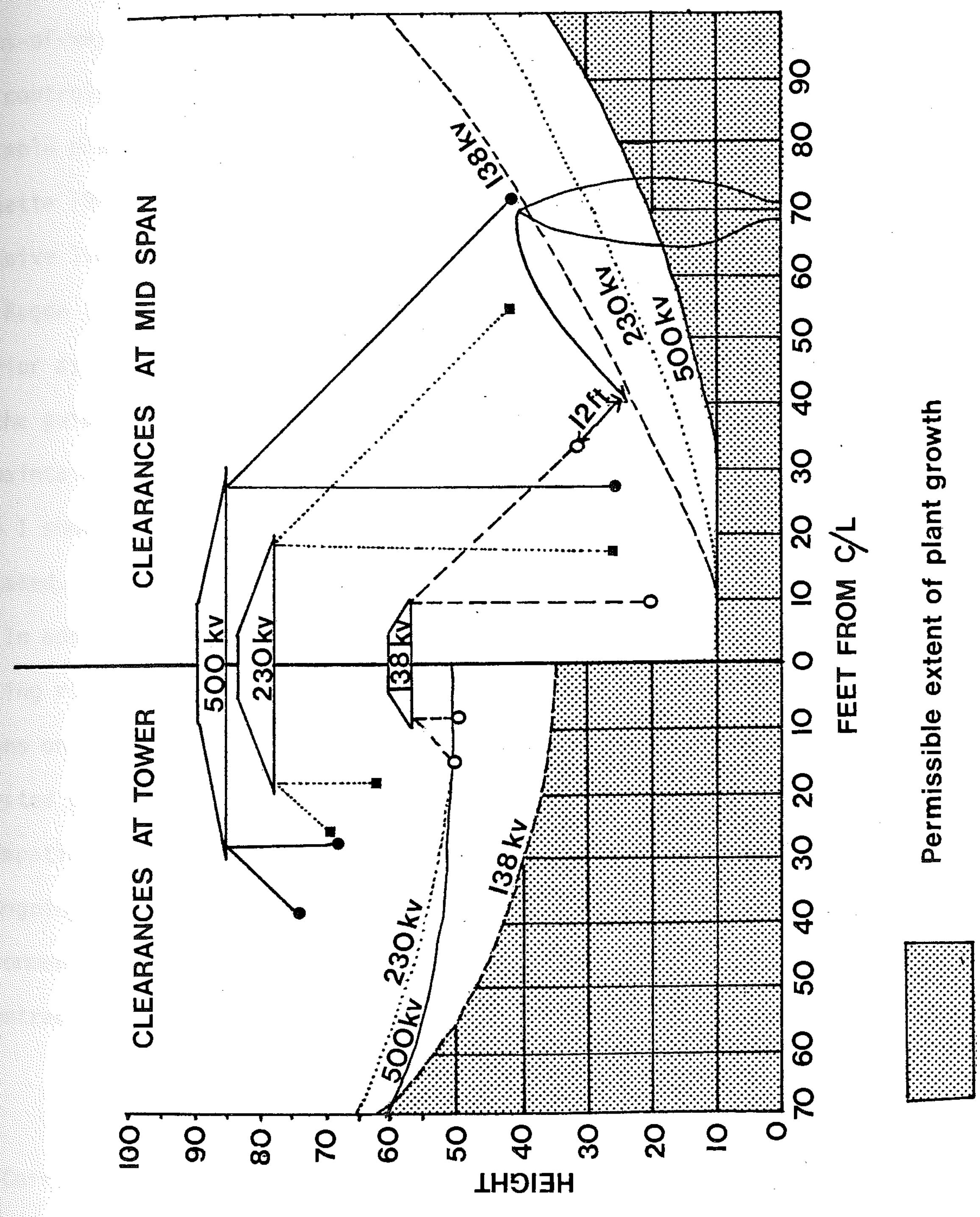
T ELECTRICAL CLEARANCE FOR TEMPORARY EXPOSURE

D DISTANCE OF CONDUCTOR FROM ℄

A PRESENT DANGER TREE

B POTENTIAL DANGER TREE

Figure 13 Minimum Vegetation Clearances for 138, 230, and 500 kV Transmission Lines


CLEARANCES AT TOWER
CLEARANCES AT MID SPAN
500 kv
230 kv
138 kv
230 kv
500 kv
138 kv
138 kv
230 kv
500 kv
12 ft
HEIGHT
100
90
80
70
60
50
40
30
20
10
0
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
FEET FROM C/L
Permissible extent of plant growth

the environmental, that has resulted in the controversy" (Dolton 1974 p.42). In order to help quell this uprising, which has led to major delays in obtaining rights-of-way route approvals (Harper 1969), utilities have introduced stringent controls over initial clearing (Anon. 1969) with retention of as many desirable plant species as possible (Wetsch 1968, Ewald 1968, Conover 1969, Robinette 1973, Wilson 1973). Middleton (1965, 1969, 1977) has published extensive lists of species suitable for retention on the right-of-way.

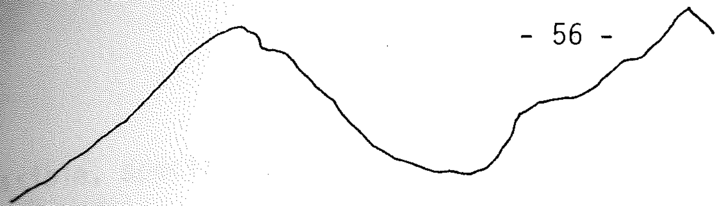
Bagge (1968), Howlett et al (1968), Slatt (1969a), Cross (1969), Department of Interior as reported in Transmission and Distribution (1970), Robinette (1973), and the guidelines mentioned later in this work, all indicate the necessity for maintaining native vegetation on the right-of-way whenever possible. Plate 1 shows four figures which illustrate the major new techniques advocated.

In addition to retention of native plant material, restoration of existing rights-of-way cleared using past practice and establishment of screens on new lines where suitable vegetation did not exist has been suggested by a number of authors. Middleton (1966) provides a plant list of compatible nursery stock. These techniques should be incorporated into the ongoing maintenance program. Further, expenditures for preservation of environmental integrity during design and construction should not be negated by contradictory maintenance practices.

Environmental Considerations

Corridor and route selection impact reports identify and catalogue environmentally sensitive or unique features. Wherever possible avoidance of these areas will be incorporated in final route selection. Where not

Plate 1	Fig. 1	-	Retention of Vegetation in Valley Bottoms
	Fig. 2	-	Retention of Vegetation to Screen Structures
	Fig. 3	-	Retention of Vegetation at Road Crossings
	Fig. 4	-	Retention of Vegetation through Contour Clearing



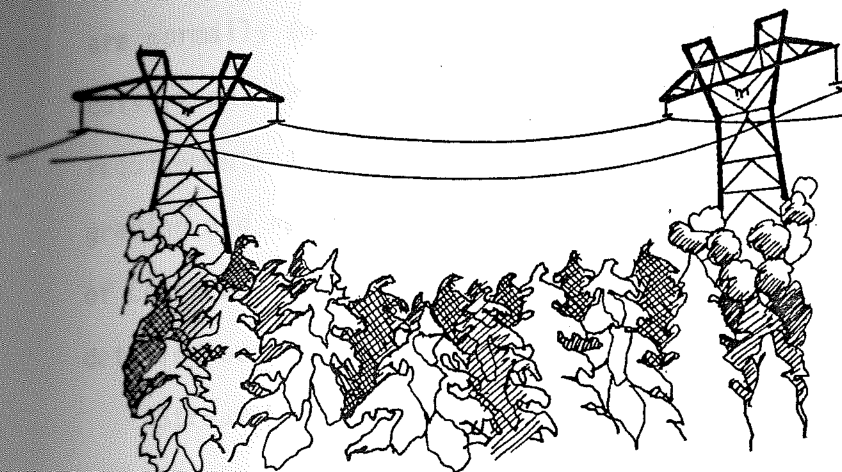


Fig.1

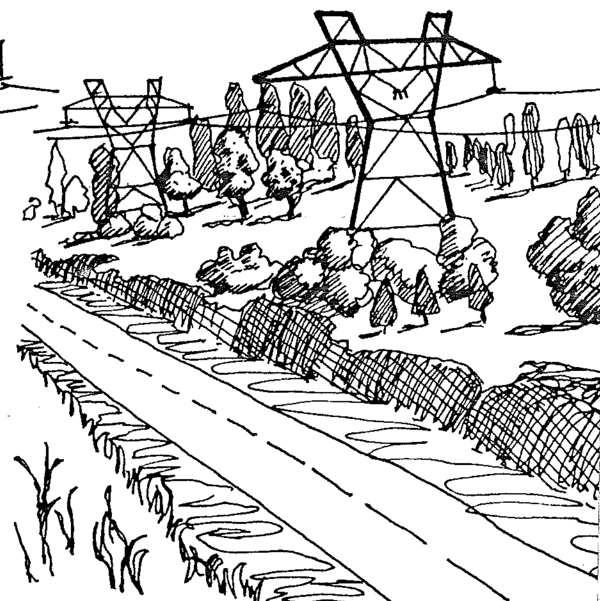


Fig.2

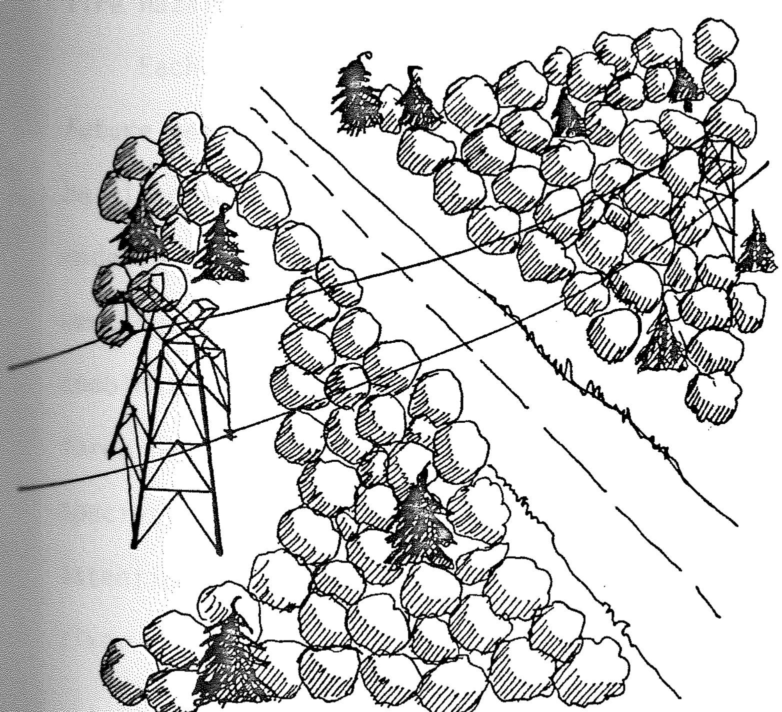


Fig.3

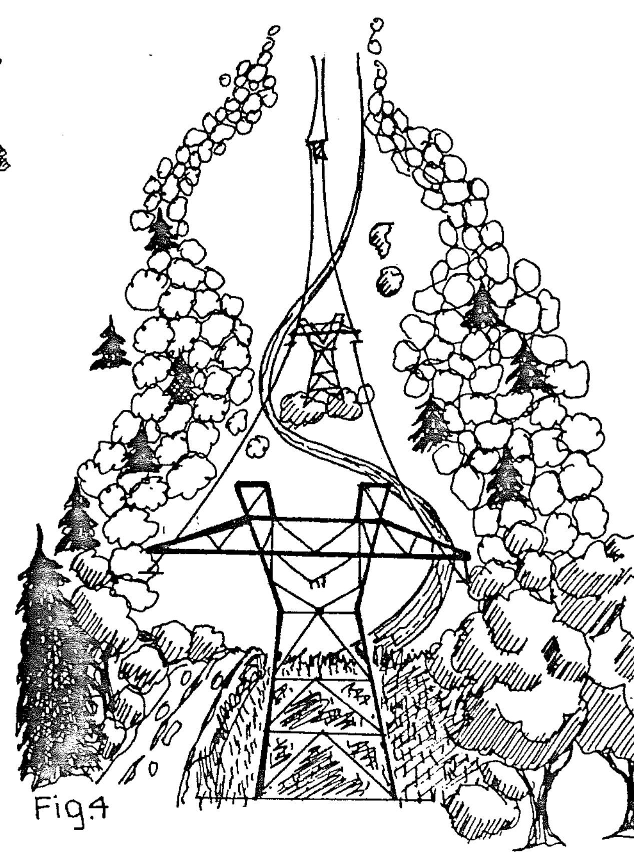


Fig.4

possible, specifications will be drawn to mitigate transient impacts and to restore disturbed land to reduce permanent impacts. Specific constraints are normally exerted on the clearing contractor to ensure road, ditch, culvert and bridge construction do not contribute to soil erosion. Specific requirements for recontouring, debris disposal or extraction, road cover - grading and reseeding, and disturbed ground revegetation may be a condition of Construct and Operate Permits. Where buried counterpoise is used, detailed soil and vegetal restoration practices may be specified.

Stream bank protection through retention of the maximum vegetation possible may be required by Fish and Wildlife Departments at fish bearing waters. Hand clearing may be required in watershed areas to prevent drinking water siltation. Specific access or timing restrictions for an area may be permanently enforced to reduce hunting pressure or to minimize fire hazard.

Each item has implications for, and should be incorporated in, the future vegetation management planning process. Specific attention should be given to formally adopting and integrating agreements and commitments made to resource agencies, land owners or the general public at open meetings before time of construction. Robbins (1968) suggests that a combination of conifers in the background and shorter hardwood in the foreground provides a suitable sight screen. Although not suggesting species, Neidig (1973) advocates screens at road crossings, with special attention to the entry point of the right-of-way access, and screens at river crossing or where the line exits from woodland in arable land.

In the first survey of utilities and the environment, Cavanaugh (1970) found that right-of-way "beautility" programs were endorsed by over 50% of the major utilities, and involved the expenditure of millions of dollars.

The most sophisticated approach to aesthetic improvement in wooded areas has been developed by the Bonneville Power Administration. Robinson (1973) describes an aerial photo mapping and computerization technique of new line clearing called Tree Monitoring System (TMS). Two "Kelsh plotters" are set up to scan stereo photographs set in terrain models; movable tracing dots in a plotter are used to locate trees which in turn are translated into "X", "Y", and "Z" coordinates for tree tops. The location and height data for each tree is processed by a Honeywell mini-computer and compared with the proposed transmission conductor profile and location. A teletype attached to the computer prints out two reports. A "Backline and Danger Tree Report" which facilitates location of the right-of-way edge and provides data on conductor swing, minimum and maximum clearances, expected tree growth, and danger tree heights and distances. A "Clearing Advisory Report" is used to more precisely locate trees in the field by identifying any danger tree across the width of the right-of-way on either side of centre line at progressions of 100 feet along the right-of-way. This detailed contour, conductor location, tree height and location analysis is providing a sculptured edge to the right-of-way instead of the former straight lines and providing savings from $2,000 to $4,000 a mile in reduced clearing costs.

Marjerrison (1973), reporting separately on the same system, concludes by noting that this type of clearing (TMS) provides reliability equal to that of the old system, substantially improved aesthetic appearance, but will probably require more maintenance effort after the initial growth period.

This apt summary can be applied to almost all aesthetic improvements relying on vegetation to moderate the visual impact of transmission rights-of-way. It will require the vegetation manager to develop new approaches to right-of-way maintenance (Patrick 1970). A new level of complex management requirements is being added to many utility systems already bereft of advanced management, making secure supply of electricity increasingly doubtful in the future.

Clearing and Restoration

Too often the initial clearing of rights-of-way has been the sole prerogative of a design, or design and construction group with little consideration for subsequent maintenance. Minimizing capital cost was the single criterion and supervision was, to say the least, marginal.

Consequently rights-of-way abound that are littered with felled timber, logging debris, suckering stumps, and former areas of bare ground infested with pioneer weeds, thistles and undesirable pollinating plants (Wodehouse 1945). A vegetation management incubus; dangerous and costly to repair.

Public and resource agency discontent, and in a number of specific instances erosion and tower failure, gradual strengthening of vegetation management groups and a more responsive engineering discipline have helped discourage such practices and encourage disturbed land reclamation.

External clearing guidelines which have been set by some agencies (e.g. Environment Canada 1974) are a feature of most general guidelines discussed in the section examining vegetation management guidelines and form a substantial segment of most utilities' new clearing tendering specifications. British Columbia Hydro, for example, has an explicit, revised policy for clearing (British Columbia Hydro 1975). This document recognizes future rights-of-way and adjacent land use, access requirements for maintenance, method and costs of maintenance, overall economics of the project, aesthetic requirements, soil stability and as already noted - environmental protection - as integral concerns of a clearing policy. Similarly, Ontario Hydro (1974) has substantially revised clearing policy to recognize both public and pragmatic concerns. Clearing practice, as demonstrated by the example here and reported for most Canadian Utilities (Canadian Electrical Association 1976) have become more responsive to all concerns. Such practices are a radical change from a few years ago (Neidig 1973).

Restoration, other than debris burning and ground contouring has largely relied heavily on reseeding with grass species or legumes (Canadian Electrical Association 1976). This has often been with direct purposes in mind as in soil conservation (Smith 1969) or for cattle grazing (Loose 1975). Availability of native shrub seed, particularly those of importance to wildlife (Martin 1940) do not appear to have a ready availability and consequently various grass species and grass combinations with fertilizer (Cloninger 1970, McLean 1971, Coupe 1974, Lawrence 1967) appear to predominate. Specific research into ideal smother crops is being conducted by at least one utility in Canada (Punhani 1971) and grass seeding is becoming accepted practice after clearing by some utilities (Francisco 1973, Leith 1974) although attempts to show their cost benefit (Tweddle 1971) while ignoring basic principles of plant succession remain unconvincing. The interest in seeding has also stimulated a desire for more refined application equipment. Improvement of various hydro-seeding slurries and nozzles has been reported (de Wilde 1976).

Chemical treatment of stumps remaining on the right-of-way after initial clearance is now fairly common practice (Mann 1963, Shuler 1968) and this in concert with seeding, provides the vegetation manager with some respite after initial clearing. However, these rights-of-way are no different than those reduced to a simple grass community after cyclical spraying. As discussed in appendix A, simple artificial communities immersed in complex communities are inherently seral and unless the standard of clearing in hardwood areas has removed all topsoil, it appears that Egler's (1954) concept of initial floristic composition will be realized from the regrowth of woody plants remaining. Indeed, Carvell (1973, 1976) suggests that a systematic encouragement of forbs and shrubs should be allowed to develop with a selective program of eliminating undesirable species.

On new right of way [illegible] machine cleared to bare soil the deliberate planting and establishment of desirable forbs and shrubs appears to be severely constrained by a combination of initial costs and the scarcity of nurseries raising appropriate indigenous species. Greater emphasis on restoration of disturbed land with native species and reclamation of mine tailings with large scale plantings may increase the market for both plants and seed allowing right of way managers to revegetate exposed areas with desirable species.

VEGETATION MANAGEMENT ON OVERHEAD TRANSMISSION RIGHTS-OF-WAY

Introduction

Vegetation management on rights-of-way once considered by some to be an "art" nevertheless has evolved to the stage where clear logic and detailed management are essential to meet the complexities and scale of most utilities. Moreover, the external pressure of public concern demands a comprehensive management style. Utility managers must prepare a sound rationale to justify each practice and in so doing become involved in the early design process for new rights-of-way. Moral and legal suasion require the vegetation manager to follow a variety of guidelines in his operating practices and to plan the long-term ecological manipulation of vegetation communities. This chapter examines each of these topics in detail.

Vegetation Management Objectives

As noted earlier, management is directed toward some "ends." In this instance, it is specifically vegetation management toward some "ends." Implicit in the concept of such "ends" are objectives and tied to objectives should be underlying rationale.

As Clement (1973) has noted, fiscal constraints are becoming increasingly severe. Operating funds are often sacrificed in the interest of capital requirements, and this to the detriment of operating continuity (Johns 1967). It is incumbent on the utility vegetation manager to develop sound rationale for his overall programs, for field projects and for individual tasks, and in turn to sequester an adequate budget, ensure efficient program continuity and demonstrate intra-corporate responsibility.

As the models note, (Figure 15, p. 84) vegetation may either Endanger or Enhance the right-of-way or, as Medicky (1976) suggests, fall into two categories, compatible and incompatible. On the one hand, vegetation plays an important role in preventing erosion and stabilizing disturbed ground after construction, in softening the harsh outline of lattice towers, mediating the size of structures toward human scale, screening right-of-way cuts in wooded country, and enhancing the habitat and food diversity in a given area (Plate 1 p.56).

On the other hand, some vegetation has inherent dis-benefits if allowed to exist on rights-of-way. The most obvious are those woody plants with sufficient height-growth to enter the limits of approach for the conductor or tower. Such vegetation may grow beside or below the conductor as discussed in the engineering considerations. Further, strong winds may cause branches or limbs to break off tall trees and become caught in conductors, resulting in forced outages, intermittent line tripping, or conductor flash burns.

Most States or Canadian Provinces maintain a schedule of noxious weeds so designated for their undesirable characteristics. Utilities are faced with a legal obligation to control such weeds. In addition, puncturing, stinging, and poisonous plants (Kingsbury 1964) may infest the right-of-way creating unfavourable relations with adjacent property owners or multiple use leasees and later requiring control or eradication. In some areas, especially of the southwestern United States, rank growth on rights-of-way constitutes an unacceptable fire hazard around structures. In addition, VandenBorn (1974) indicates that a serious potential exists for forest fires in areas where danger tree removal is not undertaken, as falling trees may strike the conductor, break it and ignite surrounding vegetation. Similarly rank growth may severely impede maintenance access, (National Academy of Science 1968, Carvell 1973) or visibility, and encourage the passage or establishment of undesirable wildlife or insects in urban areas (Nelson 1975).

In reviewing the utility or disutility of vegetation on rights-of-way, it becomes evident that the basic objectives of management are, or should be, twofold: to manipulate and encourage some species, and to control, suppress or eradicate others, in order to facilitate the safe and continuous operation of the electrical system.

Subservient to these principal objectives must be concerns of corporate compliance with pertinent legislation, regulations and bylaws, protection of integrity in the natural environment, understanding in the social environment, preservation of any initial selective clearing design concept, and accomplishment of the whole in the most judicious and economical manager when viewed over the long term.

The changing attitude of society about the responsibilities of all land managers has recently confronted most electrical utilities with new problems and decisions (Leth 1967). As a result, many companies that were confident during the sixties that they were managing their rights-of-way in the most expedient manner now question long accepted goals, and are re-examining their basic objectives (Carvell 1973). For the most part, neither company management, nor the public questions the necessity for some type of vegetation management. The major area of disagreement concerns how control should be obtained and what type of plant communities should be developed and maintained.

Vegetation Management Planning at the Design and Construct Stage

A feature of the past decade of environmental awareness has been the translation of public concerns into comprehensive and binding controls in Law. The passage of the National Environmental Policy Act of 1969 (Public Law 91-1190) now makes environmental protection a prime concern in the United States with Federal review procedures including electric power facilities. Further, legislation has been proposed that would require all public utilities to announce proposed routes of transmission lines 230 kV or higher at least two years in advance of scheduled construction (Abbott 1973). In addition, Federal agencies providing power are also bound by similar requirements as public utilities. In 1971 guidelines for preparation of the principal instrument in affecting the review process, the Environmental Impact Statement, were published (National Environmental Policy Act Guidelines 1971). Similarly in Canada, all power projects impinging upon Crown responsibilities, receiving Federal aid, or exporting power to the United States must be the subject of either an Environmental Assessment Review Process (Fisheries and Environment Canada 1977) and/or a National Energy Board Environmental Information Submission (National Energy Board 1974).

Abbott (1973) notes that many United States State regulatory agencies now review the routing of high voltage transmission lines planned by the utilities under their jurisdiction. In Canada a number of Provinces have recently published extensive guidelines for impact assessment which embrace electrical generation and transmission facilities (Alberta Environment 1977; and Environment and Land Use Secretariat, British Columbia 1976).

Construction of transmission lines has a substantial impact on vegetation removed to construct towers, access roads, laydown areas, line stringing and tensioning, and line safety zones. Removal of vegetation can result in loss of wildlife habitat, visual qualities, and renders an area susceptible to erosion and its associated hazards (Schaal 1973). An existing vegetation inventory is required by all impact analysis procedures. For example, most impact statements require the mapping of bioclimatic zones and forest cover with a description of forest stand structure and maturity. A description of plant communities within the proposed corridor by species and abundance, and an indication of relative importance to man and to native fauna as habitat and food is required. Identification of undisturbed, rare or unique vegetation and plant life of special economic, historic, social or scenic value is normally documented. In addition to requiring base-line information on existing vegetation, soils, and topography, increasingly detailed mitigation or restoration practices must be identified for the post-construction phase (O'Riordan 1975). This, coupled with the proposal to incorporate proposed maintenance practices within environmental impact reports (National Energy Board 1974, National Environmental Policy Act 1971), would indicate a very thorough review and documentation of vegetation information will be available prior to commissioning and acceptance of new transmission lines by utility operating and maintenance departments. Early collection of background information should provide a clear indication of viable restoration practices and predicate the maintenance plans proposed for subsequent vegetation management. (See Right of Way Management Plans, Appendix H)

During the construction phase, a vegetation management group should continue to collect useful data and participate in the clearing and restoration phase. A flow chart for new line construction would normally involve the following steps after the determination of an acceptable route: preparation of the sensitivity mapping and inventory from the Environmental Impact Report, centerline survey, boundary survey, detailed 400 feet to inch strip chart preparation, selection of clearing standards, revised strip chart, prelogging of merchantable timber in forested areas, preparing clearing tenders, actual clearing and main road construction, excavation and setting tower grillages, erection of towers, stringing and tensioning of conductors, and final restoration. The vegetation manager may make a valuable contribution in selection of clearing boundaries, clearing standards, prelogging specifications, early vegetation treatment during clearing and at any stage which involves major ground disturbances. This will ensure early and sound revegetation practices.

Compartmentalization of responsibilities in many utilities has, historically, excluded the maintenance department from involvement until the completion of the commissioning phase. The pressures of environmental legislation and public concern regarding aesthetic impact now provide the vegetation manager with the ideal opportunity for early involvement in the planning, design and construction process, and a ready inventory of dynamic information for subsequent vegetation control practices.

This process can evolve to the advanced stage where maintenance criteria are incorporated in new line location assessments (Gardner 1977) and should eventually develop to a clear continuous input from the conceptual design stage through corridor and route selection, construction and commissioning to the operation and maintenance phase.

Vegetation Management Guidelines

Robinette (1973) suggests that the rapidity of communications has meant that no issue of mankind has moved from the problem identification stage to the development of administrative guidelines and legislation faster than has the environmental issue. Consequently all levels of government and industry have been inundated with rules, regulations and procedures to protect and enhance the environment. Certainly this is true of those environmental factors controlled or affected by the electrical utility industry. Robinette also submits that destruction of the environment is more pervasive, it exists at more scales and is more obvious to the general public in the electrical utility industry than in many other industries. This, coupled with the fact that it is a relatively regulated industry which has experienced quantum growth, and an industry with a conscience or an imposed conscience, has caused considerable disruption and compounded the lack of orderly development. Moreover, all Elements of the industry impinge upon environmental quality and pressure for improvement has not been exerted uniformly. Nor is the industry itself uniform. In the United States there are at least 215 investor owned, 700 public, two federal and 65 cooperative utilities operating HV or EHV transmission systems. In Canada, nine government agencies or Crown corporations and seven investor owned or private systems exist, albeit some with minimal transmission line mileage.

Guidelines which address all, or many, environmental aspects are not relevant to this work. However, a number of important vegetation management frameworks are contained in guidelines of both utility sponsored groups and government agencies. The first published reference which infers that guidelines for vegetation management were available, is given by Egler (1953) in the American Museum System of Rights-of-Way Vegetation Management. Later Niering (1958) records that the Connecticut Botanical Society had established a Right-of-Way Vegetation Committee which was to investigate the management policies of power companies in the State, publish releases to aid the utilities and offer an advisory service on request. It is not noted if the impetus for the committee came from government, the utilities or from the Botanical Society.

In 1965, the Eastern Region of the Forest Services, U.S. Department of Agriculture, were sufficiently concerned about the lack of adequate vegetation management expertise and planning evident in the utility industry to hold two week-long training sessions for Forest Service and utility personnel. The training manual and field visits prepared under the joint auspices of the Forest Services and Dr. F. Egler were later published (U.S. Forest Service 1966) under the title <u>Vegetation Management on Rights-of-Way</u>.Utility system growth, Forest Policy, selective vegetation control, permits and preparation of right-of-way management plans (as noted previously) were discussed.

In 1968, the United States Working Committee on Utilities filed its report (Bagge 1968) to the President's Council on Recreational and Natural Beauty. The report contains four specific guidelines for rights-of-way: they should be properly maintained, grass cover should be maintained at towers but low-growing trees and shrubs should be planted and maintained at adequate distances from transmission facilities, access roads should be maintained to prevent erosion. In scenic areas brownouts should be avoided and when herbicides are used on suckering stumps, other plants should be protected. Finally, frequent vegetation inspections should be undertaken and the use of aircraft should be encouraged in this respect. A number of multiple-use alternatives were also listed. Although not spelled out in detail, a number of good basic management practices are implicit in the guidelines. Guidelines for initial clearing were also embodied in the report. The relationship between right-of-way establishment and subsequent maintenance, however, was not fully recognized.

Following this report a slightly more detailed formal government response was issued by the Energy Policy Staff of the U.S. Office of Science and Technology (1970). In the same year, the U.S. Department of Interior and Agriculture jointly issued the Criteria for Electric Transmission Systems (1970) and devoted three pages to the subject of maintenance but displayed little expansion on the simple theme in the original Working Committee's report.

The Western Power Pool area (which embraces eleven western U.S. states and British Columbia) issued suggested Environmental Guidelines for member utilities (Western Systems Coordinating Council 1971). Once again right-of-way maintenance received little attention and vegetation management, a major factor for west coast utilities, is mentioned in only one sentence in the context of fire hazards.

In Canada, the Canadian Electrical Association, an amalgam of utilities and the electrical equipment manufacturing industry, prepared Environmental Guidelines in 1975. Again the document lacks detailed content and the section on maintenance makes few substantive suggestions on methods.

The most recent guidelines issued are a series from the U.S. Forest Service which concern landscape management in National Forests. One volume deals specifically with utilities (USFS 1975). A small section is devoted to maintenance practices and a separate section to vegetation manipulation. It is noted that vegetation manipulation is one of the key problems to be studied at all stages of a utility project. The connection between construction clearing, revegetation, and ecological management is given tacit recognition. No detailed principles of maintenance are however developed.

Present guidelines appear, in summary, to be poorly conceived and ill prepared in the area of vegetation management. It remains then for individual utilities to follow their own consciences as to preparation of guidelines. These become more properly operating policies and procedures, but lack the cohesiveness of practice, rationale or philosophy necessary on a national basis. The requirement to address maintenance on new lines may now be more rigorously applied, however, under the U.S. EPA and Canadian Environmental Impact Statement procedures which have evolved since the beginning of this decade.

Vegetation Management Planning at the Operate and Maintain Stage

The long term nature of silvicultural practice in forest operations has meant that forest science developed comprehensive working plans at an early stage in the evolution of that science. The usefulness and appropriateness of this approach to long term management of resources has not been realized until recently amongst utility land managers, and still is applied by few utilities.

The first requirement for vegetation management plans arose from the Eastern Region U.S. Forest Service experiencing continued encroachment into forest land by electrical utilities with vegetation management objectives which eliminated all "brush" by cyclical retreatment with herbicides (USFS 1966). This practice which had eliminated substantial wildlife habitat, caused considerable complaint and was adjudged biologically unsound, resulting in enactment of Forest Service Policy R9 (1965). This policy required that all utility rights-of-way Special Use Permits contain a clause requiring (1) the joint preparation of a management plan for establishment and maintenance of vegetation on rights-of-way or (2) the application of selective maintenance to the right-of-way in accordance with a management plan prepared by the Forest Supervisor (USFS 1966). The spectre of outside agencies preparing right-of-way management plans must have jolted utility land managers into action since no record obtains in the literature to indicate that the Forest Service embarked on a program of writing linear corridor management plans.

The Forest Service publication on Vegetation Management for Rights-of-Way (USFS 1966) contains both a description of vegetation management plan requirements and an appendix with a suggested outline. Seven sections: General Consideration, Cooperation, Vegetation, Techniques of Control, Restrictions, Aesthetic Considerations and Photo-Records were further subdivided into detailed subsections. The most important part of the management plan (congruent with the objectives of policy R-9 to replace blanket spraying with selective maintenance) required the preparation of two cover type maps; one detailing existing species and a second predicting species response in relation to the control practices proposed and documenting the expected conversion complex. The management plan requirements were well thought out, but no record remains as to their effectiveness nor as to their present status in the Eastern Region of the Forest Service.

A number of other writers have alluded to management plans. Wetsch (1968) notes that a management plan is necessary for each new right-of-way and should include considerations of quality and reliability of electrical service, desires of the landowner, the requests of special interest groups, and most recently, appearance. Specific methods of executing such a plan are detailed. Farmer (1970) indicates that plans should be developed during initial construction to aid the maintenance program and should project management needs some five to 10 years into the future. Separate plans for rural and urban areas are recommended but the author fails to expand on content. Johns (1969) endorses the concept of programmed right-of-way maintenance and discusses environment, chemicals, methods, personnel, business economics, season and equipment in the context of management plans. It is concluded that "total programming" relating to all management; human, botanical and technological, can achieve real results and conserve aesthetics and physical resources. MacConnel (1967) examining the Holyoke Water Power System in the context of multiple-use research, contends that a comprehensive management plan for entire rights-of-way is necessary to integrate management of vegetation with desirable multiple-use. Gross (1969) observes that power line management plans will become essential as management of each area of line requires more intensive planning. Zonation, grouping areas with similar uses, problems and intensity of management, is recommended. Carvell (1973) expands on the idea with a breakdown of four zones intended to be compatible with topography, population density and demands of the public for various priorities. A high intensity zone is proposed for urban and residential areas, and an intensive management zone for lines visible from primary and secondary roads and adjacent to towns and small communities.

Lines frequented by the public for hiking and hunting are included here. An extensive management zone is delineated for all other areas except for the fourth zone which is designated for areas maintained by adjacent landowners.

Slatt (1969b) describes a program plan specifically geared toward retention of vegetation on rights-of-way in the interest of harmonizing this functional facility with the surrounding landscape, while Mann (1968) reviews the necessity of adequate plans to integrate various control practices on the Tennessee Valley Authority System.

There has only been spasmodic improvement from the time when Lincicome (1964) surveyed eighty utilities and found that most utilities (62) followed only a loose program of maintenance with little organized planning. Medicky (1976 p.58) aptly poses the question: "Are you prepared to initiate right-of-way development and management plans before someone does the job for you?" The answer on the part of utility vegetation and land managers should obviously be a clear "yes." Little evidence is available to suggest that this challenge has, or will in fact be met in the foreseeable future.

VEGETATION MANAGEMENT MODEL

Introduction

Websters Dictionary (1976) defines management as "the judicious use of means to accomplish an end," and manage, "to handle or direct with a degree of skill." The earlier section of this work on vegetation management objectives suggested that the "end" of concern is to manage vegetation on electrical utility rights-of-way efficiently, effectively, with least impact on the quality of the Total Environment consistent with the other aims and objectives of the utility, legal constraints, public desires, and most up to date knowledge. The model defined here attempts to graphically portray in simple fashion the "means" and "direction" in the context of vegetation management available to the skilled manager or to the manager who wishes to improve his present skills.

Egler (1958) expressed the concern that it is the biologist who has been missing, ignored or ridiculed at the council table of utilities. This may be so, but Egler goes on to note that some companies have employed biologists - but all too often they have chosen foresters, agriculturalists, agronomists, etc. - "men who may be competent in their own fields but are as handicapped in vegetation management as a surgeon would be if asked to treat an emotional disturbance." (at page 574)

Egler's guidance in vegetation management principles is most prudent. His assessment of the importance of formal background in a specific discipline is not. What is lacking in many programs is not scientific background, but pertinent staff experience and training, formal or otherwise, in simple management techniques. The problem of greater concern is that of electrical utilities where existing vegetation management expertise and ability is largely neutralized by engineers unaccustomed to decision making that involves biological principles. The attempt here is to provide a model that may be readily understood by any expertise found in utility operations, whether based on experience or formal education.

The model consists of two schematic summaries. One outlines electrical utility and vegetation management operations. The other outlines vegetation growth and control. The model also includes a schematic outline of vegetation control operations in the social and natural environment, and six tables that address the basic concerns in operating a vegetation management program on utility High Voltage and Extra High Voltage transmission lines.

Concepts of the Model

The basic concept of the model is embodied in its simplicity. It is intended to be complete and reductionist in display yet holistic in scope, illustrating the dynamic nature of vegetation management.

In addition to temporal and spatial dimensions, utility vegetation programs are a two-tier management of interrelated technical and administrative concerns, tempered with scientific application of biological principles. Quantitative and qualitative targets of such programs should be responsive to the scale and growth of the electrical system and to fiscal constraints. Such targets must recognize social and environmental effects and avoid negative perceptual or disruptive task methods.

In order to portray this interactive nature of vegetation management and some management constraints or options, alliteration is used as a readily remembered vehicle wherever possible in the model schematics. The synoptic tables are based on tersity of presentation while retaining conceptual and contextual validity.

It is intended that the management model and tables may be essentially choate without recourse to the text and may serve as a foundation for existing program examination or new program development.

Components of the Model

The initial component of the model (Figure 14) outlines in a logical progression, the basic Elements of an electrical utility. Of particular relevance to this model is the Transmission element and concomitant rights-of-way. All elements pass through a number of stages of which the operating and maintenance Function bears directly on the problem of vegetation management. Though a number of different maintenance operations occur on transmission rights-of-way, the Tasks associated with Vegetation and Multiple Use management alone are of concern in this management analysis.

To carry out the tasks which follow from vegetation management and from multiple use of rights-of-way it is suggested that five operational items are necessary: Men, Methods, Machinery, Materials and Money. In turn, these task needs respond to identified Problems. These problems evolve primarily from the need to manipulate and control undesirable woody plants. To accomplish this control, a number of alternative techniques are possible, ranging from mechanical or hand cutting through the use of herbicides, cultivation and seeding, fire and destruction with large rollers and chains to a combination of these methods. Multiple use of rights-of-way that destroy the continuity of growing conditions for tall growing woody plants are also a desirable alternative and are discussed separately.

Figure 14 Schematic Model of Utility and Vegetation Management Operations on Electrical Utility Rights-of-Way

ELEMENTS

Generation Transmission Distribution Administrative Facilities

FUNCTIONS

Planning

Design

Construction and Commission

Operations and Maintenance

MAINTENANCE TYPES

Civil Mechanical Electrical Vegetation Multiple Use

TASKS

(Operational Task Needs)

Men Methods Machinery Materials Money

PROBLEM IDENTIFICATION

Source Sign Size Severity Significance Solution

VEGETATION GROWTH CONTROL

Alternatives

Cut Chemical Cultivate Combust Coaretate and Crush Combinations

LOGISTICS

Who What Where When Why

Biological control of undesirable woody plants on rights-of-way except through the ecological manipulation described later may not be possible as the undesirability of these plants is in association with the right-of way use and is not an inherent characteristic. At present it appears that this site specific incompatibility will preclude use of biological control agents without a method which would ensure specificity within the right-of-way.

There are however, two important exceptions to this general premise that warrant further investigation. Niering (1974) records the grass littlebluestem (Andropogon scoparius) as forming stable pure dense stands, (though suggests that the inflammability of this species may support its perpetuation making it unsuited to rights-of-way). Huckleberry and low blueberry (Vaccinium sp.) and greenbriar (Smilax rotundifolia) are recorded to have formed single dense stands stable for over 15 years. This is only one example of many in the right-of-way literature (Damman 1971, Niering 1955, Pound 1953, and more recently, Bramble 1972, 1976). In some cases shrub complexes or individual species have exhibited stability and resisted invasion for decades.

The various successional hypotheses are now being supplemented with observations on possible plant allelopathy. All the species cited above are suggested to produce allelopathic litter (Niering 1974). Middleton (1977) describes work at the Kane Experimental Forest where the impact of various grasses, ferns, asters (Aster sp.) and goldenrod (Solidago) on forest regeneration is being investigated. Leachate samples taken separately from either top or roots of these species have shown significant inhibitory effects on other species. With more explicit understanding of allelopathy some promise may attend the future of biological control for rights-of-way.

Evolving from forestry failures is the second area of possible study. Successful establishment of forest crops, planted or naturally regenerated, has been plagued by two problems. Certain species and certain individuals within species appear particularly prone to ungulate browsing or attack by rodents. The continual search for rapidly growing individuals of merchantable form or for individuals hardy to the rigors of particular adverse locations has meant the establishment of long term provenance and improvement trials. Always there are "failures," plants which are moribund, lacking in vigor, or attractive to mammals.

The genetic significance of this individual differentiation is important. The very conflict between the forester and his needs, and the right-of-way manager and his needs, may serve to illustrate possible research directions for the latter land manager.

Problem solutions, and the resulting implementation tasks for vegetation management require an ordered strategy for execution. It is suggested that the Logistics involved can be elucidated by answering the prompting questions of: Who, What, Where, When and Why? This concept is described in greater detail in the appendix on Logistics.

Figure 15 begins with a description of the interaction between vegetation, transmission lines and rights-of-way. Vegetation may, on the one hand, Enhance the right-of-way by providing amelioration of the stark outline of towers and protuberant facilities, by blocking the view down the right-of-way, through provision of wildlife habitat and food, and by protecting the soil surfaces from erosion. On the other hand, tall growing woody plants may Endanger the transmission line from below and by encroachment from the edge of the right-of-way where dangerous trees may eventually fall inward and strike the line.

The significance of the broad ecological type, the site specific community, the stages through which that community will pass for that location, the particular stage that has been reached, and the stability of the seral stage are recognized in the model. These factors must play a large part in a vegetation manager's documentation, consideration and judgement of appropriate task methods, and of the timing for implementation appropriate to a particular location, in order to fulfill the objectives of management. Species and individuals present in a community will exhibit different growth rates depending on their inherent potential and the climatic and edaphic factors prevailing at a given site, at a given time. Simple key words are given in the model to indicate the factors that influence the plant growth rates which must be incorporated in planning decisions for program projects.

From Figure 15 it is apparent that a number of alternative methods for undesirable vegetation control exists. It is possible to anatomise the considerations for any particular Task Method Alternative. The resulting Task Method Breakdown identifies the most important options and decisions which are required for each project method. The example given here is for the choice of selective herbicides. A more detailed breakdown is contained in Appendix G. A similar breakdown can be prepared for each method alternative.

Moreover some methods, circumstances, and locations require removal of the resulting dead vegetation. Concerns of fire hazard, appearance, and rodent harbourage, for example, arise from cutting large dense patches of young trees in urban areas. A description of the alternative methods for Vegetation Disposal completes the second schematic model, Figure 15.

Figure 15 Schematic Model of Vegetation Growth and Control Operations on Electrical Utility Rights-of-Way

IMPACT OF VEGETATION GROWTH

Endanger Enhance

BIOME & COMMUNITY

Sere Successional Stage Stability

INFLUENCES ON VEGETATION GROWTH RATE

Species Size Season Sustenance Space Sun Soil Site Slope

TASK METHOD BREAKDOWN FOR GROWTH CONTROL

Chemical Example

Selective Chemical Control Consideration

CHEMICAL CHARACTERISTICS

Selectivity	Retains desirable species
Susceptibility	Efficacy on undesirable species
Stability	Rate of degradation
Sensitivity	Environmental hazard, social acceptance

APPLICATION CONSIDERATIONS

Technique	Dormant, stem, foliage, etc.
Specific Chemical	Manufacturer, chemical composition, etc.
Type	Formulation, carrier, etc.
Rate	Selectivity, hazard, cost, etc.
Application Techniques	Broadcast, spot, etc.
Application Method	Hand, ground or aerial equipment

METHODS OF VEGETATION GROWTH DISPOSAL

Chip

Collocate

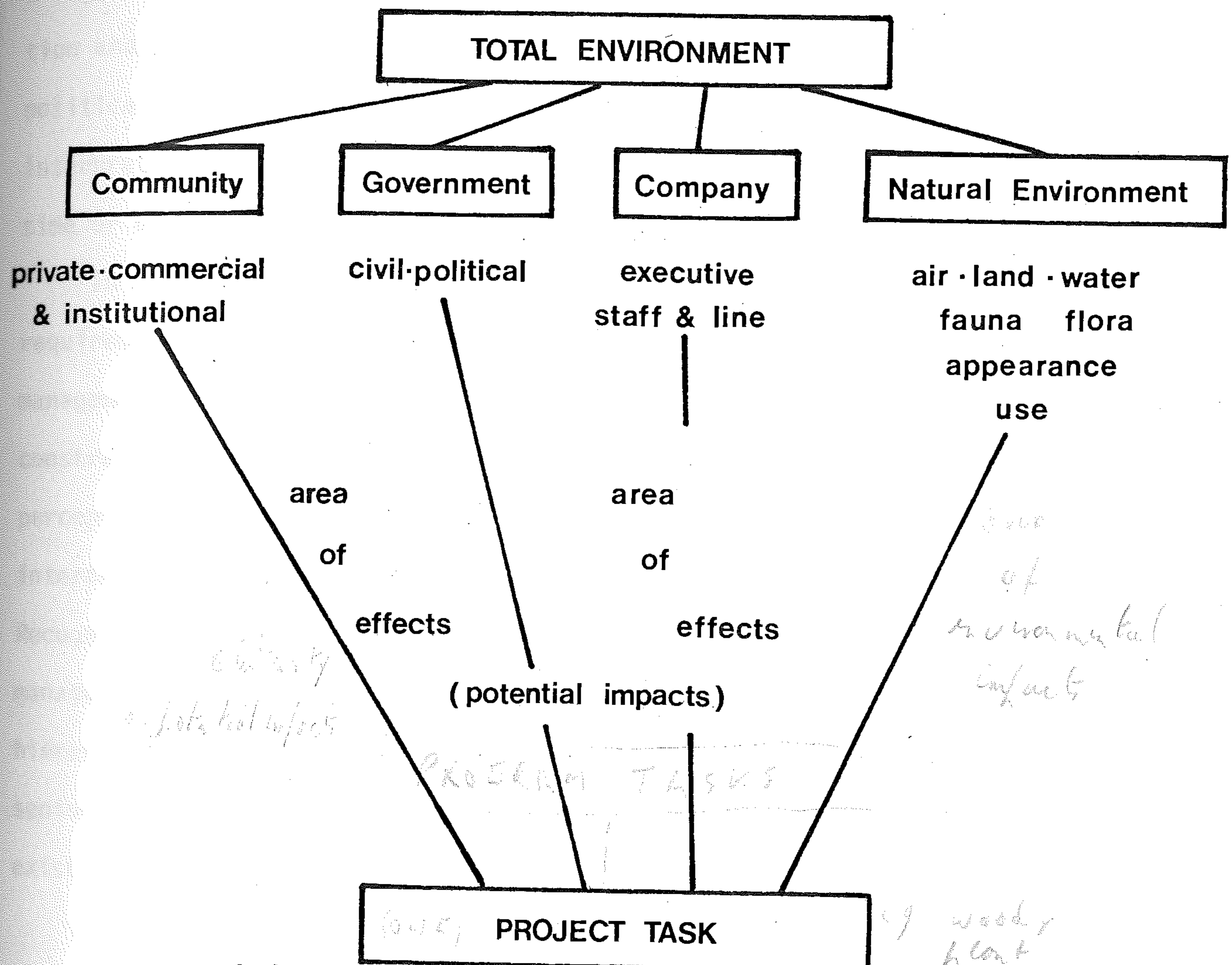
Combust or carry

The execution of project tasks on the right-of-way may incur some predictable consequences. Figure 16 displays the identifiable components of the Total Environment which may be affected by vegetation management operations. It is suggested that the total environment is a combination of social and physical entities which should form an 'impact checklist' for each task method. By plotting the actions associated with each method alternative, it becomes possible to test the acceptability and efficiency of each method in the context of each entity of the total environment. Although given in simple form each sub-component of an entity must be identified. For example, civil government would consist of various levels of government and departments that might be involved in a vegetation project, as discussed in the appendix on Communications. The "natural" environment would require expansion into sub-units for each entity. Water, for example, would be divided into surface and ground water, and surface water into streams, rivers, standing water and lakes. Each identifiable existing unit would be determined from the Historical Profiles listed in Figure 18, page 149.

By comparing each entity against the proposed task method, it is possible to judge the viability of choice, the potential for undesirable impacts, identify potential hazards, and prepare contingency work plans or environmental safety procedures. This simple analysis affords the vegetation manager a methodology for predictive planning and strategy preparation that has not characterized utility programs in the past. Inattention to this detail has consequently produced a public scepticism about the ability of vegetation managers to manage responsibly their assigned mandates.

The utility vegetation manager normally operates some considerable way down the corporate organizational structure, which in totality is either directly or indirectly in the sphere of government regulation. Table I

Figure 16 Schematic Model of Interaction Pathways Between Environmental Components and Vegetation Management Tasks on Electrical Utility Rights-of-Way


TOTAL ENVIRONMENT
Community
Government
Company
Natural Environment
private·commercial & institutional
civil·political
executive staff & line
air · land · water fauna flora appearance use
area of effects
area of effects
(potential impacts)
PROJECT TASK

shows the hierarchical nature of the external influences that may impinge upon a vegetation management group. Each step above the group is one further removed in appreciation of the direct problems and responsibilities faced by a vegetation manager. To further pervert the orderly transfer of communication and understanding up, down, and across the hierarchy, factors of political pressure, precedent, alteration or enactment of laws, and erratic interpretation of regulations, bureaucratic zeal or indifference, as well as time or organizational limitations, may modify the technically ideal plan.

In addition to subtle negative influences there are a number of corporate requirements that are not necessarily compatible with the ideal vegetation management plan, such as expediency and program alteration prompted by fiscal constraints. In addition, factors arising from senior and middle management perceptions or lack of perception, corporate image, Function priority, poor interdepartmental communication, and interpersonal discord are often evident. Recognition of these factors and compensation for them must underlie a well managed program. It must also build on the positive influences of the hierarchy; administrative flexibility, willingness to expend funds, sensitive senior management, and environmentally sound corporate policy, where these exist.

Below the department level and directly within the purview of the vegetation management group, it is possible to influence the management style and responsibilities and the scope and execution of the vegetation management program from a central location. A division of responsibilities is outlined in Table II. The centralized group in a decentralized system may exert management influence by approval mechanisms, issuance of standards and guidelines, assignment of task and responsibilities, by supervision and

TABLE I ELECTRICAL UTILITY RIGHT-OF-WAY VEGETATION MANAGEMENT SYNOPSIS: MANAGEMENT INFLUENCES AND CONSTRAINTS

POLITICAL MANIFESTO

PUBLIC PREFERENCE

GOVERNMENT GOALS

GOVERNMENT POLICY

CORPORATE RESPONSIBILITIES

CORPORATE GOALS

CORPORATE FUNCTIONS FOR OPERATION

CORPORATE POLICY

DIVISIONAL RESPONSIBILITIES

DIVISON POLICY

DIRECTIVES ON METHODS

DEPARTMENTAL RESPONSIBILITIES - VEGETATION MANAGEMENT GROUP

DEPARTMENTAL TASKS

DIRECTIVES ON METHODS

SUPERVISION

RECORDS

TABLE II ELECTRICAL UTILITY RIGHT-OF-WAY VEGETATION MANAGEMENT SYNOPSIS: CENTRALIZED FUNCTIONS IN A DECENTRALIZED SYSTEM

CORPORATE OBJECTIVES

CORPORATE POLICIES

CORPORATE FINANCIAL CONTROL

LONG RANGE PROGRAM PLANNING AND STRATEGY

ASSIGNMENT OF RESPONSIBILITIES AND ACCOUNTABILITY

INITIATION AND UPDATE OF STANDARDS AND GUIDELINES

PRINCIPLE GOVERNMENT LIAISON

PRINCIPLE PUBLIC LIAISON

SUPPLY OF SPECIALTY EXPERTISE ON A CONSULTING BASIS

PERSONNEL PLANNING AND TRAINING

ARBITRATION, MEDIATION, AND NEGOTIATIONS FOR REGIONS AND HEAD OFFICE STAFF

INTERDEPARTMENTAL CO-ORDINATION

PURCHASING AND SUPPLY

RESEARCH AND DEVELOPMENT

PRINCIPAL ACCOUNTING AND RECORD KEEPING

inspection, and with formal review of field records and summaries.

The summary of program rationale outlined in Table III provides a skeleton for corporate and public understanding of the reasons for vegetation management. Safety for the general public, utility workers, and wildlife is of paramount concern. Also of prime importance is continuity of service and prevention of outages or system disturbances caused by vegetation. Following these principal reasons are a variety of other concerns that have importance which varies with location, line priority, and special circumstances primarily associated with surrounding land use.

The core requirements for vegetation management programs are delineated in Table IV. It is suggested that it is not possible to operate a complete or effective program without these fundamental items. Table V outlines the operating influence and constraints that dictate the form of a program generally and of each project specifically. Each field of influence is described with a few examples which are self-explanatory.

Table VI expands on the concept of Task Needs and suggests some basic considerations that should attend the decision making process. This checklist format, which can be expanded or adapted readily for any organization, provides the vegetation manager a simple query tool with which to test program or project components and predictably determine problem areas.

The intendance of an electrical utility vegetation management program is normally dispersed over a wide geographical area. Table II has suggested that a number of functions operate most effectively at a central location. Although some support services and program control are centralized and are described here, it should not be inferred that a policy of centralized operation should apply to vegetation management programs. On the contrary, the

TABLE III ELECTRICAL UTILITY RIGHT-OF-WAY VEGETATION MANAGEMENT SYNOPSIS: REASONS FOR VEGETATION MANAGEMENT OPERATIONS

SAFETY

CONTINUITY OF SERVICE

LEGAL STIPULATIONS

RESPONSE TO COMPLAINTS

ACCESS

APPEARANCE

VISIBILITY OF STRUCTURES ETC. FOR INSPECTION

FIRE HAZARD REDUCTION

SECURITY

DRAINAGE

MOISTURE PREVENTION AT STRUCTURES

PLANT SELECTION IN ECOLOGICAL MANAGEMENT

WILDLIFE HABITAT IMPROVEMENT

ANIMAL PREVENTION - REMOVAL OF COVER AND HARBOURAGE

DERELICT LAND IMPROVEMENT

BOUNDARY DEFINITION

Table IV Electrical Utility Right-of-Way Vegetation Management Synopsis : Requirements for Vegetation Management Operations

Appropriate Corporate Operating Policies

Individual Line Clearance Policies

Individual Line Protection Policies

Staff Attitudes Supporting Integrity of the total Environment

Management Objectives

Management Plan

Staff with Appropriate Training

Updated Standards and Guidelines

Workload and Equipment Inventory

List of Approved Chemicals

Individual Property Profiles & Legal Description

Complete Support Services

Complete Support Documents & Records

Public, Government & Internal Communication Systems

Data Collection and Analysis System

Right of Way Management Historical Profiles

Appropriate Tendering Specifications

List of Approved Contractors

TABLE V ELECTRICAL UTILITY RIGHT-OF-WAY VEGETATION MANAGEMENT SYNOPSIS : OPERATING INFLUENCES AND CONSTRAINTS

OPERATING POLICY - CLEARANCES REQUIRED - METHODS APPROVED - PROGRAM RATIONALE

LAW - REGULATORY CONSTRAINTS - PRODUCT REGISTRATIONS

HISTORICAL - DISRUPTIVE CLEARING - GRADE AND RESEEDING AT CONSTRUCTION - REGROWTH

PHYSIOGRAPHIC - TERRAIN - GROUND CONDITION - OWNERSHIP - USE

BIO-PHYSICAL - SOIL - CLIMATE - ALTITUDE - VEGETATION ASSOCIATIONS

TARGET - SPECIES & COMPOSITION - DENSITY - RATE OF GROWTH - ACREAGE & HEIGHT

LOGISTICS - ACCESS TRAVEL TIME - SAFETY - STAFF TRAINING - STAFF EQUIPMENT & MATERIALS AVAILABILITY - TIME - SEASONS - WEATHER

ECONOMICS - AMOUNT BUDGETED AND AVAILABLE - OPPORTUNITY COST - PROJECT SENSITIVITY & QUALITY

AESTHETICS - PROXIMITY TO HABITATION & ROADS - VISTA IMPACT VISUAL IMPACT

(NATURAL)

ENVIRONMENT - WATER - FISH - BROWSE - SENSITIVE CROPS -

(SOCIAL) CONCERNED LANDOWNERS -

TABLE VI ELECTRICAL UTILITY RIGHT-OF-WAY VEGETATION MANAGEMENT SYNOPSIS : MANAGEMENT CONSIDERATIONS

METHODS	MEN	MACHINERY	MATERIALS	MONEY
LEGALITY	EDUCATION	SUITABILITY	HAZARDS	FISCAL CONTROLS
ADMINISTRATIVE COMPLEXITY	TRAINING	PROVEN RELIABILITY	PUBLIC ACCEPTANCE	WAGES
INTERPRATIVE SIMPLICITY	QUALIFICATIONS	SAFETY	COST	OVERHEAD
SAFETY	EXPERIENCE	COST - CAPITAL	FORM	FUNDS AVAILABLE
EFFICIENCY	RANK	COST - OPERATING	DEPENDABILITY	FUNDS BUDGETED
COST EFFECTIVENESS	JOB TITLE	DEPRECIATION	SUPPLY	BUDGET TERMS
FLEXIBILITY	JOB DESCRIPTION	DESIGN	PACKAGING	COST SHARING
ALTERNATIVES	SALARY	MAINTENANCE	EFFICACY	PRIORITY OF TASKS
GUIDELINES	MOBILITY	EFFICIENCY	AVAILABILITY	AMORTIZATION PERIODS
STANDARDS	AVAILABILITY	AVAILABILITY		
RECORDS	ASPIRATIONS	UTILIZATION		
PRESENTATION	AFFILIATIONS			
COMMUNICATION	CREATIVE FREEDOM			
	WORKING CONDITIONS			
	MORALE			

centralized functions suggested here are a maximum with the bulk of responsibilities and accountability resting with field staff.

Capabilities of the Model

The capabilities of the model are based on simplicity of elaboration and an intrinsic facility for comprehension.

Vegetation management organization and interrelationships are complex and subtle. The model attempts to cut through the irrelevancies of detail to the basic core of concerns. This core may then be expanded by logical development of each theme. Such development should allow insight into the administrative logistics of identification, analysis and planning. Identification of problem areas, method or management omissions, staff needs, and budget inequities should become apparent. Analysis of growth trends, trade-off options, and policy requirements should be simplified. Mission setting, predictive and contingency planning, and critical path program planning should be readily accomplished.

Inter and intra company understanding of the driving principles, program rationale, and management options for vegetation manipulation should allow development of a reasoned and less volatile operating climate than in the past. Demonstration of system dynamics may be used to offset or overcome regulatory agency inertia and public mistrust.

Induction of new staff and teaching of existing personnel can be based on a simple to complex progression in discussion of the model which would allow easy assimilation and ready retention of the basic parameters which govern vegetation management. In addition, senior management perceptions can be heightened and budget requests strengthened by utilization of well reasoned and illustrated rationale developed from origins in this or similar models.

Conclusions Based on the Model

Vegetation management on electrical utility rights-of-way has a clearly discernable structure, identifiable logic and distinguishable parts. The interrelationships are complex but may be distilled to a simple scopic pattern. Experience and expertise play an important role in the decision making process for vegetation management, but may be aided by reference to a dialectic and central framework.

Management concepts presented here are given for vegetation on high voltage and extra high voltage transmission rights-of-way only. Organizational and efficiency demands may extend a right-of-way management group's responsibilities to encompass all non-engineering tasks as outlined in Appendix G. Task method breakdowns and integrated scheduling would follow a similar pattern to that established here for vegetation management. A very complete right-of-way management force would then supplement those staff directly responsible for operation and maintenance of the electrical facility. Further, vegetation management and allied tasks have an aspect for each utility element. Overhead Distribution of electricity has a basic incompatibility with urban shade or ornamental trees and undesirable vegetation in rural areas. A study of the management components of this facet of utility operations has already been published (Gardner 1976). Generation and Administrative Facilities have a substantial vegetation requirement in establishment and upkeep of landscaped areas, moss and slime control, and a variety of tasks of an environmental nature which arise from each generation type.

Headpond debris collection and disposal from hydraulic generating stations, soil sterilization for tankfarm dykes and wells at thermal generating stations, fire hazard prevention, aquatic weed control, and visitor facility servicing are diverse examples. A fully integrated vegetation management group with a broad mandate may well suit a utility faced with these many peripheral yet important tasks.

No attempt has been made in the model to expand in detail on either task needs or on vegetation control alternatives. Some considerations for task needs is outlined in synoptic form in Table IV while vegetation control alternatives have been comprehensively reviewed by other authors (Jenkins and Fisher 1970, Carvell 1973, Goodland 1973, Cody 1975, Tillman et al 1976).

Multiple use of rights-of-way was comprehensively reviewed by Randell (1973). However, a further examination of this aspect of right-of-way management is warranted as it will play an increasing role in future right-of-way management plans and limit vegetation management options.

Right-of-way multiple use, that is, the incorporation of one or more additional and compatible uses within the demarcation of the right-of-way, has four differing forms. The most common is probably the use of right-of-way land for farming and does not require further explanation. The next most common use is coincidental to right-of-way operation and exists wherever the corridor is undisturbed in rural or wilderness areas. Here wildlife habitat and browse can be substantially improved by selective retention of desirable plants (Cavanagh et al 1976, Mayer 1976). This intrinsic value of selectively maintained rights-of-way to wildlife has long stimulated an outspoken advocacy by wildlife managers for responsible land use.

Egler (1953) observed that he knew of no other aspect of land management where a new approach promised to reduce costs and enhance multiple use than application of ecologically sound management. That promise has made slow progress toward universal fruition. Work by Bramble and Byrnes (1955a, 1955b, 1957, 1958, 1967a, 1967b, 1969, and 1972) has contributed most to the understanding of the long term evolution of right-of-way succession when manipulated with herbicides and the concurrent utilization of the corridor by many forms of wildlife. A later paper by Bramble (1974) determined enhanced songbird occurrence on properly managed rights-of-way. Early work by Jenkins (1955), Coffey (1954), and Gysel (1962a, 1962b) has also demonstrated the increased food potential and diversity of selectively maintained rights-of-way.

Oetting (1971) has demonstrated the importance of rights-of-way in upland game bird production and condemns the current maintenance practices on rights-of-way. Patterson (1974) observed that herbicides used on rights-of-way are not directly toxic to higher animals but their common blanket use may be an extremely important limiting factor (to wildlife populations). On the one hand, responsible utilities have taken a direct approach to wildlife enhancement and have earned deserved praise from the public and resource agencies (Pass 1970). In contrast, Clement has sadly reflected (1973) that despite the science of ecological vegetation management being ably enunciated by Egler beginning in 1946, most utilities have been more concerned with "killing brush" than with manipulating vegetation.

A survey by Loncia (1976) established that even now utilities are not well predisposed to adopting wildlife enhancement as a specific objective of management. Of three hundred and twelve utilities surveyed, only 24% indicated a plan for wildlife management, and this group represented only 10% of the rights-of-way controlled by all respondents. Enhancement for wildlife values has apparently received little priority.

Multiple use for wildlife apart, a number of other compatible uses have been suggested for rights-of-way, particularly those in or near urban centres where land use pressures are high and open space resources scarce. Most important uses are recreational in emphasis, and a few "productive." Carvell (1973) states that the past decade has seen a notable change in public attitudes toward the right to trespass on large holdings of privately owned lands and that today most people consider it their right to use utility rights-of-way for their own enjoyment (despite the fact that many utilities do not own their rights-of-way). Furthermore, it is suggested, many people feel that their use of these areas, since tacitly permitted by most companies, should warrant a type of vegetation management harmonious with their use. Actually, utilities have, through their past policies, fostered this attitude. In rural areas, agreements have been made to farm land, raise bees, and grow Christmas trees (MacConnel 1968 , Young 1970). Pressure is now exerted by community groups, municipal governments, and individuals for the similar privilege in urban settings. Linear parks, game refuges, hiking and nature trails, golf courses and driving ranges, playing fields, and court games, picnic areas, orchards and garden plots, equestrian and bicycle paths, and general parking are all potential uses. Limiting the spectrum at the moment is the standard of protection generally applied by North American Utilities and which is considerably more conservative than those in Europe (Luther 1973).

Finally, the common corridor concept advocated by Bagge (1968), Roy _et al_ (1970) and Howlett (1973) has complex implications for vegetation management. The concept presupposes that a number of utilities can exist within a right-of-way. Regulations already exist for gas pipelines and electrical transmission lines (American Society of Mechanical Engineers 1968), and transmission systems in highway allowances are commonplace. Railroad, telephone, irrigation, oil and water, and similar services may be combined in large multi-use corridors.

Integration of the vegetation management needs of each use without conflict or duplication will provide a unique opportunity to raise the simplistic graphic model presented here to a responsive, interactive computer model with sophisticated option and consequence analysis, and detailed predictive planning capability.

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The general proposition argued in this paper is that vegetation management on utility rights-of-way can be markedly improved by simplifying the underlying principles of management and exposing them for scrutiny. In so doing it is suggested that a number of themes exist, or should exist in a well balanced efficient vegetation management program but that many have not previously enjoyed complete or widespread currency within the electrical industry.

Detailed vegetation management option analysis at an early stage and longterm economic appraisal have not been undertaken by most utilities nor has comprehensive management planning been prepared or supported by clearly elucidated corporate policy. Without a strong commitment to a theme of advanced management it is not possible to operate a satisfactory program.

There has been an incomplete or, in many cases, incorrect perception of ecological principles that govern the dynamics of plant communities. The theme of biological competence is reiterated throughout the paper.

Of paramount importance to the success of any vegetation management program is a comprehensive, accurate, open, information network. This is underscored in the final theme of communications.

Without attention to these three themes, and their implicit implications there will be an inevitable and continuing conflict between electrical system growth and desired system reliability. If that reliability is reduced to the stage where major outages occur and electrical requirements for system protection are intensified the gains possible through environmentally and socially sound vegetation management will be lost or negated.

Twenty-two of the following forty-three conclusions and recommendations are drawn from the main body of the text while the balance, though of equal importance, are drawn from the detailed appendices and pertain to the strategies and methods for specific program management and execution.

CONCLUSIONS AND RECOMMENDATIONS

1. Even to the present day many electrical utilities simplistically substitute chemical brush control on rights-of-way in the place of integrated vegetation management. The most apparent consequences are unwanted impact on environmental and aesthetic quality coupled with reduced public confidence in utility land managers. This in turn makes planning, land acquisition, construction, and maintenance of new facilities substantially more complex and time consuming than is necessary.
2. As we face the energy demands of the future, electricity will have to provide an ever increasing share of those needs. Virtually all our basic energy, after gas and oil sources are used up, is best utilized in the form of electricity. This includes coal, fusion, geothermal, pyrolysis, wind, fuel cells, the energy of the tides, ocean currents, and thermal gradients, as well as the direct energy of the sun.
3. Historically the use of electricity has been doubling about every ten years. If the current trends persist in the next two decades, the demands for electric power will triple or quadruple.
4. The phenomenal increases in electrical power requirements and the necessity for greatly enlarged, reliable and economical electrical systems, coupled with increasing pressures on urban land use, are providing new and complex challenges to the utility vegetation manager.
5. As major transmission lines traverse many diverse land uses, are conspicuous, and are often the subject of easement agreements rather

than being constructed on utility-owned property, the conflicts which exist are considerable. The utility vegetation manager must be concerned with the security and safety of the transmission line, the desires of the immediate landowner, the aesthetic and environmental considerations of the general public, his own corporate operating policies and objectives, and the dictates of a wide variety of regulatory agencies.

6. The problem will continue to intensify as the undesirable side effects of some vegetation management techniques are documented and as the multiple use of rights-of-way increases in response to increasingly scarce green space resources in and around major urban areas.

7. The technological complexities of insulation, heat dissipation, reactive compensation requirements, the problems of prolonged service loss as a result of faults, and the difficulties encountered in construction and maintenance, would appear to make underground transmission of high voltages, in all but the most demanding sites of short distance, unlikely at least for the next two decades. Cost penalties alone, that are at present some 15 to 25 times that of equivalent overhead, would seem to indicate that underground cable will not be favoured unless a major technological breakthrough occurs.

8. Due to the advantages from transmission with high voltage and extra high voltage over long distance, including fewer structures per mile and greater efficiency in megawatts per acre, there has been a continuing trend to higher voltage transmission. Growth in the United States has been from about 3,000 miles above 230 KV in 1940; 8,000 in 1950; to 22,000 by 1960. Present HV and EHV equal 65,000 miles and rights-of-way occupy some 1.5 million acres and are expected to rise to about 165,000 miles

and 4 million acres by 1990. In Canada there has been an increase from 1960 of about 11,000 line miles occupying some 130,000 acres to about 24,000 miles with 434,000 acres of right-of-way today. Projected Canadian growth would indicate 60,000 miles and 1.4 million acres by 1990 to give a combined U.S./Canada total of 2 million acres now rising to almost 5.5 million acres by the last decade of the century.

9. Secure transmission systems are becoming extremely crucial as the trends associated with remote generation from load centres, increasing dependence on electricity, interconnection between major systems, and generation delays or cost constraints reduce systems' capacity. Outages caused by vegetation cannot be tolerated. General policies for clearance and individual line policies for protection should be developed by each utility for its own system.

10. The situation concerning system security is further complicated by the continuing pressures arising from the public demand for retention of vegetation on rights-of-way in order to mitigate the visual impact of construction and maintenance and by resource managers who wish to maximize wildlife and water quality values.

11. The increasingly sophisticated management requirements necessary to maintain both desired levels of system security and of aesthetic and environmental integrity are, in many cases, being superimposed on existing management systems which are ill-staffed, funded, organized and equipped. The conflict is obvious and iniquitous.

12. The initial clearing standards and quality of supervision at time of construction on rights-of-way play an important part in determining the complexities of subsequent vegetation management. In the past, initial clearing was an engineering function predicated largely by cost constraints. More recent environmental concerns and regulation have improved the situation, but advances are retarded by restricted knowledge on restoration of distributed land and restricted availability of native plant seed sources.

13. Vegetation growing on rights-of-way may either enhance or endanger the electrical facility. When of the appropriate size and placement, it may screen unsightly views, stabilize ground, and provide wildlife food and cover. Conversely, tall growing vegetation may endanger the facilities and impede access for inspection or repair. Vegetation management objectives are directed toward maximizing the benefits and minimizing the dis-benefits of each vegetation type while maintaining the values of environmental and aesthetic integrity.

14. The vegetation management group should be involved in the planning process at an early stage allowing maintenance criteria to be included in the new line route location decisions. The group should continue to be involved during construction and restoration to ensure that final maintenance is achieved as part of a planned evolutionary process.

15. The development of vegetation management guidelines from time of initial clearing until final maintenance cycles, has been attempted by a number of agencies. Few, if any, have been successful since the most

important component, that of an integrated management plan, remains to be adequately defined or utilized by most utilities.

16. A clear understanding of the dynamics of plant succession, the forces, influences and conditions which affect secondary succession on rights-of-way after initial clearing and the impact of each method of control on community stability is absolutely necessary before an adequate attempt can be made to prepare the necessary long term plans for properly managed corridors. Stabilized community development with shrub species has been shown to be possible and demonstrated to be ecologically and economically attractive.

17. If the use of foliar spraying of herbicides can be restricted from the beginning of maintenance on new rights-of-way or phased out on existing rights-of-way, a number of important benefits will result. These include cost savings over the long term, improved community relations, improved wildlife utilization of the right-of-way in non-urban areas, reduction in the undesirable appearance associated with blanket spraying and a natural balance of appearance throughout the season. In addition, the potential environmental impacts on water, soil and plant material contamination or erosion from plant removal, associated with widescale use of blanket spraying,are avoided.

18. As electrical utilities are predominantly staffed by the engineering professions, a problem has existed in applying appropriate biological principles to vegetation management. A simple model can be prepared to assist in understanding the complexities of integrated vegetation management. The model used here consists of three synoptic outlines and six supporting tables.

19. A suitable model must examine the elements of a utility operation, the policies used to manage that operation, the resulting tasks, the alternate task methods, and a breakdown of the components of that method. Each method must then be assessed in terms of social and environmental impact. Such option analysis has not been commonplace.

20. Organizational components and linkages require detailing for each utility. Simple guides may be prepared in the form of checklist tables similar to those given in this paper. Understanding of these components, program rationale, and management options allows reasoned communications with, and decisions by, senior utility staff and resource agency personnel.

21. Multiple use of rights-of-way should be seen as an important management alternative to physical vegetation control, especially in urban areas where active recreation is possible on rights-of-way and in rural areas where farming or wildlife enhancement is possible.

22. A clear distinction can be drawn between those tasks which directly execute the objectives of management in a utility vegetation management program and those tasks which are primarily administrative and supportive in nature.

23. Accurate field inventories of right-of-way conditions and good records are fundamental requirements in any program before it is possible to plan and manage effectively or protect aesthetic, social and environmental values.

24. It is possible to prepare graphic and written records in the form of roll plans prepared from initial clearing aerial photography and environmental impact statements. Such records should contain informa-

tion in four categories: static base data, critical base data, changing base data, and treatment data. The last two categories would be updated as time passed and maintenance conditions changed. New developments in remote sensing equipment and techniques are providing a wide range of possibilities to the vegetation manager responsible for linear corridors. Multispectral scanning, airborne radar, infrared colour, high resolution colour and black and white, high speed low level photography and advances in photogrammetry equipment require detailed study and appropriate application in order to simplify collection, interpretation and recording of field conditions.

25. Several image enhancement techniques are available which allow simple and accurate interpretation of particular ground signatures. Density slicing of tonal character is possible using a micro-densitometer. With high resolution, low level photography, it is now possible, with a minimum of development time to fly the right-of-way and produce a detailed and semi-automated determination of vegetation types, particularly tall growing woody plants which may endanger line security.

26. Further development of multispectral scanning and computer analysis will allow fully automated digital thematic mapping to be made in "real time", and for ground coordinates, record information, vegetation types with heights and terrain or conductor profiles to be printed directly on the final printout.

27. In order to prepare strategic plans, identify project manpower needs, and adequately prepare base data for budgeting, a comprehensive workload analysis should be prepared by each district vegetation manager.

Such an analysis must examine work quality and quantity in relationship to task needs and options. Workload analysis also allows preparation of realistic program targets and comparisons to be drawn with actual field programs in order to assess potential system security.

28. Systematic work records are vital to a vegetation management program in order to make program judgements which reflect the high level of management needed to ensure an efficient, effective and environmentally sound operation.

29. Work costing and cost effectiveness assessment of various methods of vegetation management are extremely important since larger rights-of-way now common with high and extra high voltage transmission lines magnify the expenditures per unit area and line mile. With increasing constraints on operating funds it becomes extremely important to choose the most efficient treatment methods over the long term, based on accurate records of past experience.

30. To date it appears that most utilities do not maintain sufficiently accurate records by which to judge cost effectiveness of vegetation management programs and are far from utilizing the advanced accounting systems which allow rapid identification of expenditures.

31. Support services, documents, and listings must be an integral part of a comprehensive vegetation management scheme in a large electrical utility. Support services are those provided by expert groups that have a general responsibility throughout an organization as, for example, with legal or salary administration. Support documents range from the policies and operating practices of the utility through

tendering specifications, to safety and filing manuals. Support listings record services, products or information sources appropriate to concerns of a vegetation management group.

32. A crucial element in the success of any vegetation management program is an awareness of communication needs both within an organization, particularly for support services, field staff, and senior management, and externally especially to the public and government resource or regulatory agencies.

33. Information concerning vegetation management programs and their rationale or methods is often the result of conjecture, misleading sources, or misinterpretation. Perception of information is readily distorted by personal biases, while retention of information is generally poor after only a few days, suggesting an important need for written communication.

34. As utility operations, and vegetation management in particular, are complex, technical and often bureaucratic processes which must interface with a wide cross section of the population, it is important to prepare a clear readable documentation of program rationale, policies, and procedures.

35. Many utilities are publicly owned and all operate in the public sector, normally without competition. The effect of their operations can have a profound impact on public resources. Consequently, it should be a public right to expect information, justification, and education about those operations.

36. Identifiable groups that should have direct access to information concerning utility vegetation management programs, or be provided with it, include private individuals or corporations likely to be

affected by operations, municipal and regional levels of government, provincial or state, and appropriate federal regulatory and resource agencies. A detailed system must also exist to inform all appropriate staff within the utility organization concerned.

37. In order to execute the management plans for a vegetation program, it is necessary to have a clear picture of the logistics involved. The stages involved, specially in a decentralized administrative system, allow for inadvertent changes to develop. To guard against this, detailed field procedures and reviews should be instituted for job planning and hazard assessment.

38. In order to sustain a viable vegetation management program, it is necessary to establish an ongoing research and development capability. It must be an integrated part of program planning and have clearly identifiable goals and respond to rigorous scientific protocols.

39. Inadequate follow-up on a long term basis has allowed many practices of dubious merit to become established in vegetation management programs. Continued scrutiny should be exercised for existing equipment, methods, and materials while through examination of new developments should allow institution of useful technological advances.

40. Areas of study requiring further research and development include safer herbicides, better methods and equipment for application, human and environmental safety implications of vegetation management, advanced planning and acquisition techniques, multiple use potentials of rights-of-way, restoration and biological controls, and most importantly, improved communication methods.

41. In order for experiences and findings to be more fully available and distributed amongst the utility vegetation management community, greater emphasis should be placed on publishing work. In turn, a centralized right-of-way information service is required to ensure simple access to new developments and conclusions.

42. In general, most utility vegetation management programs lag behind our present knowledge on biological and administrative systems. With a concerted effort by vegetation managers and a more open minded and enlightened approach by senior utility executives, it is possible to substantially improve the quality and effectiveness of such programs and reverse the often severe criticism which has attended right-of-way vegetation management operations in the past.

GLOSSARY OF

UTILITY RIGHT-OF-WAY -- TECHNICAL TERMS

Alignment	-	The specific, surveyed location or route of a utility line.
Alive, live, energized	-	Electrically connected to a source of potential difference or electrically charged so as to have a potential different from that of the earth.
Beautility	-	The application of aesthetic techniques to improve the appearance of utility operations or plant.
Brush	-	A term applied to woody shrubs and trees.
Cable	-	A conductor with insulation, a stranded conductor with or without insulation and other coverings (single-conductor cable), or a combination of conductors insulated from one another (multiple-conductor cable).
Circuit	-	A conductor or system of conductors through which an electric current flows.
Clearance	-	A proscribed distance free of intrusion required for safe operation of a Non-Insulated conductor and normally dictated by voltage rating.
Corridor	-	A linear strip of land which accommodates or is expected to accommodate a utility or all the utilities with similar orientation passing through a given land area. Its width can be variable and is normally measured in feet.
Corridor analysis	-	A study of the visual, environmental, physiographic and sociological characteristics or land areas considering the technical requirements of a utility for the purpose of locating the most appropriate utility corridor.
Coaretate	-	Press together.
Collocate	-	Pile side by side.

Conductor	-	A material, usually in the form of a wire, cable, or bus bar, suitable for carrying an electric current.
Grounding conductor	-	A conductor used to connect equipment or a wiring system to a grounding electrode or electrodes. Used to provide a potential reference.
Line conductor	-	One of the wires or cables carrying electrical current, supported by poles, towers, or other structures, but not including vertical or lateral connecting wires. (There are overhead ground conductors which are not capable of carrying much current).
Grounded conductor	-	A conductor which is intentionally grounded, either solidly or through a current-limiting device.
Counterpoise	-	Buried ground wire.
Danger tree	-	A woody plant which may by reason of height, instability, placement, species or other factors endanger the security of an electrical line.
Deenergized	-	Free from any electrical connection to a source of potential difference and from electric charge; not having a potential different from that of the earth.
Double circuit	-	A line having twice the number of conductors as that of a single circuit line. (See: Single Circuit Line.)
Easement	-	A permanent legal grant to a utility for the purpose of placing and maintaining plant etc. on private property.
Edge effect	-	Provision of wildlife food and habitat on the periphery of a right-of-way by allowing the growth of low growing shrubs and trees steadily increasing in height toward the desired boundary.
EHV	-	Extra high voltage (greater than 400KV).

Elements	- Those major segments of Electrical Utility Operations normally described as Generation, Transmission and Distribution.
Energized	- See: Alive.
Environment natural	- Those parts of the environment natural origin which are required to sustain life, namely: air, water and land as modified by man and including present fauna, flora, use and appearance.
Environment total	- The ecosocial environment comprised of the public sector, government sector - both civil and political, the company, and the natural environment.
Functions	- Those major work categories covering all phases of utility operations in each of the Elements.
Grounded	- Connected to earth or to some extended conducting body which serves instead of the earth whether the connection is intentional or accidental.
Grounded system	- A system of conductors in which at least one conductor or point (usually the middle wire or neutral point of transformer or generator windings) is intentionally grounded, either solidly or through a current-limiting device.
Group	- A formal assemblage of staff with individual and collective responsibilities oriented toward a common goal.
High tension	- High voltage circuits.
HV	- High voltage (greater than 230kV).
Impingement	- The range of effects on the Total Environment, or the point at which the effect changes environmental quality.
Insulated	- Separated from other conducting materials by a dielectric sheath.
Interruptable load	- A supply of electrical power which can be terminated for varying periods at the option of the supplier.

Joint use - Simultaneous use of a right-of-way or structure by two or more kinds of utilities.

kV - Kilovolt (1,000 volts).

Lightning arrester - A protective device for limiting surge voltage on electrical equipment by a discharging or bypassing surge current; it prevents continued flow of follow current to ground and is capable of repeating these functions.

Line - A group of wire conductors electrically insulated from each other and ground supported by a series of wooden poles or metal towers used for the purpose of transmitting electrical energy from the point of generation to the point of consumption.

Line security - The degree of protection required to prevent outages occurring on a circuit.

Linemen - Men qualified to climb the structures and carry out repairs and maintenance to transmission lines.

Load centre - The centre of an area that consumes or utilizes electrical energy such as a large city or industrial complex.

Low growing shrubs - Shrubs which do not normally attain a height in excess of three meters at maturity.

Low growing trees - Trees which do not normally attain a height in excess of seven meters at maturity.

Megawatts - One million watts, a unit of quantity of useful electrical energy, i.e. the equivalent of horsepower.

Mitigation - Alteration of the scope of a project in order to avoid or reduce adverse environmental effects, modification of a project design while not modifying its objectives, or measures taken during the execution of a project to avoid or minimize environmental impact.

Mode - The specific type of method used to accomplish the requirements of each Element of a utility's responsibilities.

Multiple use - Simultaneous use of a right-of-way by a utility or utilities and another compatible land user or activity.

Open wire - A non-insulated conductor or pair of conductors separately supported above the surface of the ground.

Outage - Loss of electrical supply usually due to faults in the power system.

Prescription maintenance - The choice of maintenance techniques best suited to a particular problem after examination of all influencing factors.

Program - A collective unit of projects conducted at separate geographical locations yet in a common time frame and directed toward a common objective.

Project - A collective unit of tasks conducted in contiguous geographical locations, in a common time frame and directed toward a common objective.

Route - The specific surveyed location of a utility line.

Route analysis - A study of the visual, environmental, physiographic, sociological, legal and economic characteristics of a land area considering the technical requirements of a utility for the purpose of locating a site specific alignment for a transmission line.

Sag - (Also known as Catenary.)

Apparent sag at any point - The departure of the conductor at the particular point in the span from the straight line between the two points of support of the span, at 60°F, with no wind loading.

Apparent sag of a span - The maximum departure of the conductor in a given span from the straight line between the two points supporting the span, at 60°F, with no wind loading.

Initial unloaded sag	- The sag of a conductor prior to the application of any external load.
Maximum total sag	- The total sag at the mid point of the straight line joining the two points of support of a conductor.
Total sag	- The distance measured vertically from any point of a conductor.
Single circuit	- A line made up of the least possible number of conductors required to transmit electrical energy from one point to another. (See: Line.)
Span length	- The horizontal distance between two adjacent supporting points of a conductor.
Strings	- Refers to strings of insulating devices formed of porcelain or glass used to attach power line conductors to the supporting structures.
Structure	- A pole or tower specifically designed for supporting an electrical conductor.
Tasks	- The specific job requirements involved in each of the Functions.
Task intensity	- The degree to which any Task is carried out. Where the degree is predetermined but flexible for a number of similar tasks it may be termed a Guideline. Where it is not flexible it may be a Standard.
Task methods	- The alternative techniques available to accomplish an individual job.
Task method breakdown	- A detailed analysis of the factors comprising a specific technique.
Tension:	
Final unloaded conductor tension	- The longitudial tension in a conductor after the conductor has been stretched by the application for an appreciable period, and subsequent release, of the loadings from ice and wind, and temperature fluctuations.

Tension:

Initial conductor tension	-	The longitudial tension in a conductor prior to the application of any external load.
Tower	-	A sometimes wood or concrete structure designed to support an electrical conductor above the ground.
Utility environmental maintenance	-	Necessary work required to sustain or improve the quality of the natural environment where affected by utility Functions.
Vegetation management	-	The application of the most efficient, safe method to resolving the variety of problems encountered in establishment, maintenance, control, or disposal of plant material.
Vertical construction	-	The method of attaching conductors to insulators mounted on and perpendicular to the side of the pole or other support used for electric line construction.
Voltage	-	The effective (rms) potential difference between any two conductors or between a conductor and ground. Voltages are expressed in nominal values. The nominal voltage of a system or circuit is the value assigned to a system or circuit of a given voltage class for the purpose of convenient designation. The operating voltage of the system may vary above or below this value.

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Appendix A Plant Ecology and Rights-of-Way

PLANT ECOLOGY AND RIGHTS-OF-WAY

Introduction

Before the phenomenal growth of electrical systems after the Second World War, the bulk of transmission line maintenance was accomplished by hand. The development of synthetic growth regulators with herbicide selectivity for many plants classed as weeds [a plant with negative value in a given management system, Roche (1967)] completely revolutionized right-of-way vegetation management. Despite the detailed work by Egler (1949, 1950, 1953) that demonstrated the importance of complete kill with application to the individual plant of basal sprays allowing retention of desirable species that would retard further regrowth of undesirable plants, the chemical companies and utilities found it more expedient to recommend and accept blanket foliar spraying which soon became well entrenched (Arner 1966). The clear distinction between "brush" control and elimination (Pound 1953) was not understood by the vast majority of utility staff responsible for vegetation management. The predominance of engineers in these positions with little or no understanding of ecological principles appears largely responsible (Egler 1958). It was this blatant lack of knowledge that allowed the incorporation into most utility vegetation management programs of practices which were generally allowed to continue without question for 25 years. Even then, it was the herbicides themselves and not the usage patterns and philosophies of use which were challenged by the leaders of a swell of public concern as to the quality of our natural environment and the potential for impaired human health. The importance of an adequate inventory (Newton 1967a, Olenik 1977) conducted by botanically trained staff (Egler 1953, Carvell 1973) as a baseline which would take account of the changing patterns of succession (Tansley 1935) and eventually evolve into an analysis of the vegetation and a planned approach to an eventual stabilized community (Newton 1967b, National Academy of Sciences 1968) appears to have been largely ignored. Consequently, rights-of-way were generally managed as simple communities, a condition well known to be unstable (Roche 1967) and where undesirable herbicide resistant species were selected by cyclical blanket spraying (Barcley 1972). Little was known as to the long term effect of constant herbicide use (Kimmins 1975) but the direct effect of brownouts and indiscriminate killing of desirable low growing woody plants and wildflowers (Grove 1956, Niering 1968) meant that the electrical utilities have developed rights-of-way where restoration may take a lifetime of effort (Day 1967) and a public reputation for unsound policies in the management of power line corridors (Tillman 1973).

As shall be seen in this section, there is no necessity for this situation. Adequate research has already demonstrated that ecologically sound vegetation management concepts exist and can provide numerous benefits in addition to direct savings. These concepts are based on detailed work extending over many decades. Much of the work is directly related to rights-of-way and has been originated there or on similar disturbed land. The impact of cyclical application of foliar herbicides is shown to be contrary to the implicit aims and objectives of vegetation management on electrical utility rights-of-way and has probably become established through ignorance, assessment by short term appearance, chemical company pressure, contracting to commercial application, little concern for adequate record keeping or cost accounting and inattention by most of the scientific community and the public at large to the expanding use of chemical vegetation control.

Concepts of Plant Succession

With very few exceptions, rights-of-way will be subject to some manner of initial clearing at least in non-urban, non-agricultural areas. Although some alpine meadow or desert areas, for example, will not support vegetation likely to interfere with electrical transmission, most other areas will have tall growing vegetation removed. In most cases, it is not practical to carry this out in a linear corridor, in all probability with preservation requirements outside the right-of-way boundary, without substantial damage to the undercanopy. It has therefore been the practice of most utilities to clear substantial areas to bare earth.

Secondary succession then, is the influencing factor which will determine the subsequent form and content of the vegetation community which will replace the initial clearing sequence. A number of theories or combinations of concept have been advanced to explain the dynamics of vegetation establishment, advancement, and replacement in this situation.

Tansley (1935) suggests that much of the credit for early knowledge for deducing the general laws of succession belongs to Cowles (1899). In turn, Tansley's work on autogenic and allogenic succession (1929) and Clement's earlier work (1916) have provided a stage for development of the two general explanations of succession on disturbed land. The wave or "relay floristics" concept suggests that changes in community structure take place as successive plants invade by seeding in, driving out the previous lower growing community which has become more vulnerable as it modified its own environment. The concept of "initial floristic composition" has been more recently advanced by Egler (1954) to explain his field observations and the inability many seedlings of woody plants exhibit to readily invade some grassland and many shrub communities. The hypothesis assumes that weeds, grasses, forbs, shrubs and trees were all there present on or in the soil at time of disturbance as seed, seedlings, cuttings or shoot producing roots. Development through successive stages eventually allows the trees, there from the start, to overtop the other plants and relegate them to understory. It is on the basis of this idea, that it is primarily existing propagules and not reinvasion that allows the prolific growth of tall woody plants after ground disturbance, that Egler bases his strong criticism of utility practice of "brush control" rather than undesirable plant elimination, suggesting that with many shrub communities there will be slow reinvasion and, supported by Bramble and Byrnes (1976), poor successful emergence of seedlings from the shrub canopy.

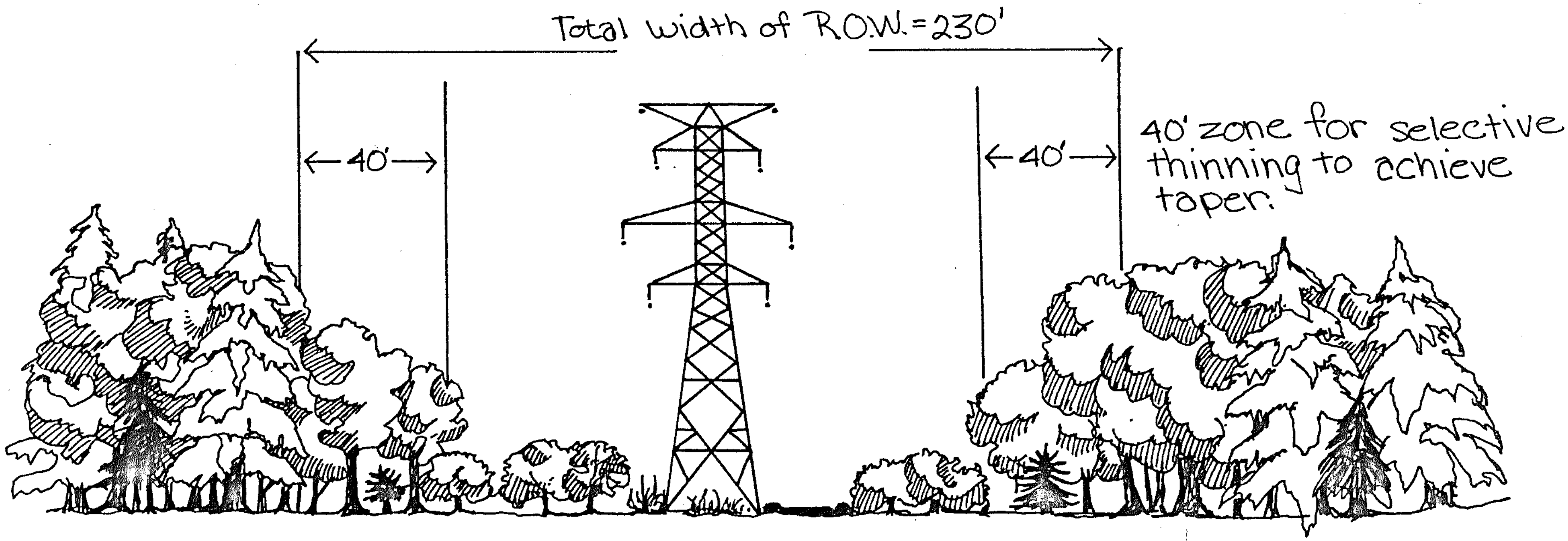
If this is the case, there are certainly a plethora of references which have documented suggested causes for this poor survival rate. Richards (1973) feels that moisture and nutrient competition especially on dry sites, meadow moles, deer, rabbits, and white grubs (<u>Phyllaphaga</u> sp.) play an important role, while changes in micro-climate, particularly frost pocketing, and edaphic changes as a result of allelopathy or mycorrhizal inhibition are cited. Bramble and Byrnes (1969) suggest that deer browsing, normal plant competition and spring frosts play an important role in controlling tree seedlings even below the shrub layer. Keever (1950) felt that succession on old fields in North Carolina was greatly influenced by light and water competition, soil erosion in open communities, and rates of organic matter decay. Allelopathic control was not thought to be a factor, but the timing of events in the life cycles of the first invaders and its relation to the season of the year at which secondary succession is initiated will influence the dominance of species. Adding to this list Buell et al (1971) felt that frost heaving, snow cover, and mode of transport for propagules were extremely important. Certainly it appears to be a combination of factors. In confirming this conclusion Odum (1969) notes that succession is not a straightforward idea. It is rather an interacting complex of processes some of which counteract each other. Buell (1971) and Richards (1973) challenge the hypothesis offered by Egler (1954). It seems reasonable to postulate that in fact secondary succession after clearing particularly on rights-of-way is a function of both relay and initial floristics, further modified by a number of important allogenic factors and the degree of disturbance at time of initial clearing. In addition, the site factors which change across the cross-section of the right-of-way, Figure 17, coupled with elevation, aspect, peripheral shading, supply of propagules, and initial maintenance practice, will largely determine the actual succession in a particular corridor.

Impact of Herbicide Use on Plant Succession

The widespread use of selective herbicides has been common on most utility rights-of-way. Blanket spraying of undesirable vegetation once it reaches a certain height has been common practice. However this technique significantly influences plant succession, often totally changing the plant community then dominant on that particular area of the right-of-way.

This section is only intended to review the literature on reported impacts of different practices without drawing substantial inference from the findings. The section on ecological vegetation management will attempt to link the information noted here and draw conclusions based on this and

Figure 17 Development of an Ecologically Desirable Right-of-Way Cross Section


Total width of R.O.W.=230'
40'
40'
40' zone for selective thinning to achieve taper.

the current knowledge about successional development on disturbed lands, to provide a conclusive outline for ecologically sound vegetation management.

Carvell (1973) suggests that there has been a general policy amongst most utilities to establish and maintain grassland communities under transmission lines. The selective capability of the phenoxy group of herbicides coupled with ecological naivety on the part of many staff responsible for vegetation management (Niering 1974), and the reluctance of most agricultural chemical companies to actively pursue and advise on balanced, ecologically sound, integrated vegetation control programs (Egler 1958, 1966; Neiring 1968), has meant that blanket foliar spraying has been the mainstay of most utility vegetation management attempts. The difficulty is in demonstrating that such use is, in the long term, directly contrary to the objectives of management stated by Neiring (1961) as ".....elimination of undesirable vegetation that would either impede access or eventually grow or fall into the lines . As much of the existing shrub vegetation should be preserved as possible, not only for its high wildlife value, but also in order to create a ground cover to minimize the invasion and establishment of new tree growth in the future". The problem is compounded by such prestigious bodies as the National Academy of Sciences (1968) suggesting in its Manual of Weed Control (p. 308) that "Foliar treatment is the most economical and frequently used woody plant control technique, particularly in early phases of a program." Frequently used, it may well be, but this section will attempt to elucidate why it is far from the most economical. The statement is, however, symptomatic of the problem referred to by Day (1967) of implementing change and the technological time gap which exists between current knowledge and current practice.

It is fundamental to the understanding of ecologically sound vegetation management that the consequences of broadcast application of herbicides (or, less common, the unselective mowing of large areas) be distinguished from the consequences of selective treatment of individual plants. Further, the efficiency of herbicide use may be largely modified by choice of herbicide formulation, rate and carrier, by technique used, timing, weather conditions, the size, density, condition, species, and individual genetic complement of the target vegetation and the work habits, pride and conscientiousness of the applicators (see also Appendix G). These factors will have a significant influence on the level and type of impact that herbicide use may have on right-of-way plant communities and their successional development.

While Day (1967) notes that the single introduction of a herbicide into the environment can influence the composition of the vegetation of a forest, range, or watershed for a lifetime, it is substantially more difficult to adequately document those influences. Kimmins (1975) suggests that despite the level of concern over the environmental implications of herbicide use (in forestry) there has been remarkably little research on the effects of such use on the structure and dynamics of ecosystems. In general, the complex logistics, cost and long term nature of detailed research into the ecological effects of herbicide use has meant that few papers of value are to be found in the literature. Thus, while there are modest quantities of information on the genetic, physiological-biochemical, morphological, and toxic effects of herbicides on a variety of types of organisms, there is little direct information on the integrated consequences of all these effects for populations and communities, and even less for ecosystem structure and functional processes (Kimmins 1975). Considering these general comments, it can be seen that references to specific long term research on a right-of-way are unlikely to be abundant. With the notable exception of Bramble and Byrnes (1955, 1957, 1958, 1967 b, 1969, 1972, 1974, 1976) little useful information exists. A number of authors have, however, drawn from long experience of herbicide use on various rights-of-way in order to report consistent findings.

It is not the purpose of this section to examine the impact of herbicide use on ecological energetics or on biogeochemistry, however, it must be recognized that these direct, though poorly documented effects, as for example with changes in sunlight capture, storage and transfer, biomass production and herbivore populations, or with interruption or alteration of the pathways and mechanisms of nutrient cycling may have a significant, if indirect, impact on community structure and stability.

More direct effects are inherent in the very purpose for selective herbicide application to vegetation. Such herbicides are normally applied to remove specific components of the plant community (Barrons 1969) with the express purpose of favouring some other component of the plant community, at least temporarily. If at all possible, the objective in right-of-way vegetation management should be to ensure that the method of application provides the advantage for as long as possible, thus ensuring the least recurring disturbance and lowest cost per annum before retreatment is required. Here lies the crux of contention between those who advocate and pursue common practice and those who support a more enlightened approach to ecologically sound vegetation control on rights-of-way. Few would deny the usefulness of herbicides for vegetation manipulation; they are an important and generally safe tool. It is the consequences of one particular use - widespread blanket foliar applications - that appear to provide ecological consequences in community structure quite contrary to the objectives of management.

As discussed under "Objectives," the principal concern to the utility engineer, and consequently the vegetation manager, are any potential causes of unplanned outages. Tall growing woody plants beneath or beside the conductor must be contained or, as previously noted, they may become a hazard or severely impede access or repair. The use of herbicides to attain this containment should be directed toward the tall woody component of the plant community. Tordon and the phenoxy group of herbicides, in particular 2,4-D and 2,4,5-T, as selective agents have been used extensively as they are particularly effective on woody plants. Their selective efficacy does not, however, distinguish between species of woody plants. In fact, some species, and more particularly some individuals within species, are highly resistant to normal rates of these materials applied as a stem foliar summer application (Newton 1967, Barcley 1971). Egler (1947, 1952, 1953) specifically noted a difference between root suckering species (such as Sassafras, locust, Ailanthus, or trembling aspen) and stump sprouters (maple, oaks or basswoods) which could be killed but which may resprout giving at least a quadrupled control problem, and those species which were more readily killed. It also appeared to Egler that resistance to root kill increased with the square of stem diameter. Niering (1968) also found that stem foliar applications often fail to root kill undesirable species, and suggests that this will result in repeated retreatment which in turn continues the destruction of desirable woody species. There is little doubt that cyclical retreatment on a four to six year routine has been commonplace. Of importance here is not only the recognition that desirable species have been diminished, but that a climax of herbicide resistant species (white ash, red and sugar maple, Egler 1947; basswood 1953, and sassafras, Bramble 1969) has often developed (National

Academy of Science 1968, Carvell 1975). Further, the residual effects of some herbicides have substantially reduced species diversity with most wildflowers, many shrubs, and of course, wildlife habitat diminished (Niering 1968, Roche 1967, Carvell 1976). As species diversity was reduced on the right-of-way, so too was stability (Egler 1954) with communities of herbicide tolerant mixed perennial groups, sedges, and certain perennial herbs (Carvell 1976) open to ready invasion particularly by pines and abundant light weight seeding hardwoods such as birch, aspen, ash, elm and maple (Egler 1953, Pound and Egler 1953, Carvell 1973).

Bramble and Byrnes (1976), Newton (1967a), and Niering (1974) have suggested a direct correlation between percentage of reinvaded tree cover to openness of sites with Bramble going further to draw a distinction between rate of invasion, and eventual tree seedling emergence in relation to community simplicity and openness.

Newton (1967a) has noted that repeated foliar sprayings are not prudent where resistant species predominate as the habit of the species remains unchanged even after prolonged herbicide use continuing to leave them in a position of dominance. While plant habit may not change, habitat may be radically altered. In addition to the biotic implications already discussed plant succession may be seriously changed by abiotic factors resulting from blanket spraying. Gratkowski (1967) suggests that although macroclimatic factors of annual or seasonal distribution of precipitation, solar radiation, and wind are not readily modified, microclimatic changes in air or soil temperature, wind speeds and air movement, decreased relative humidity, reduced amounts of solar energy per unit area at lower levels, and decreased interception of precipitation may have significant influence on the competitive leverage of fast tall growing woody seedlings. This advantage may be further assisted by changes in edaphic factors such as increased soil temperatures at the surface and subsurface, increased soil moisture, and increased activity of soil microflora and fauna leading to rapid decomposition of nutritious organic matter.

In summary, the common utility practice of indiscriminate foliar herbicide applications (Smith 1976) has tended to produce simplified communities susceptible to invasion and populated with resistant tall growing woody species or individuals of species. Simplified communities are not, however, synonymous with instability as some single communities have resisted tree invasion for many years (Pound and Egler 1953, Niering and Egler 1955, Bramble and Byrnes 1976). It is, however, now well documented that it is the shrub layer (so vulnerable to broadcast use of selective herbicides) which is most important in resisting both initial seedling invasion and also suffering successful emergence. A number of herbicide application techniques (basal bark, root collar, dormant stem, stump treatment, notching and frilling, pellets, and direct injection) are both specific to the undesirable plant or its immediate root area and highly effective against resistant species. This in turn has allowed removal of undesirable species with a high percentage of success (97% versus 66% for stem foliar; Bramble and Byrnes, 1976) and development of a stable, diversified, aesthetically pleasing canopy with high wildlife utilization. Retreatment of the right-of-way is substantially reduced, the amount of herbicide released to the environment both deliberately and inadvertently as drift (Norris 1971) and consequent ecological impact reduced (House et al, 1967) and where succession has been arrested, maintenance manhours and costs are lowered while timing manpower and planning benefits are maximized.

Utilities who were, at one time, faced with curtailment of all herbicide use (Cran 1969, Middleton 1970, Ulrich 1976, Olenik 1977) have now adopted very selective removal of undesirable species and instituted detailed specifications aimed at stabilizing plant succession, reducing public concern and effecting long term savings.

Concepts of Ecological Vegetation Management

The concepts which underlie sound ecological vegetation management are those which support the basic objectives of management relating to safety, line security, wildlife utilization, other multiple uses, aesthetics and lowest cost of maintenance over the long term. The undesirable tall growing woody plant component of right-of-way vegetation must, after initial clearing, be discouraged from the regrowth which will appear from existing propagules (Egler 1953, 1958) or from reestablishment from outside sources. If these initial sources of potentially troublesome species can be severely restricted, then subsequent management of the right-of-way will, in turn, be simplified.

The importance of this initial step has not been well stressed and consequently practices such as initial stem foliage spraying have been advocated (Ashbaugh 1968, National Academy of Sciences 1968) which are, as previously discussed, quite contrary to the basic action of establishing a stable, low growing shrub community resistant to reinvasion (Egler 1958). In large part, the difficulty to comprehend the simple concepts of ecologically sound vegetation management has sprung from the common usage of terms which do not reinforce the ideas. Egler (1958) takes particular exception to the common term "brush control" often used and thought of as synonymous with vegetation management. As "brush" refers to all woody vegetation, there has been a general tendency to consider it all undesirable. Egler suggests that many utility vegetation managers (particularly those trained as engineers) conceive of only two types of right-of-way vegetation: brush and grass. Because brush grows "high" and grass does not, many programs have concentrated on "brush control" to the extent that it has become commonly used in chemical company advertising effectively promoting the idea that no brush can be tolerated on rights-of-way. Goodwin and Niering (1962) blame this type of pressure for the common indiscriminate stem foliar programs which have been widespread for the control of undesirable vegetation. Moreover, Egler (1958) notes the concept of "controlling" has also engendered a concept of repeated treatments without the realization that "elimination" of undesirable species is possible at least with the correct chemical techniques. This has been, it is suggested, further supported by the common practice of contracting work where it is not in the interest of the contractor to eliminate his future work and where a high percentage of topkill has been accepted as satisfactory by utility clients.

It is Egler's (1958) firm contention that the botanical aspects of a right-of-way should be planned prior to construction and extend for the full life expectancy of the line again with clear objectives in mind. Olenik (1977 p. 306) suggests that a clear policy statement such as, "Provide reliable service while at the same time manage (rights-of-way) so as to provide an aesthetically pleasing appearance and a land area useful for wildlife and recreation," should be followed. There is little doubt that a clear concise policy supported by utility senior management should be stated and adopted regarding corporate attitude to vegetation management. Not only does it provide a clear indication of intent to the general public and resource agencies, but it fully supports a vegetation manager who may have difficulty in justifying high initial vegetation control costs to middle management. A further complexity is, however, encountered in spelling out both the concepts and the methods of attainment acceptable for implementing such a policy.

Premeisel and Carsner (1951) and Premeisel (1954) suggest that the initial concept should be one of "replacement control." Although noting that replacement control makes use of the natural process involved in secondary succession, the work of these authors in agricultural crops cannot be directly related to rights-of-way. A more relevant discussion is developed by Pound and Egler (1953) and Egler (1952, 1954). Here a distinction is drawn between "conversion"(the elimination of unwanted plants by root killing the larger individuals which are conspicuous while also rendering ineffective the seedlings, seeds, rhizomes, or other propogules that may be in or on the soil), and "maintenance." "Maintenance" is suggested as the subsequent management process concerned with the removal of unwanted species that reinvade from the outside of the area and then develop successfully. Such reinvasion will only occur peripherally (as with rhizomes from edge trees) or scatteringly (as by windborne seed). Unfortunately, this simple separation of concepts has escaped many vegetation managers and programs are commonplace where both types of vegetation control are mixed together with the more difficult "conversion" stage never being accomplished necessitating cyclical return and constant retreatment. This, in turn, even with "selective" foliar application will kill desirable plants up to 30 feet around an undesirable individual (Egler 1958), diminishing the stocking in the area and opening up an opportunity for reinvasion. Instead of concentration on the "conversion" stage and simplified removal by cutting, cutting and stump spray, or one of the very specific basal or pellet treatments for maintenance, the vegetation manager in this (all too common) situation is faced with a never-ending battle of retreatment. And, whereas maintenance can be carried out in an ecologically sound program with a minimum of power equipment and soil disturbance, high intensity foliar programs will compound the problem with a reduction in the natural competitive and relatively stable cover, probably a low percentage of root kill, and soil disturbance allowing more rapid reinvasion.

On new rights-of-way it would seem important to involve the vegetation manager at an early planning stage. In this way, a long term management plan tailored for the individual location and conditions can be drawn. This would involve stump treatments of suckering and root sprouting species at the time of initial prelogging, surveillance of the clearing standards, and early revegetation of disturbed land with suitable species (Vaartnou 1977), concentration on initial conversion after tower erection, stringing and commissioning, with an intensive program the first few years (quite contrary to the common practice of spending no maintenance funds for three to five years after construction) and then a subsequent maintenance program which eliminated only the undesirable reinvading woody plants while maintaining the integrity of desirable cover.

Programming of work under this type of regime would be simpler and more predictable than at present as stocking densities of undesirable species diminish rapidly while the U-shaped profile of the right-of-way corridor, favoured by many authors (Egler 1953, Ulrich 1976, Niering 1968, Richards 1973) for edge effect and wildlife habitat, may be gradually developed - Figure 17, Page 129.

Benefits of Ecological Vegetation Management

A more ecologically sensitive approach to vegetative management brings with it a number of important benefits. Were these benefits more readily recognized or more readily demonstrated and measured over the short term, ecologically sound vegetation management would enjoy broader acceptance and support from vegetation managers, senior corporate management in utilities, and from the general public.

Potential benefits fall into five categories: edaphic, biological, aesthetic, economic and social. The sum of these benefits would appear to substantially outweigh, both for the utilities and the public at large, any short term apparent benefits which can be attained by cyclical broadcast application of foliar herbicides.

The stabilization of erodable slopes has long been of concern to gas utility companies (Arner 1960) but is suggested as being of little concern to electrical utilities. Although the right-of-way literature does not specifically discuss erosion, there is little doubt that unstable soil types and erodable slopes are of considerable concern where any transmission line structure might be threatened, particularly after initial construction and before natural vegetation becomes fully established. To then subject such areas to broadcast spraying and removal of the upper canopy, allowing rain erosion and unrestricted surface runoff, would seem unreasonable. The writer has, however, personal experience of this happening in two utilities, with complete collapse of lattice type structures, prolonged outages, in one case exceeding three weeks, and substantial relocation costs. A more conscious attempt to control vegetation on a spot specific program would have allowed preservation of a diverse understory and little exposed soil susceptible to erosion. The biological benefits of ecologically sound vegetation management evolve from the diversified canopy and ideal food and cover for a wide range of wildlife species (Bramble 1972, 1974). The programmed change in community structure from mature edge through decreasing height to centre line of the right-of-way actually provide improved wildlife utilization of some areas (Cran 1969) especially where the U-shaped valley of the right-of-way is made up of a composition of herbs, forbs and small trees (Niering 1958).

Aesthetic benefits result from reduced visual impact associated with summer foliage spraying commonly called "brownout." This factor, perhaps more than any other, has prompted a public outcry against utility vegetation management programs. With a more concerted effort to make both the method of application for herbicides plant specific and the chemicals more selective, the specificity of treatment, the more flexible timing including winter application, and the philosophy of elimination rather than recurring "control" allows a fairly consistent appearance to be retained on most rights-of-way. Coupled with the selective clearing and buffer or screen retention techniques now endorsed by many utilities, it should be possible to eliminate the stark sudden change of right-of-way appearance associated with the summer foliar or unselective brush cutting methods common in the past.

Other advantages notwithstanding, it seems quite justifiable to strongly endorse the concepts of ecological vegetation control on the basis of cost advantages alone (Egler 1958).

If it is indeed feasible to reduce the number of emergent undesirable species on rights-of-way treated initially to reduce the number of potential suckers after clearing and then, by successive basal sprays, eliminate undesirable species allowing competitive leverage to advance the lower growing shrubs and forbs, it may well be possible to extend retreatment cycles substantially. Pound (1953) has found that such systems can provide low growing stable shrub communities lasting fifteen years while Richards (1973) suggests that periods up to 25 years are feasible. If the basic criteria for method choice is lowest cost per unit area over the period before retreatment, it can be readily seen that long cycles, even with periodic touchup and higher initial cost (which may well be capitalized and not of direct concern to the vegetation manager) still strongly favour ecological management over three or five year cyclical spraying or cutting.

Social advantages are possibly the most important aspect of ecological control to the vegetation manager. Most programs using foliar applications or non-selective mechanical cutting have received considerable public criticism; however, if the notification procedures suggested in the section on communications are carried out, ecologically sound vegetation management provides a program and rationale which can be more easily justified and which, it may be argued, will have a substantially decreasing incidence of retreatment over time. Multiple use potential will remain constant without periodic large scale spraying and subsequent "brownout" an important factor where the right-of-way may be a natural corridor within a largely urban area.

Finally, an indirect social and probably economic benefit that evolves from ecologically sound programs is the necessity to have a more highly skilled and stable work force than that associated with a predominantly foliar spray program. The more intensive management scheme is based on an understanding of ecological principles, on ability to recognize successional stages, and to identify a wide range of plant species. In addition, the regional and district work forces must be able to assist in the compilation of detailed management plans and implementation of their recommendations. The advent of highly sophisticated data collection systems, vegetation species, specific herbicides, plant specific delivery systems and increasing public contact will require the vegetation management fieldman to undergo intensive training programs and possess advanced technical skills.

With an ecologically based program, the emphasis for summer treatment is removed and work may be assigned throughout the year. Once the major portion of the right-of-way net is on such a program, the annual penetrations of staffing need are reduced. During the transition phase while both old methods are reduced and new methods instituted, a general reduction in staff size and upgrading of appropriate staff is possible. The eventual work force should be smaller, more stable in employment, highly trained, and be encouraged to foster the esprit de corps so necessary in developing individual pride and quality workmanship.

Appendix B Management Support Services

MANAGEMENT SUPPORT SERVICES

Introduction

A distinction can be drawn between those tasks that directly execute the objectives of management in a utility vegetation management program and those tasks and interactions that aid in maintaining a viable program. Further, these tasks and interactions may be separated into those that embrace the scientific and technical needs of a program, and those which are administrative and supportive in nature. This chapter examines these latter components.

Historical profile data bases (HPD's) provide the collected documentation of past experiences and conditions that form an important component in the decision making process for proposed future actions. Ongoing field data collection and appraisal of present conditions is the most important factor that will influence these decisions. The technology for right-of-way surveillance is moving away from untrained ocular estimation toward sophisticated automation using remote sensing and high resolution photography. New computerized techniques are being developed to translate base data into management information.

The maintenance of stock, equipment, and resource inventories provide an opportunity to monitor the general "holdings" of a program. These holdings will then be applied to the tasks identified from field problem or administrative requirements. These requirements can be identified using various workload analysis techniques. In turn, the projects which result from the eventual project execution phase should be recorded and appropriately costed. The hard copy planning and recording production from these phases will eventually result, in most cases, in the preparation of various types of reports.

In order to sustain the organizational continuity of a program and to take advantage of expertise existing within each utility, the vegetation manager may turn to a number of support groups to prepare outlines and support documents. The shared services available to the vegetation manager allow for cost effective application of specialized knowledge and training, without directly incorporating it into the staff complement of the vegetation group. The incorporation of working policies and information sources into formal support documents provides an unambiguous information source for general guidance of the program and review by those outside the vegetation management group.

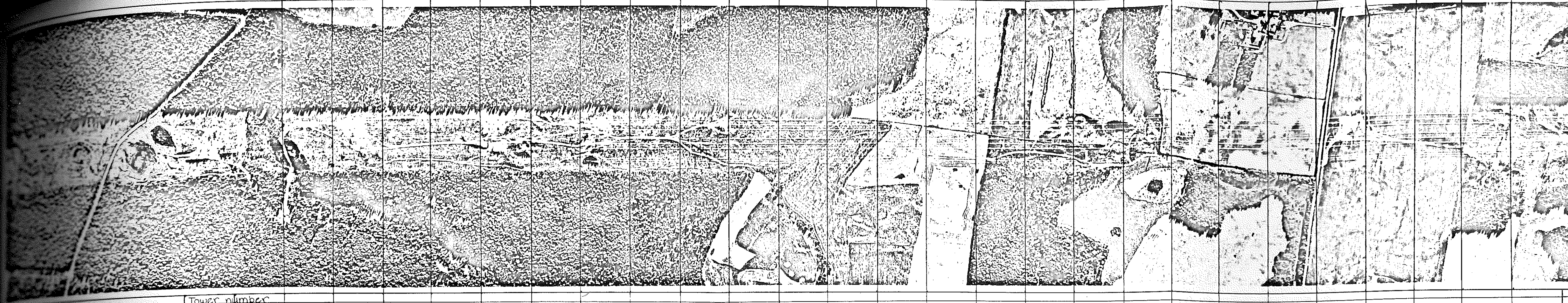
Historical Profiles

Few authors have noted the importance of maintaining detailed field data as a basic underpinning to utility vegetation management. Pitman (1969) and Turner (1967) note, in the context of claims handling, that a record system is essential but give no definitive discussion as to type. Sorensen (1976) in one of the few comprehensive papers, notes field inventories and good records are two basic ingredients of any successful vegetation and/or land management program. It is suggested that inadequate field inventory data results in inefficiencies in planning and overall management, while comprehensive information allows maximization of environmental values without jeopardy to line security. A 35% increase in right-of-way acres added to the (Minnesota Power and Light) system in a five year period ending in 1973 meant that management requirements increased from 14,000 acres to 22,000 acres. In order to accomplish better management and more detailed budget requirements, a computerized "Line and Vegetation Control History" was developed. This system provides computer printout only, as a working copy.

The Bonneville Power Administration has also developed a detailed computer record system for right-of-way information storage and retrieval (Slatt 1973). One of the principle features of this inventory system, noted in the introduction to the inventory system manual, is the capability of providing an historical record. It is suggested that this will be particularly useful in evaluating the effectiveness of vegetation management. Eight other advantages are recognized: budget preparation, planning and programming, location of problem areas, multiple use development, provision of statistical data, ancillary facility data, summary information for impact studies and analytical studies on plant growth. A more detailed outline of the system is found in Appendix H. Sophisticated systems which incorporate outage statistics and vegetation management/land use records with civil and electrical information are being developed by some utilities, but will not be operational for some time (McPhail 1977).

One failing of most historical profiles is an inability to provide a graphic representation of the area recorded. Although most right-of-way data inventorying systems rely heavily on maps and air photos, it is not apparent that any system has been developed which incorporates both historical record information and a right-of-way image. An initial approach to such a system is shown in Figure 18. A 9" x 9" aerial panchromatic vertical film flown to produce a scale of 2,000 feet to the inch has been enlarged five times to produce a 400 feet to the inch image track. This image track of the right-of-way and vegetation on either side is transferred

Figure 18 Historical Profile Format Used to Record Vegetation Management Information on HV and EHV Transmission Systems



Static Base Data
- Tower number
- Tower design
- Voltage
- R/W width
- Acres per mile
- Slope
- Elevation
- Soil type
- Clearing Date
- Clearing Standard
- Seed type
- Access Road: all weather, summer, winter
- Swamp
- Stream
- Lake
- Ditch
- Bridge
- Culvert
- Fence
- Locked gate
- Helicopter landing site

Critical Base Data
- Clearance
- Hazards
- Critical areas
- Unique features
- Impact statement constraints
- Special agreements
- Water rights
- Bio climatic zone
- Growth rates: conifer, deciduous

Changing Base Data
- Vegetation association
  - conifer: area, density, height
  - deciduous: area, density, height
- Danger trees
- Road crossing screens
- Other vegetation
- Land owner ship
- Easement restrictions
- Land use

Treatment Data
- Treatment Objectives
- Year and treatment date
- Method
- Cost
- Restrictions
- Results
- Remarks
- Retreatment projection

DESCRIPTION | NAME | DATE

B C HYDRO & POWER AUTHORITY
TRANSMISSION RIGHT OF WAY
MAINTENANCE RECORD

WILLISTON TO KELLY LAKE
TRANSMISSION RIGHT OF WAY

SCALE : 1" = 400'
DWG. NO.
SHEET OF

to a master Cronoflex with existing data headings and approximately forty 100 yard wide recording segments. The occurrence of any item in the data headings for each segment is readily recorded for permanent record. In addition, these historical profiles may be joined end to end to produce a continuous roll plan. This can then be mounted on a small automated viewing table for use in direct data collection during the helicopter line inspections, allowing real time updates for field management between aerial photograph retake cycles.

It is not a purpose of this thesis to develop a fully operational historical profile system. Refinement of the idea presented here is possible in a number of ways. For example, the six inch image track is sufficiently wide to superimpose ghosted ground and conductor profiles in side elevation on the mosiac without loss of fine detail. Similarly some ground contour and elevation detail could be added to the plan image.

Investigation of new high resolution multispectural scanning or side-looking radar techniques (Jensen et al 1977) may supplant some normal aerial photogrammetric methods of aerial mosaic production. In addition, digital thematic mapping may allow computer production of updated fine resolution historical profiles with static information printed directly on the image shoulder beside the right-of-way with revised or changing information on a smaller extended leaf than in Figure 18. Alternatively the low level photographic techniques discussed in the following section on Data Collection may have attractive simplicity and cost advantages.

Two categories of historical profile are required: that which traces new rights-of-way from the time of initial survey, clearing, construction and restoration to subsequent maintenance, and that which establishes historical profiles for existing rights-of-way based on current records and updated air photos.

Information recorded on historical profiles can be designated in four groups; Static Base Data, Critical Base Data, Changing Base Data, and Treatment Data.

Static Base Data implies data which will remain unchanged during the life of the right-of-way and will include terrain, bio-climatic and engineering details. Critical Base Data is distinguished from Static Data by a potential for change and a 'critical' importance in management decisions. Changing Base Data, as the name implies, contains details of information requiring constant revisions as in the case of vegetation growth, land use, and regulatory agency restrictions. Treatment Data will note maintenance activities as they occur and possibly record success of treatments if post-treatment monitoring is conducted. The number of actual items recorded in the four groups will depend on the sophistication of systems desired, Base Data available, and cost constraints. Figure 18 suggests a minimum 45 items. The Bonneville Power system records 51 "information bits". As right-of-way management intensifies and pressures on land use increase, the trend will be toward more refined historical profiles.

Such refinement is already available using additive colour quadro-channel image viewers. For example, the International Imaging Systems I^2S Mini-Addcol System 6040 allows four multispectral and/or multidate images to be viewed and superimposed simultaneously. The optical projection can allow for arbitrary colour signature assignment in order to enhance and record visual comparisons among a combination of images. Magnifications of up to 20 diameters are possible. This system, which is designed specifically for 70mm photography, allows photographic records to be maintained on the right-of-way and immediate analysis of changes over time. Individual species can, for example, be colour coded and a sequential overlay prepared and printed directly on a colour print console.

Coupled with the advances in computer technology and colour air photo techniques discussed in the following section on Data Collection, it would appear that very detailed managerial, ecological, and sociological profiles are presently possible and will enjoy increasing acceptance in vegetation management on rights-of-way.

Data Collection

One of the most important, yet onerous and time consuming direct tasks which face right-of-way vegetation managers is the acquisition and interpretation of situational data. The transmission right-of-way net falling under the responsibility of a single utility vegetation management group may exceed 20,000 miles (Medicky 1976). In order to manage this resource efficiency, a constantly updated situational information data base (SID) is required. An accurate assessment of existing conditions is necessary for reasoned judgements for program and project planning. In the past, stereoscopic pairs of 9" x 9", black and white aerial photographs, ground, and helicopter patrols have provided the vegetation manager with planning information. Substantial drawbacks exist from reliance on these methods. Aerial photography appropriate for maintenance is normally of doubtful accuracy unless of recent origin or purpose flown. Forest cover type photography, the most common available for transmission line areas, rarely has flight lines corresponding to all of a right-of-way, and does not provide ideal scales for identification of small undesirable vegetation, making useful, uniform mosaics impossible.

Ground patrols are often conducted by linemen rather than botanically trained staff, and even when such staff are available, continuity and uniformity of recording is unlikely. Helicopter patrols, though often on a regular schedule for electrical and civil inspection, have vegetation management concerns as an incidental interest and normally require ground confirmation of observed vegetation hazards or conditions. The need therefore, is to develop a cost-effective, detailed, accurate, and readily interpretable update of right-of-way conditions. Ideally it should also later form, or become a contribution to, a historical profile data base (HPD).

As with other technologies, photogrammetric engineering and remote sensing have advanced rapidly in the last 20 years. Techniques developed for remote military surveillance, aerospace experiments in resource analysis, new film, camera and electronic instrumentation, now allow high resolution photography and remote sensing in a wide variety of wavebands and at numerous scales. Satellites (Sullivan 1975, Oswald 1976), spacecraft (Fleming 1974), high altitude aircraft (Rehder 1972), various conventional aircraft (Zsilinsky 1972a), and helicopters (Bernstien 1974) have all provided vegetation or power line information of various types. Equally diverse collection media obtained from the carrying vehicles mentioned above have, or are becoming, appropriate for right-of-way information analysis.

Satellite imagery from Landsat-1 (now ERTS-1 L. Stewart 1974) in the redband (0.6 - 0.7 um) has been used for revisions to Canadian topographic map series at 1:250,000 to include new 735 kV transmission lines from Churchill Falls to Sept-Illes in Quebec (Fleming 1975). It is also noted that the infrared band (0.7 - 0.8 um) is exceptionally accurate for water determinations. Sullivan (1975) used imagery from the same source to provide prints at 1:10,000 to determine power line corridors in Montana. Constraint mapping was then prepared at 1:31,500 from colour infrared air photographs for the various route options within the five mile corridor. Despite poor filming conditions, small "bushy" vegetation could be readily determined. ERTS imagery has also been used for forest managers to monitor changes in the forest environment. In particular the control of logging operations and power line clearing in the interior of British Columbia is reported (Lee 1974) with the additional use of 1:500 or 1:2,000 low level 70mm for ground truth comparison. Progress is being made toward ERTS MSS5 or a composite MSS4, 5 and 6 waveband enhancement in order to better distinguish hardwood from conifer regeneration. Oswald (1974, 1976) reports that objects such as water bodies, river drainage patterns, perpetually wet areas, and short non-shrubby vegetation are readily distinguishable on band 7 and usually on band 6, while major pathways such as roads and power lines (presumably rights-of-way) are discernable on bands 4 and 5 especially when they pass through forested areas. These areas exhibit tonal differences which indicate variations in stands. Tonal signatures for various species or mixed stands is discussed with the conclusion that composites of bands 5, 6 and 7 are best for this vegetal cover while bands 4 and 5 record clearings most visibly.

Rehder (1972) in a cooperative study with NASA using RB-57 high altitude aerial surveillance aircraft and small scale imagery (1:120,000) found that interpreters using 9" x 9" Ektachrome colour contacts and a 4x light table could detect and identify transmission towers with surprising regularity. Of 795 observations, 717 had positively identifiable towers.

Vegetative cover and clearing conditions within the right-of-way swaths was easily distinguishable and the observer could certainly detect (for a monitoring capability) changes in ecological (vegetation versus non-vegetated versus erosional) conditions on the right-of-way. Lewis et al (1969) have examined the possibility of determining rights-of-way with K band multi-polarized radar imagery and have concluded that like-polarized (HH) imagery is more suited to determination when the right-of-way traverses land when aligned to the flight path and cross polarized (HV) imagery when the feature is at right angles to the flight path. Statistical analysis provided a 99.9% confidence level for detections.

High altitude photography and imagery does not at present have the fine resolution with the magnification needed to distinguish detailed features on rights-of-way. It does, however, have a possible place in preparing system overview net maps, regional base maps and providing broadscope determinations of ecological change or possibly identifying areas of stressed vegetation resulting from poor soil (Wobber et al 1975).

Low level photography and multispectral scanning appear to hold greater potential for direct detailed data acquisition of right-of-way features, new conditions and vegetation growth. The important limiting factor appears to be cost. With the exception of Bennet (1974) no technique cost comparisons are available and no cost to scale analysis was found in the literature, the majority of papers remarking only on decreased coverage per unit of film with improving scale and consequently higher film and print cost. Klein (1970) and Zsilinszky (1972a) argue strongly in favour of 35mm film format using a motor driven Nikon F 250 in two, three and four vertical camera mounts (Zsilinszky 1972b) producing stereoscopic pairs for contact scale printing or enlarged scale projection or magnification. Scales of 1:2727 (flight at 500 a.g.l. with 55mm f.l. lens or 7 x lens stereoscopic magnification) to 1:390 are recommended. Scale and other parameters have been calculated for various combinations of altitude and focal length by Smyth (1972).

Plantation inventories of small regeneration has been attempted with varying degrees of success in forestry. Bernstein (1974) reports that work at 1:1,000, 1:3,000 and 1:5,000 did not provide encouraging accuracy on trees ranging from 1 to 4.5 feet in height. Slightly better results were obtained at 1:5,000. Black and white, colour (MS Aerographic, Kodak Ektachrome), and false colour infrared were used. The paper omits to record either film size or resolution obtained. A more useful study by the Canadian Forest Service (1975) using Kodak Aerocolour 2445 negative 70mm film, found that, using a regression equation which relates photo stocking to ground stocking, reliable determinations could be prepared for trees 30cm or taller.

Baribeau et al (1970) has successfully developed a system for distinguishing the difference between herbaceous and ligneous vegetation and subsequently determining herbicide control effectiveness as soon as 10 days after treatment. Kodak Aerochrome 2443 Infrared 70mm negative film in vertical stero from a fixed wing aircraft is now preferred for this program (Baribeau 1977).

A similar film in 35mm format was used by this author to prepare oblique tower span takes from a Bell helicopter. The results (Figure 19) provide good definition of undesirable woody species from 600 feet a.g.l. at an air speed of 45 knots using a hand held 35mm single lens reflex Konica TL.

Figure 19 35mm Kodak Aerochrome Infrared 2443 Film-
Enlargement of Right-of-Way Oblique View
Showing Vegetation Growing Under Conductors

Photography for the tree monitoring system Initial Clearing described in the section in engineering considerations, is presently flown at 6,000 feet a.g.l. on standard aerial panchromatic film to provide 60% overlap 9" x 9" stereopairs.

Relatively low level multispectral scanning data may also hold considerable potential for vegetation determination on rights-of-way. Much of the work so far (Girard 1974, Institute of Sciences and Technology, University of Michigan 1970) has been directed toward agricultural crop determinations, although the latter have provided detailed orchard surveys, Figure 20. Air transportable equipment, able to scan in 24 discreet wavelength bands from ultra violet to thermal infrared can provide thematic mapping. Developments by General Electric, Bendix Corporation and Itek are presently being declassified. Information on the Mohawk AN/AAS - 14 airborne infrared scanning detector which incorporated complete on film data annotation and could transfer 1/R pictures and data directly to a ground station many miles away is now available (Sup R 1976).

Chandler (1972) notes that remote sensing is "data," not "information," while Zsilinszky (1972a) suggests that photography or remote sensing is like a book written in a foreign language yet containing essential information. Such information can only be revealed by an interpreter or if the reader learns the language himself. Oswald (1976) observes that the recognition of an object is largely dependent upon its size and reflective contrast and distinction (signature) between the object and its background.

Several image enhancement techniques have been developed to assist in recognizing the information content of an image. These range from simple magnification or image combining techniques that require little photo-interpretation skill or expense to operate, to sophisticated electronic devices (Blansjaar et al 1972) requiring highly trained, skilled operators. The advantage of daedal interpretative equipment is the possibility of separating different objects possessing nearly similar signatures.

Schlosser (1974) reported the Spatial Data Systems development of a television scanning densitometer which will allow density slicing of signatures into 32 colour bands over a range of two density units (2 DU). This allows for rendition of 250 presentation levels. Source data can range from thermal infrared scans in the 8 to 10 um band to photographs in the visible or infrared portion of the spectrum. Density slicing using this equipment allows any colour or gray scale contour to be displayed on a cathode ray tube (CRT) in highly contrasting colours. Schlosser records tree stress, oil spills, arctic ice distribution, hot water effluent, air pollution, water quality and soil type determination as possible applications of the technique.

The potential use of the microdensitometer for enhancing right-of-way vegetation signatures from low level 70mm colour and false colour film was investigated. Four frame strips of Kodak MS 2443 Aerographic film (Fig. 1) and Aerochrome 2443 infrared film (Fig. 2), Plate 2, were selected. The colour film was flown in coastal British Columbia from an Otter aircraft using two Hasseblad ELM's coupled with an intervalvometer to expose stereo pairs from 300 feet a.g.l. The infrared film was flown on the 735 kV 7017 transmission line in Quebec for Quebec Hydro and is the first flight photography used to conduct the prior/post herbicide treatment analysis mentioned earlier (Baribeau 1970). Each film negative was placed on a light table and viewed with a Videocon TV camera equipped with a Cannon TV, V 10 x 15 Zoom

Plate 2 Fig. 1 - Four Frames - 70mm Kodak MS Aerographic 2448 Film Contact Printed at Actual Size

Fig. 2 - Four Frames - 70mm Kodak Aerographic Infrared 2443 Film Contact Printed at Actual Size

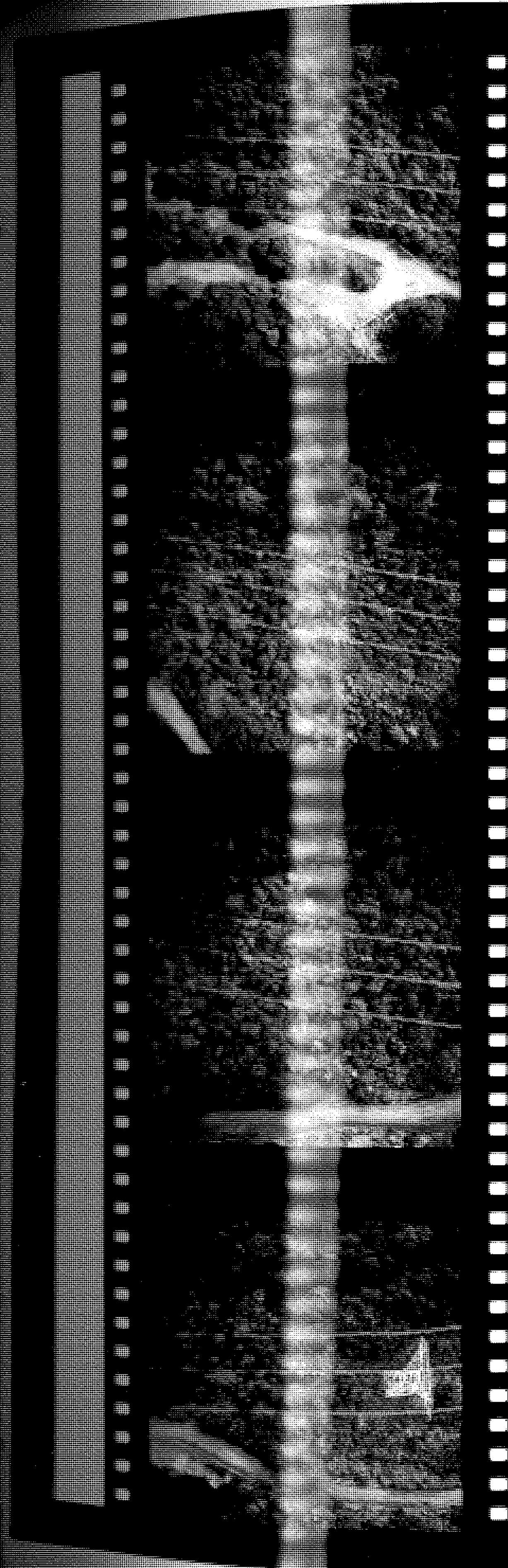


Fig. 1

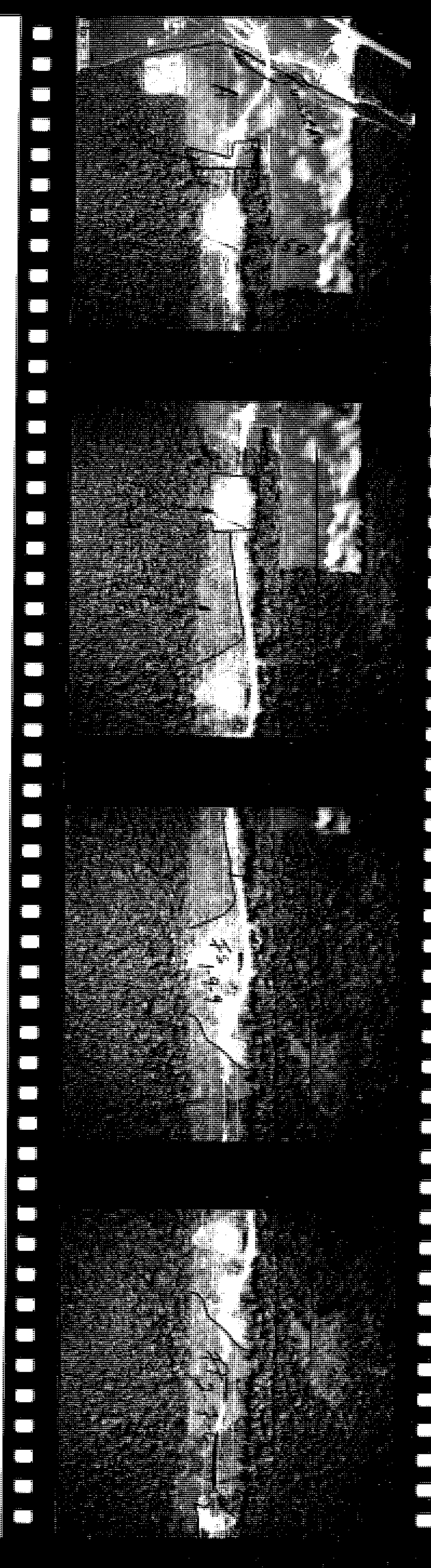


Fig. 2

lens. A Spatial Data System Microdensitometer Model 703-32 density slicer was used to analyze the tonal differentiation of the film at various magnifications. The results are shown in Plates 3, 4, 5 and 6. Fig. 1 in Plate 3 shows the infrared false colour film without magnification or colour enhancement photographed from the CRT screen, while Fig. 2 shows low growing vegetation on the right-of-way, colour enhanced with a red signature. Plates 4 and 5 record enlargements of the transmission line from the Quebec infrared film. Fig. 1, Plate 4 shows the right-of-way with the conductor passing over a narrow band of vegetation without colour enhancement. Fig. 2, Plate 4 shows an attempt to determine woody vegetation shown with a deep purple signature. Plate 5, Fig. 1 shows the removal of all signatures except that for shadows, while Fig. 2 shows the difficulty in showing a discrete signature for woody vegetation compared with the signature for shadow. Plate 6, Fig. 1 shows low level British Columbia photography without colour enhancement and Fig. 2, a brown signature for woody plants.

The difficulty in separating the vegetation signature from shadow can be clearly seen.

This technique holds promise for future development in automated vegetation analysis. Limitations at present include the difficulty of obtaining discrete signatures for individual species and the probable necessity for continuous ground truthing. If these limitations can be overcome with high contrast, high resolution film, it may be possible in the future to record rights-of-way on 70mm film, automatically distinguish between species, electronically determine vegetation heights, planimeter species boundaries, store, manipulate, and print out cover type mapping. Ability to record

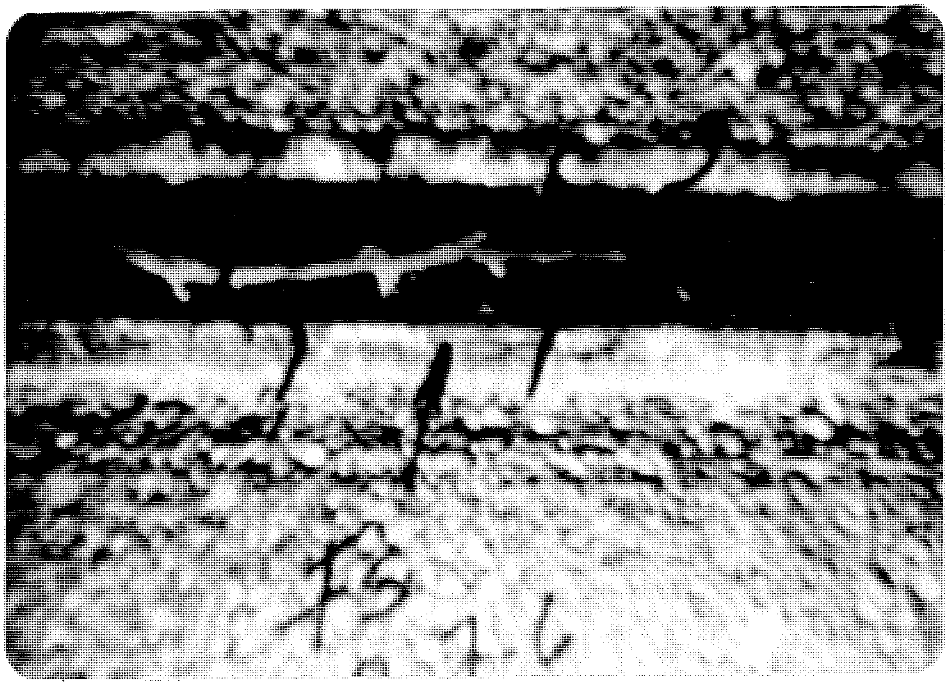


Fig. 1

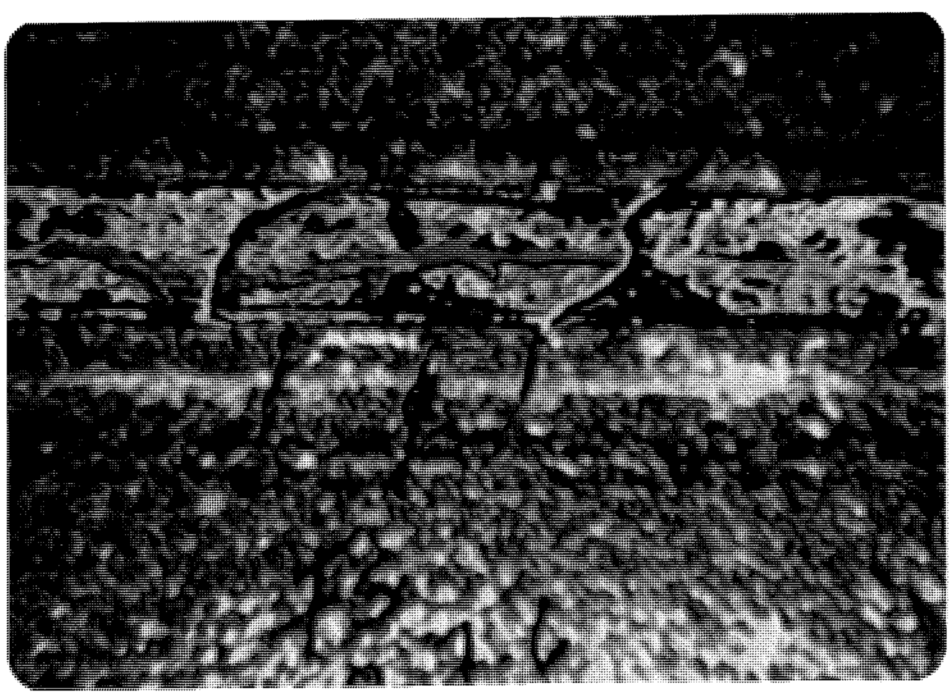


Fig. 2

Plate 4 Fig. 1 - Kodak Infrared 2443 70mm Single Frame Enlarged - Photographed from Density Slicer CRT Screen Without Colour Enhancement

Fig. 2 - Kodak Infrared 2443 70mm Single Frame Enlarged - Photographed from Density Slicer CRT Screen with Tonal Enhancement Providing Blue Wave-Length Separation

Fig. 1

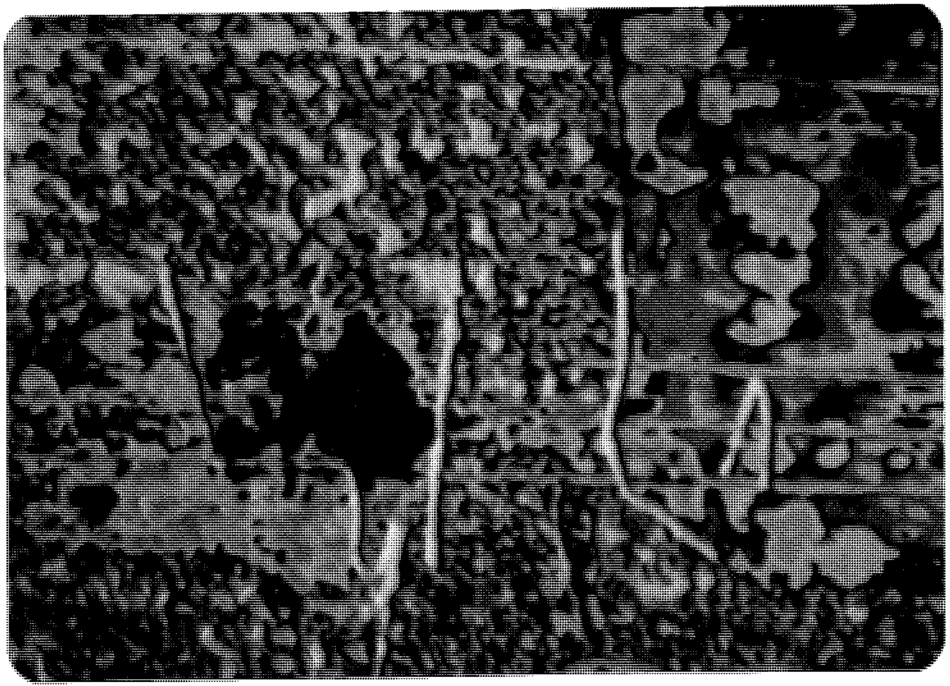


Fig. 2

Plate 5 Fig. 1 - Kodak Infrared 2443 70mm Single Frame Enlargement - Photographed from Density Slicer CRT Screen with Removal of all Signatures Except Specific Colour Waveband for Shadow

Fig. 2 - Kodak Infrared 2443 70mm Single Frame Enlargement - Photographed from Density Slicer CRT Screen Showing Difficulty of Separating Discrete Signature for Woody Vegetation from that for Shadow

Fig. 1

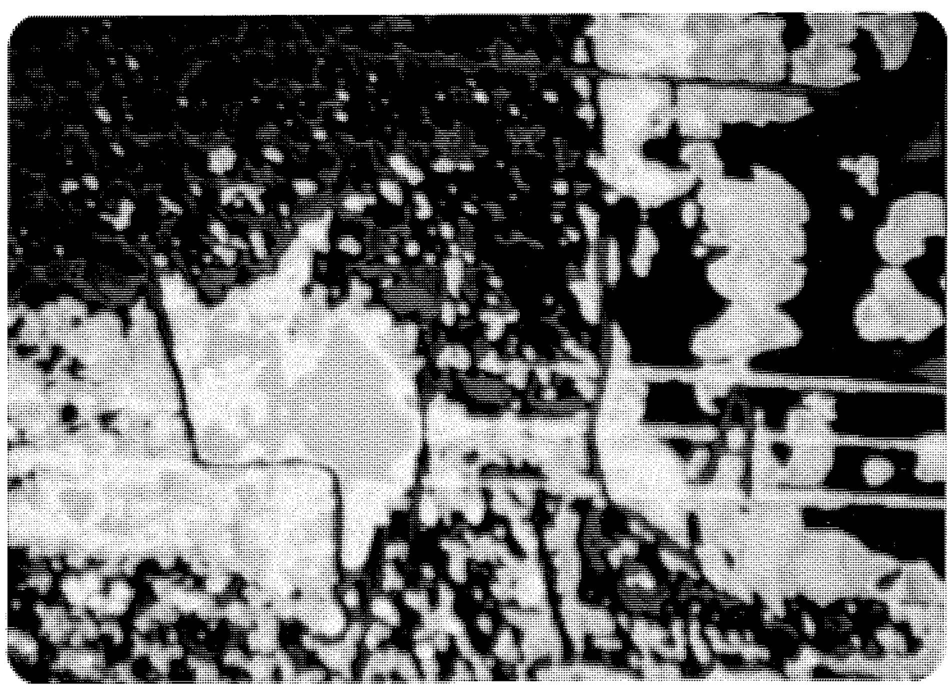


Fig. 2

Plate 6 Fig. 1 - Kodak Aerographic Colour 2443 70mm Single Frame of Low-Level Aerial View with Minimum Magnification Photographed from Density Slicer CRT Screen Showing Right-of-Way Vegetation Without Colour Enhancement

Fig. 2 - Kodak Aerographic Colour 2443 70mm Single Frame of Low-Level Aerial View with Minimum Magnification Photographed from Density Slicer CRT Screen Showing Right-of-Way Vegetation Enhanced with a Brown Signature but Poor Discrimination of Shadow and Ground Reflections

Fig.1

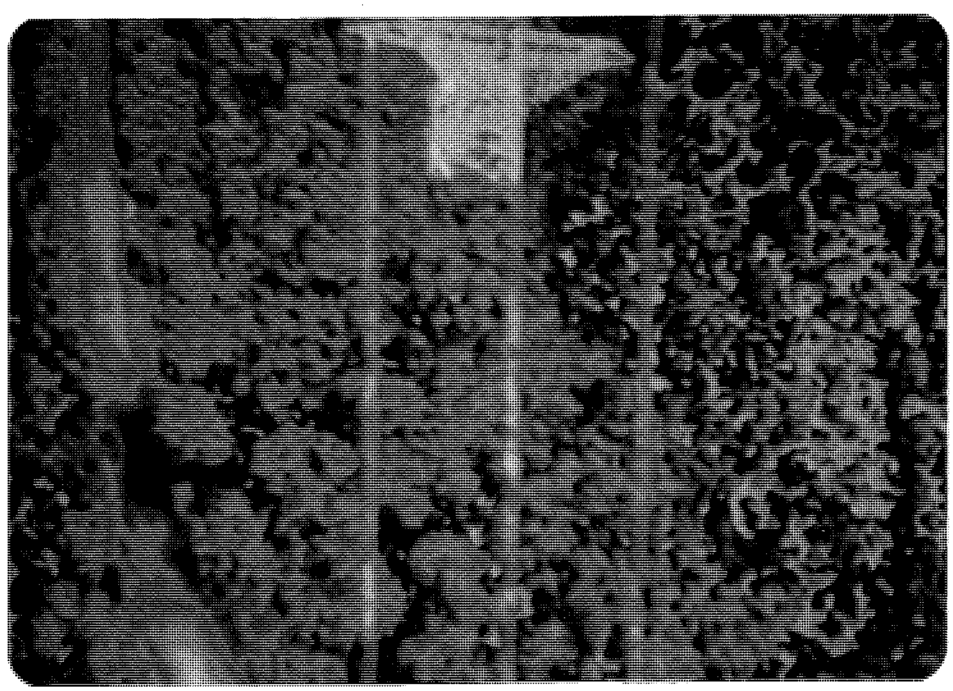


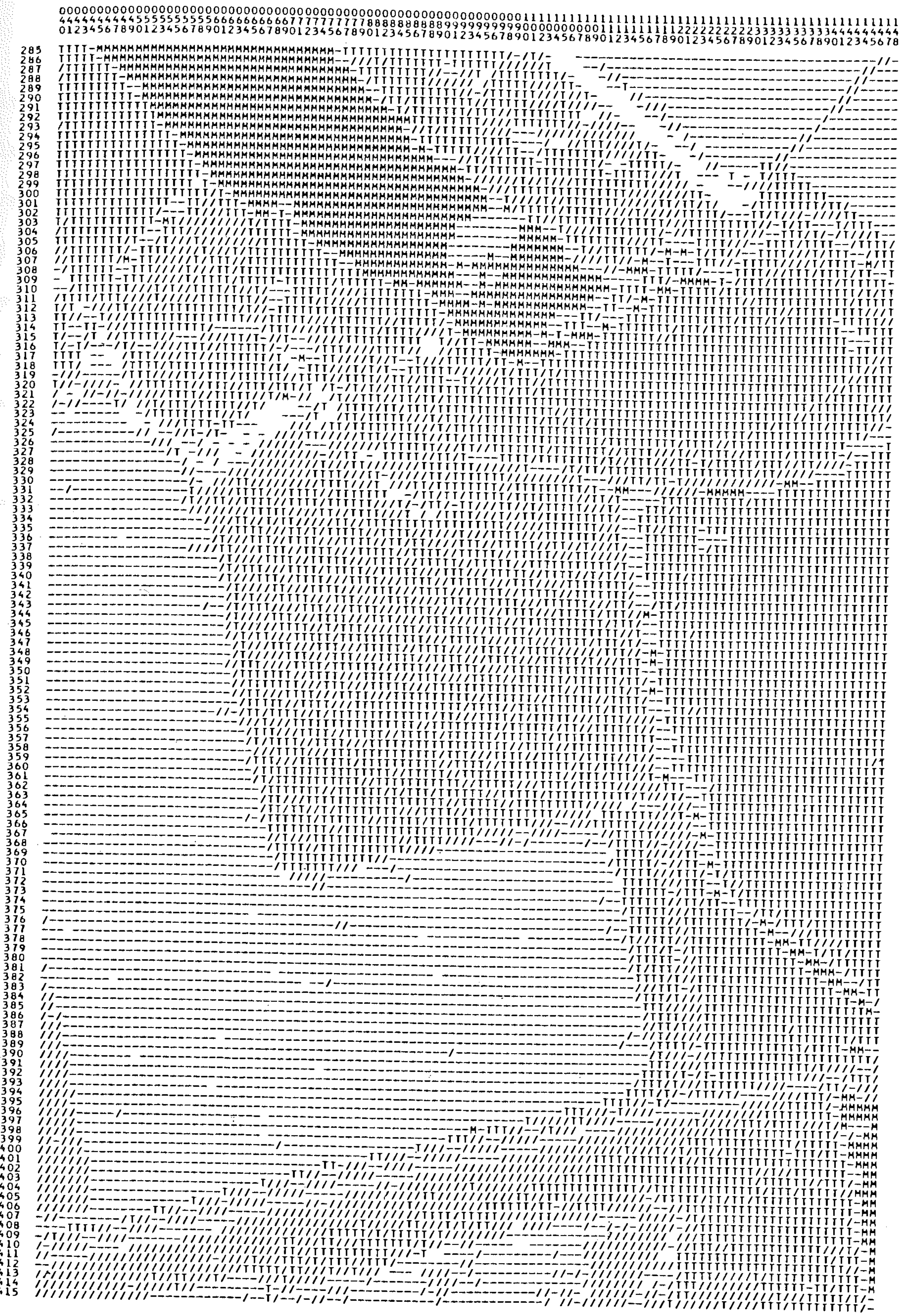
Fig.2

vegetation stress may also allow automated assessment of herbicide applications.

Not only is data interpretation an odius exercise for the vegetation manager, the task of data handling and information presentation offer a daunting challenge. Photographic and remote sensing techniques generate immense quantities of data and computer interpretation, storage, and retrieval appears to present optimum handling efficiency. Analog digitizing of multispectral scanning output or of CRT scans can be prepared on computer compatible tape (CCT). In the United States the Laboratory for Applications of Remote Sensing (LARS) has been able to demonstrate accurate automated crop recognition, Figure 20. Digitized radiance values for small resolution elements (RSU's) in each of four wavebands are combined to provide a computer symbol. This pattern is then categorized by a pattern recognition algorithm and the individual RSU's classified as to crop species or cover type. It appears possible to differentiate and identify crop species rather accurately using automated pattern recognition techniques (LARS 1970). Differentiation of various tree species has also been documented and the reflectance values published (Hoffer 1967, 1969).

It would appear that with sufficient development of existing technology it would be possible to fly rights-of-way at relatively low level with a variety of waveband receptors and, with adequate ground truthing or "training sets," to automatically process and computer identify (Blansjaar et al 1972) both desirable and undesirable vegetation by height, density, species, location and percentage cover per unit area. With bioclimatic data, weather data, soil type or by sequential height analysis, it would be possible to predict growth rate and consequently develop long range planning

Figure 20 Computer Classification of an Orchard in Weslaco, Texas. The Individual Remote Sensing Units are "M" - water, "---" soil, "/" vegetation, and "T" trees. "T" do not represent individual trees due to poor scanner resolution. (From LARS 1970, p. 77)



TOTAL NUMBER OF SAMPLED POINTS = 14279

schedules and by retrospective analysis, predict program effectiveness and projected cost.

Presentation of information in field usable form requires more sophisticated application of computer graphic printout programs. Gray scale printouts, RSU direct printouts, Figure 20, overprinted tonal display as used in the Harvard University (1977) synagraphic mapping system (SYMAP) or line plotter three dimensional contour maps (SYMVU) and CRT automated oblique perspective views, as with the ASPEX computer programs also from the same source are available. These powerful programs allow presentation of information in a variety of modes or the preparation of cartographical data base (CD's).

Computerized corridor and route alignment constraint mapping (EDAP) has been undertaken by at least one organization (Madeson Gas and Electric 1973) and provided detailed vegetation density and height printouts for a wide study area.

Computer assisted corridor route selection has also been undertaken by a number of other workers using locational cell analysis but with larger cells and less specific vegetation data. Giles et al (1976) report a weighted system on a 42 "stacked" component 1/9th Km^2 cell data base which expressly excludes maintenance concerns from the analysis, while Rosemarin (1976) uses a 40 acre cell but again does not appear to incorporate future maintenance constraints in new line location analysis. The same is true of similar systems developed by Schaal (1972), Wenger (1974), and Niemann and Murray (1974), the original project manager in the 1973 EDAP Study.

Of more interest to the vegetation manager is the detailed soil analysis conducted on 2.5 acres cells by Smart et al (1976). This study expressly relates soil type and productivity potential (site index) to vegetation type and notes that information on the relative vigor of woody growth on transmission rights-of-way is one valuable input to the process of scheduling maintenance activities and determining appropriate control techniques. It is the view of Howlett (1976) that although computer inventory systems are possible, large cell size precludes their use on a reliable basis. Further, it is suggested that as most output systems are single purpose, single use, and difficult to interpret for the layman, cost will relegate computer use to evaluation of data rather than actual route selection. Development of these techniques into a broader base construction and maintenance management plan may offset these disadvantages. If such programs for new line location become commonplace, a natural linkage should evolve with subsequent maintenance, documentation, and handling systems. Utilization of multi-stage hierarchical photographic and sensing systems (Langley 1969, Legge 1974, Simonson et al 1973) and multiple scales will provide the vegetation manager with very powerful, cost effective, predictive management information. Given the electrical utilities, the trend toward state and province wide computerized data banks (Zimmermann 1977) and the necessity to predict and quantify vegetation management needs or possible environmental impacts, it seems that possible advanced data collection systems will be operational in the near future.

Inventories

In order to maintain a systematic and comprehensive resource account, it is necessary to maintain a number of inventories. Workload and project planning require basic data. To some extent trend analysis and projections, although relying heavily on records and summaries for a data base, require inventory information in order to test capability or stock on hand against anticipated needs.

Inventories may include figures or written synopsis on equipment, tools and spares, consumable material, personnel capabilities or accreditation and similar resource information.

In addition to administrative desirability, inventories may be required to serve an economic or accounting function. In order to compute amortization, enforce stock control, and satisfy taxation appraisal of assets, rapid and accurate information is desirable.

Inventories should also be established and maintained where emergency supplies are held. For example, petrol caches, clean-up materials for spill response, electrically insulated tool emergency stores, location and status of first aid equipment should be considered.

Wherever possible, systems which allow for ready update and retrieval such as magnetic tape and computer printout should be utilized for inventory data, otherwise usefulness in management decisions is seriously impaired.

Workload Analysis

In order to prepare strategic plans and to identify project manpower needs, it is necessary to determine the anticipated time blocks which must be allocated for individual tasks. A proportion of these tasks will be administrative, a proportion supervisory, and the bulk actual execution of projects.

The essence of effective vegetation management must evolve from comprehensive examination and assessment of apparent conflicts. It must then predict consequent cost in time and effort required to overcome the examined problems under incremental degrees of effectiveness.

This assessment procedure is commonly known as workload analysis. Such analysis must address the suggested need for tasks, establish a rationale for undertaking such tasks, then move to quantitatively and qualitatively examine the work in a temporal dimension. The analysis must then provide a review of solutions as task methods, with a further assessment of their relative capital costs and cost effectiveness. It must also calculate the effort in terms of manhours or mandays which must be expended over time. Without such basic information, it is neither possible to objectively assess present conditions, nor comprehensively plan for the future.

Figure 21 displays the subsets which form a workload analysis. Predictive planning utilizes an assessment of what tasks, where, over what area and to what intensity, to prepare the anticipated program workload.

Project planning is derived from an assessment of more definitive information from field records, and the intended project size to provide a time based unit area workload. Program quality is an option analysis which allows the vegetation manager to conceptually manipulate a number of different factors and determine the range of workload variance between a particular task carried out at any level from very high quality, to minimum acceptable. Project unit cost are calculated by assessing expenditures per task and dividing them by task area.

Work and manpower scheduling and program budgeting become readily visible with workload analysis. Long term budget projections can be calculated from aggregate unit costs, inflation rates and anticipated program

Figure 21 Workload Analysis Schematic: Predictive Program and Project Task Workload Components

Predictive Planning	What Projects Where Quantitative dimension Qualitative dimension	Per Task=	Workload anticipated
Project Planning	Method Proposed Effort Time Problem dimension	Per Task=	Workload per unit area
Project Quality	Place Productivity Pride Training Supervision	Per Task=	Workload quality per unit area
Project Costs	Overhead Method effectiveness Productivity Manhours Materials & Equipment needs	Per Task=	Workload costs per unit area

size providing corporate financial planners a clear picture of anticipated operating costs. In the field, individual budget requirements can be prepared from actual project cost records and projected workload assessment.

A final and important function of workload analysis is to provide the baseline information that allows a program manager to eventually compare current task productivity against planned targets of time and quantity. This step is required in utility vegetation management as a check on program effectiveness for any system that would rely on problem appearance cannot apply where a basic management objective is to ensure continuity of service. Without this checkloop, it is possible for a district to gradually slip behind in program accomplishment. Since vegetation control is cyclical in nature and is based on providing a number of years protection, inattention to annual program reevaluation can lead to a false sense of security. This in time may precipitate a major discontinuity in normal workload and demand a crash program, unscheduled costs, unplanned contract work, and similar program aberrations.

Work Records

Systematic record keeping is vital in a vegetation management program. Without a record system, it is not possible to exercise the judgements implicit in the concept of "management." The vegetation manager arrives at program decisions using both established information and experience. Together these meld to form judgements on which will hinge the efficiency and environmental safety of a program. If the established information is inaccurate or incomplete, or experience the result of perception not written record, then the program manager forsakes his professional, ethical and social responsibilities (Gardner 1975).

Record keeping has four clear purposes and three distinct phases. Documentation of past and present right-of-way status, establishment of projections for the future, and problem identification justify record keeping, while collection, compilation and computerization represent the phases in information gathering for records.

The format for information collection will largely influence its acceptance and accuracy while completeness and purpose will govern its usefulness. Simple, clear instructions should be obtained. An example of a comprehensive herbicide application record form, by this author, is contained in Appendix I. This field form provides the base data for a comprehensive system which would compute and provide project summaries on a weekly and monthly basis, allowing the project and program manager a comparison update on work completion versus desired targets. This allows a manager to feel the pulse of a program as a season progresses and alter a project as circumstances dictate.

Records should be maintained on productivity in all task methods, on equipment available, hours and down time, accident type and frequencies, and public concerns. In addition, more fundamental information on staff training, salary and benefits, and on project locations, timing and method effectiveness should be recorded. When necessary, vegetation management group records and supporting systems should be compatible with, or conform to, the requirements of regulatory agencies.

At a predetermined stage, the infeed system should be transferred to a data base and a tabular or graphic compilation of all program sets published. In this way, the program manager receives a picture of all activities. In turn, the information on past experience becomes source data for projections on costs and budget requirements, manpower and training needs, and program consumable requirements. It also serves as an indicator of research and development fields and the basis for workload calculations.

Present fiscal constraints in many utilities demand the establishment of reasoned task priorities. Although vegetation management tasks may be delayed for some years, plant growth will ultimately endanger system security. The longer vegetation is allowed to grow, the more expensive and complex become the methods of control. The false economy in delaying vegetation management tasks can only be well illustrated with accurate costs and outage records. In addition, with the trend toward integrated vegetation management with other elements of the utility, emphasis must be placed on efficient and effective task scheduling. The budgeting rationale then, for the five and 10 year plans now prevalent in utility operations, can only be established from a benchmark of accurately recorded data to be effective. Record keeping should not be burdensome; properly designed and implemented, it should be a flexible, dynamic management tool which substantially assists in planning, implementing, and maintaining advanced management techniques and field methods.

Work Costing

A clear distinction must be drawn between budgets, that is proposed expenditures or work costing that is retrospective in scope, and documents or calculated expenditures which have occurred. Quite obviously work costing does, however, provide the baseline information used in preparing both short term operating budgets and long term financial projections.

The choice of task method can and should be regulated by a realization that a method providing short term control, say two growing seasons, though providing cheaper initial cost, is more costly than an expensive method which provides control over five growing seasons. If the elapsed time in years before retreatment is required is divided into the accumulative job cost, a Cost per Unit per Annum can be calculated. An obvious comparison here is between mechanical and chemical brush control costs and the relative time effectiveness of each, the social and environmental considerations apart.

Measurements of vegetation are normally those of density, diameter, height, and area covered. Small areas, no matter the problem, can be readily managed, however, rights-of-way are unique as a land use covering hundreds of miles. Moreover, increases in width substantially increase area. For example, a six meter wide right-of-way 1.6 kilometers long encompasses one hectare, a 20 meter right-of-way, 3.2 hectares, but a 152 meter wide right-of-way, 24.2 hectares. When viewed in the light of manpower limitations imposed by union agreements, productivity variance, lost time and logistics, it can be seen that small increases in growth are magnified considerably as right-of-way length increases. It follows that it is incumbent on the aware and motivated manager to examine his methods and costs with great care as system expansion, voltage step up, and environmental demands increase program size.

Using the costs and cost effectiveness information available from records, it is possible for the vegetation manager to base choice and comparison of methods, staff, contractors, equipment, and materials on a sound economic footing. On the one hand, project unit costs which provide the source of this information are primarily internal to the vegetation management program and should be retained as such since a considerable amount of interpretation and experience is required to draw valid conclusions from site specific field charges. On the other hand, program cost and operating overhead should be corporate knowledge and incorporated into company financial planning and strategy. A natural reticence appears to pervade the science of vegetation management in making public unit costs associated with vegetation control activities. Admittedly individual project costs are not reliable for comparison unless similar conditions and requirements existed. Collective unit and program costs can, however, provide the public with an insight into the scale and scope of vegetation management practices on rights-of-way.

In addition to the survey by Lincicome (1964) which suggested a $17 million conservative figure spent by 68 utilities in 1963 for vegetation management, a number of other authors have discussed cost in varying degrees of detail. McPhail (1972) reporting on the Ontario Hydro program records 40,000 acreas of "brush" sprayed at a cost of $1,200,000 and 5,000 acres of weeds controlled at a cost of $50,000. It is suggested that by comparison, hand cutting (conducted on 1,500 acres) is 6.5 times more expensive. Since some 200,000 acres comprise the Ontario Hydro right-of-way management program, it is calculated that a change from herbicide use to cutting and accounting for the shortened period of clearance would escalate the annual cost of maintenance to $11,700,000. In an earlier study on the same system, (Wilson 1970) [and assuming a cost increase to only $7 million],it was estimated that this increase would be reflected in a rate increase to direct customers of 0.7% and retail customers 2.5%. Accurate work costing can obviously be used for public purpose to help support a rational argument for retention of certain methods or restrictions of others.

Beck (1973) in examining environmental issues and utilities, observed the need to demonstrate, in economic terms, the industries' commitment to environmental protection and beautification. In more detail the same author noted the advantages of accurate work costing to support a large percentage of operations and approaching contract work only a three-year bid basis. A relationship between effectiveness, costing, scheduling judgements, and a drop in customer interruptions is developed.

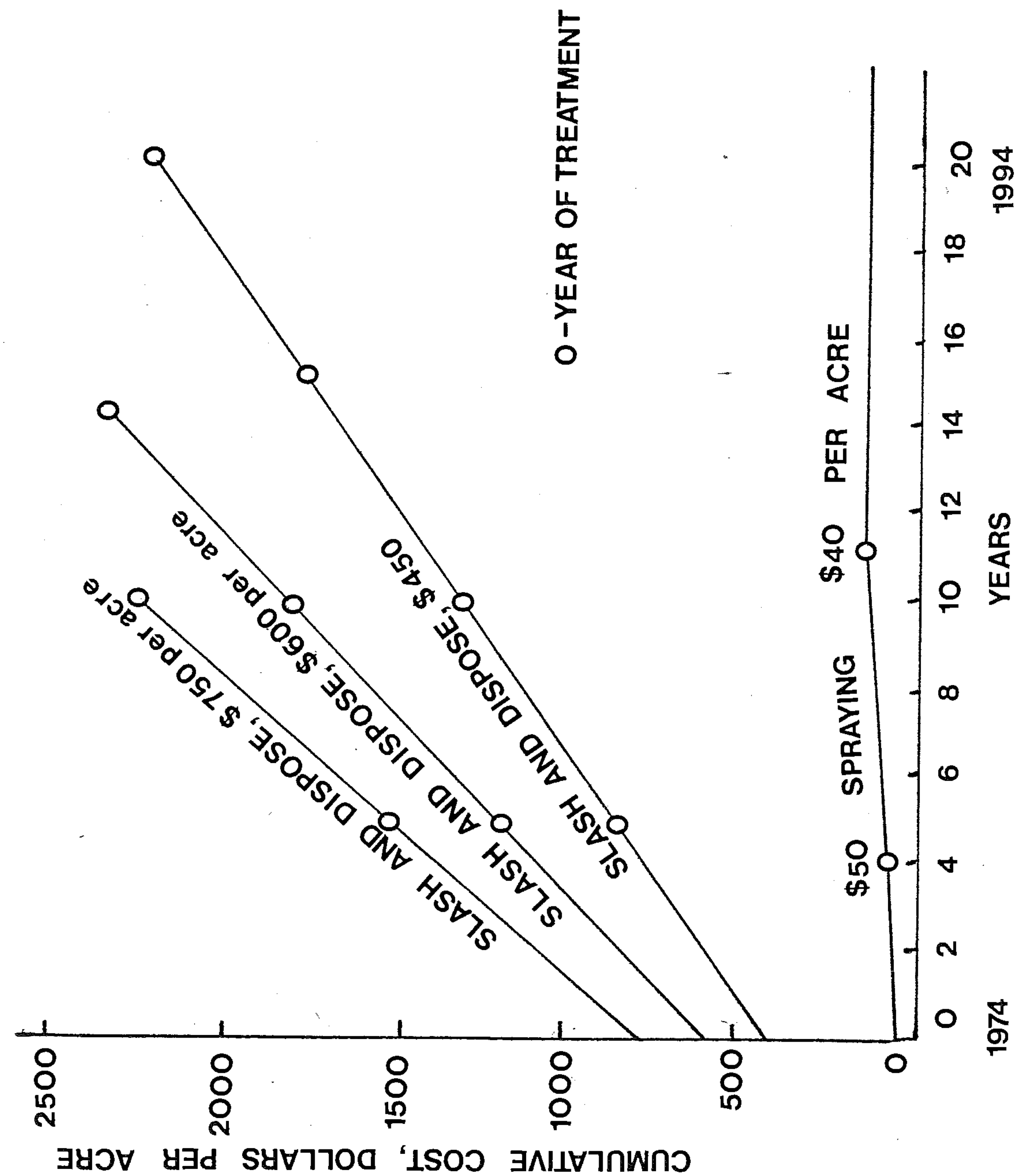
Abbott (1964) indicates a reduction of 41% in average annual right-of-way maintenance costs per mile as a result of herbicide use over hand cutting. Pacific Light and Power (Anon 1968a) reportedly used a survey of western utility practices and costs to establish their right-of-way policy, while Miller (1975) records savings of $250,000 per annum as a result of costing audits of line clearing contractors. The Potomac Edison Company have used accurate work costing as a means of demonstrating the implications of the undesirable trend toward "Ultra sophisticated clearing". The initial clearing and ten-year maintenance cost comparison for an 800 acre line indicates a differential of $2,792,000 between the "Sophisticated" method and a more practical but equally acceptable "selective clearance and maintenance" method.

Carvell (1973) alludes to, and Johns (1969) expressly notes the importance of accurate costing in developing a rationale for continuity of work.

Reduced personnel and training problems, lower overhead and supervision costs, and better results can be identified. Further, it is suggested that most utility managers, researchers, and contractors have had little appreciation of equipment costs and that greater care is required in determining chargeout rates.

Clements (1973) suggests that for the first time in their history the electrical utilities are having to fully justify increasing power costs. It is predicted that this scrutiny will require utilities to reexamine their budgets and in the field of vegetation management favour more economic and socially sophisticated programs. VandenBorn et al (1974), in a Brief before the Alberta Environment Conservation Authority examining pesticide use in that province, maintained that the utility companies have successfully used the most economical vegetation management systems in order to keep consumer rates as low as possible. As evidence of corporate responsibility Figure 22 was submitted to the Authority. It was offered that it is incumbent on utilities to take full advantage of the economics offered by the use of herbicides as long as they can be satisfied that no detrimental effects, either temporary or permanent, will result to the environment. The graph prepared was based on work costing over a prolonged period and the records open for inspection. It was concluded on the basis of the cost considerations (without allowances for inflation) that the use of herbicides in vegetation management has distinct advantages over alternative methods of controlling undesirable plant species. It is doubtful if such a sweeping conclusion can be drawn from the information provided without recourse to a more complete study of alternatives over a prolonged period as is contended

Figure 22 Right-of-Way Vegetation Control Cumulative Cost Analysis: Cost of Herbicide Treatments in Poplar Compared with Three Different Mechanical Cutting Costs Depending on Density. (From Actual and Projected Costs by VandenBorn 1974)


CUMULATIVE COST, DOLLARS PER ACRE
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
1974
1994
YEARS
SLASH AND DISPOSE, $750 per acre
SLASH AND DISPOSE, $600 per acre
SLASH AND DISPOSE, $450
$50 SPRAYING $40 PER ACRE
O-YEAR OF TREATMENT

by Egler (1953, 1958) and Niering and Goodwin (1974).

It is evident, however, from the replies to a Canadian survey (Canadian Electrical Association 1976) that most Canadian utility managers do not maintain sufficiently detailed costs to judge maintenance program success or adequate outage statistics in order to compare vegetation management expenditures with targets of reliability.

Little emphasis appears to be placed on determining productivity and the literature does not contain any references to work study, standard times, or similar cost-effectiveness criteria used in other industries. As noted in record keeping there seems little point in maintaining detailed cost data unless, or until, it is used as an accurate and dynamic tool for management decisions.

Reports

Information flow through complex systems must normally make the transition from the document level to the report level in order to provide a more definitive subject review, or "hard copy" resource for reference. This author suggests six report types.

Strategy reports are those which outline a conceptual approach or approach options. For example, a broadscope strategy report would examine system wide the management options for vegetation management in a utility and recommend courses of action. Once approved, the appropriate courses of action would form the skeleton Management Plan for operations or administration.

Status reports provide an examination of present conditions, either technical or administrative. The degree of development or "state of the art" with regard to particular herbicides, classes of equipment, or training program effectiveness are illustrations. Right-of-way conditions for a given reference date would also be the subject of status reports and would form important summaries between, or a contributor to, historical profiles not updated directly from aerial photography.

System reports attempt to examine a complex unity of many often diverse parts, and subjects the parts to ordered placement in a common plan. A study of a vegetation management group's role in relation to other operating or support groups, or a systematic examination of individual vegetation management projects over time are examples that might be the subject of a system report.

Scheduling reports provide a temporal dimension to work programming. They may prescribe the time frame for particular projects by location or indicate predetermined servicing requirements for equipment, for example.

Scopic reports provide a visual appraisal of situations, locations, conditions, equipment, results, or aesthetics. Three dimensional presentations are in terrain constraint mapping, two dimensional tables and graphs, or planoptic oblique and stereo photographs may be used for presentation. Panchromatic, colour and false-colour rendition are possible.

Schematic reports present organization or project relationships, workload and staff consociations or similar patterns in a hierarchical or flow diagram format allowing ready appraisal of component interdependencies.

Support Services

If full attention is to be paid to the administrative planning and technical roles in vegetation management, access to a number of support services is required. Most utilities already maintain a variety of capabilities to service other elements. Purchasing and supply, cost accounting, salary and benefits administration, safety, legal, land, medical and occupational health services, community and labour relations, cartography, drafting and computer science are best provided by staff groups who are responsive to the day to day program of the operating units.

Distance, centralization, unclear policy and objectives, poor interpersonal trust and communication, and compartmentalization of responsibilities may nullify many of the potential benefits of an interdepartmental framework. The utility vegetation manager must be aware of all system protocols, personality or efficiency conflicts and procedural blockages which affect program continuity. He should be alert to procedural and personnel changes in support services which may diminish or improve past experience and work actively for improvement within his own operation and lobby for efficiency in support operations.

A number of support services must, by necessity, operate at many levels in a utility. Salary and cost accounting is an ubiquitous example. Inventory and stock control, vehicle maintenance, and work study may also span all levels of the organization. Research and Development, discussed in a later section, should be conducted on two levels. Basic research into "state of the art" development may best be undertaken by a corporate research group. Applied research and field testing on a large scale should be a cooperative venture between research and vegetation management field services. For personnel improvement, the manpower and training group should work closely with the vegetation management group to establish training and career planning objectives. These objectives should dovetail with the long range mission and program workload outlined in the vegetation management and corporate management plans.

The relationship between the vegetation management group and the utility support services must be clearly established. Overlapping and ill defined responsibilities lead to administrative tensions which cloud the work objectives. In order that support services do not "drive" the system, a clear client/user consociation should be recognized.

Three critical components, all interrelated; data base, records and work costing are often the weakest in many utilities. There are a number of reasons for this, of which lack of management training, lack of corporate interest, and a dearth of information in the literature appear prime. The vegetation management group should rely heavily on the appropriate expertise in support groups to ensure these facets of management are upgraded to a degree of reliability which ensures confidence in their use in program decisions.

In order to fulfill then, the objectives of management in a utility vegetation program on rights-of-way, it is necessary to provide a structured summary of support services. A proportion of these services deal primarily with information handling and are internal to the vegetation management program while some have shared responsibilities and some must provide a true client/user relationship. Without these services clearly identified, developed, and documented, there is a very real possibility of program, or at least project failures, administrative dislocation, undefined staff accountability, poor morale, and both public and company judgements of poor management.

Support Documents

In order to operate a vegetation management program successfully a number of formalized documents require preparation. Some are noted in the Synopsis of Operational Requirements, Table 4 and a number are dealt with more directly in the sections on Records and Support Listings. These documents form the hardcopy skeleton necessary to provide continuity and consistency in a vegetation program.

The first and most important written instrument of management must be a Policy and Procedures Manual (PPM) which outlines the administrative and operational guidelines approved by corporate management. The preamble to the manual should set out the vegetation management group role, responsibilities, objectives and strategies in the context of Corporate Goals and Policies.

Sanctioned task method alternatives should be layed out in the manual as a series of Policy and Procedure Instruments (PPI's). Where stipulations and intensity of a work method alternative or procedure are flexible, it should be viewed as a guideline and where immutable, as a standard. For example, in a PPI dealing with mechanical cutting of vegetation, the general parameters may be layed out while the choice of machine is left to the discretion of field staff, while a PPI dealing with clearance between vegetation and electrical conductors would set out, as a standard, minimum limits of approach which must be maintained. A working example on herbicide use is contained in Appendix J.

As the underlying factor in success of any ongoing program is one of the attitudes, it is imperative that an active role in shaping attitudes be assumed by the vegetation management group. Attitudes crystallize information. Education, then, is a critical factor in ensuring safe and efficient programs - education at all levels of responsibility (Gardner 1975). Programmed study for craft and supervisory staff requires detailed training manuals. Comprehensive utility vegetation management training manuals have been prepared, for example, by Ontario Hydro (1963, 1967a, 1967b) and more recently by Washington State University (Johns 1976). Following from the noted necessity for training manuals, there is a further requirement for a Safety Practices Manual (SPM). Utility vegetation management by its very nature is a potentially hazardous occupation and requires detailed rules and procedures to protect both plant and personnel. Preparation and updating may require a four party participation from the vegetation management group, from the corporate safety practices group, Provincial or State Workman's Safety Boards and, of course, union representation.

A constant concern with support documents is the problem of updating. Between the formal issuance of PPI's and Safety Code sections, Bulletins should be issued which specify new approved practices, procedures, materials, etc. Bulletins should not be regarded as a newsletter medium but rather as a communication level only once removed from PPI's and codes, and equally binding.

In order to appraise new staff of approved procedure, to ensure a feeling of accountability in field personnel and because Policy and Procedures Manuals and Safety Code become cumbersome references outside office conditions, individual Field Manuals should be issued in the form of condensed reference books. As major new practices and safety rules are approved, a synopsis should be prepared as a replacement or addendum to such

Manuals. These documents should be seen as important personal responsibility, signed by the owner and inspected by management from time to time. A very thorough knowledge of the manuals should be required of all members of the vegetation management group.

Where contracts are let for field work, consultants engaged for special projects, or research agreements concluded with other agencies, form and content of the appropriate documents should be a joint undertaking with the legal support group. Specifications, tender documents, terms of reference or research protocols should be the responsibility of the Vegetation Management Group.

Although not strictly documents, adequate provision should be made for acquisition, distribution and storage of Equipment, Maintenance Manuals, Material and Chemical information sheets, computer printouts and research development reports. In order to organize, file and retrieve all working copies, a Filing Manual and Thesaurus should be prepared. A decimalized version specifically for forestry has been published by the Oxford University and one utility has a comprehensive example for environmental management (Gardner 1974).

Clear responsibilities and accountability are necessary for staff to function in a productive, independent and innovative climate. The simple personnel job description form should be elevated to a dynamic individual discussion and appraisal form. This can then be coupled with the expectations developed from one of the many "Managements by Objectives" work and staff planning schemes. A detailed vegetation management staff job description is given in Appendix K.

Support Listings

Lincicome (1964) has noted that only 20% of utility vegetation management work in the United States is undertaken by utility staff while 80% is conducted on their behalf by contractors. Since the low bid for vegetation control is often favoured and is, except in extenuating circumstances, often required by law for many Government owned or regulated utilities, it is evident that some mechanism must exist to protect the utility from unscrupulous contractors whose work practices will be damaging to corporate image or where work performance is incompetent. A strategy for overcoming this operating constraint is to establish a system of Approved Listings. A contractor wishing to be considered, when tenders are issued, must previously have had work inspected and approved, be bondable, and have references from previous clients. Where a new contractor wishes to become established, small contracts should be awarded and inspected. An ongoing program of inspection and completion holdbacks should be enforced for all contract work. Where productivity or work quality drop below a certain standard, one warning only should be issued and after that a contractor should be dropped from an approved list.

Such lists and independent inspections should also confront the problem of favouritism in contract awards prevalent in some utilities. A variety of competent contractors should be encouraged by utilities, with emphasis placed on local employment except where economics and advanced equipment or methods are more than marginally in favour of large organizations. The utilities may wish to extend training and instructional facilities to approved contractors.

When vegetation management programs are supported by external expertise in universities or the commercial consulting field, listing should be maintained of competent experts. Area of specialty, report writing capabilities, expert witness experience, past utility experience and current fee schedule should be maintained as an updated listing.

Government agency staff that interact with the vegetation management staff should be catalogued as to Department, responsibilities mandate, reporting structure, interest and qualification. In this way communication system with external staff will flow smoothly.

A large number of suppliers normally interact with a vegetation manager. In particular, herbicide and equipment suppliers are important in providing program continuity and information updates. Supplier staff should be listed by background, expertise and orientation towards sales or technical developments. Supplier resources of research, development, competency, and comprehensiveness should be documented. Supplier products, costs and terms should be recorded.

Confidential listings should be maintained as appropriate on staff qualifications, job definition, experience, competency and personnel profile. These listings are suggested in addition to the normal Personnel File retained by the appropriate support services group. The vegetation program manager at each level in the organization should have an ongoing interest in developing the fullest potential from their staff and should initiate or collaborate on training and career planning programs.

It is later noted that an important component of an ongoing vegetation management program is a Research and Development capability. The aware manager should always be appraised of current practice and new developments in other electrical utilities and linear land management.

To this end, the vegetation management group should consider receipt and circulation of the journals and magazines cited in Table 7. A central group location or library support service may be designated to abstract or photocopy pertinent articles to distribute to field locations. In this way the head office group can assist in fulfilling its obligatory resource role in a decentralized system. Two further functions in new information source access can be performed by the central location. It can act as a repository for research reports, scientific papers, consultants' findings and provide an updated list of statutes and regulations which govern vegetation management operations. In addition, it should be able to service requests for references particularly those now held in computerized data banks. A remote terminal for searching INFOMART (Southam Press Ltd.) WATDOC (Fisheries & The Environment Canada) DIALOG (Lockheed Information Systems) and CCRS (Canadian Remote Sensing Technical Information Services) holdings should be considered.

Once prepared, every effort should be made to keep listings current and circularized to field staff. Direct addressed computerized printouts should be considered for all general use listings.

Many Provinces and States, manufacturers' consortiums, and transportation groups maintain accident response capabilities. Access numbers for these and local emergency services should be accumulated, updated and circulated to all staff.

TABLE VII SUPPORT LISTING : UTILITY VEGETATION MANAGEMENT INFORMATION SOURCES

CARY ARBORETUM REPORTS

DOWN TO EARTH

ELECTRICAL WORLD

FOREST ABSTRACTS

GROUNDS MAINTENANCE

INDUSTRIAL VEGETATION MANAGEMENT

JOURNAL OF AMERICAN RIGHT OF WAY ASSOCIATION

JOURNAL OF HORTICULTURAL SCIENCE SOCIETY OF AMERICA

JOURNAL OF INTERNATIONAL SOCIETY OF ARBORICULTURE

JOURNAL OF WEED SCIENCE SOCIETY OF AMERICA

LABEL RECOMMENDATION PRINTOUT - NEW PESTICIDE REGISTRATIONS - CANADA AGRICULTURE & U.S. ENVIRONMENTAL PROTECTION AGENCY

ONTARIO ANNUAL GUIDE TO CHEMICAL WEED CONTROL: PUB.75

PROCEEDINGS OF BRITISH WEED CONFERENCE

PROCEEDINGS OF N.E.WEED SCIENCES SOCIETY

TRANSMISSION AND DISTRIBUTION

UTILITY ARBORISTS ASSOCIATION NEWSLETTER

WEED ABSTRACTS

WEED RESEARCH

WEEDS TODAY

WEEDS TREES AND TURF

Appendix C Communications

COMMUNICATIONS

Introduction

Public Acceptance of Vegetation Management Programs

A great deal of criticism has shadowed the expansion and execution of utility operations in the last decade. Books by Carson (1962), Whiteside (1970), Shoecraft (1971), and others, have directly or indirectly caused critical examination of utility vegetation management programs in the public forum. The press and environmentalists have extrapolated from *in vivo* laboratory tests to field conditions and condemned vegetation managers as party to deliberate degradation of environmental and human health.

Paterson (1974) has suggested that vegetation control on rights-of-way is normally accomplished in the most economically advantageous way to the specific agency with no consideration of the public. As a consequence it is proported that the Canadian public has been reacting strongly against these practices on the basis of aesthetic change and the loss of valuable wildlife habitat. As a result of public pressure two provinces, New Brunswick and Nova Scotia, banned the use of herbicide on right-of-way. Although such public pressure may have in part precipitated enquiries into pesticide use in these provinces VandenBorn (1974) notes that these programs were soon reinstated. Similar experience in British Columbia (Mackenzie *et al* 1975) and Alberta (Environment Conservation Authority 1976) have served to examine but not radically change right-of-way practices.

There can be little doubt that public concern was fueled by military use of a variety of herbicides in Vietnam (Barrons 1969, Tschirely 1969).

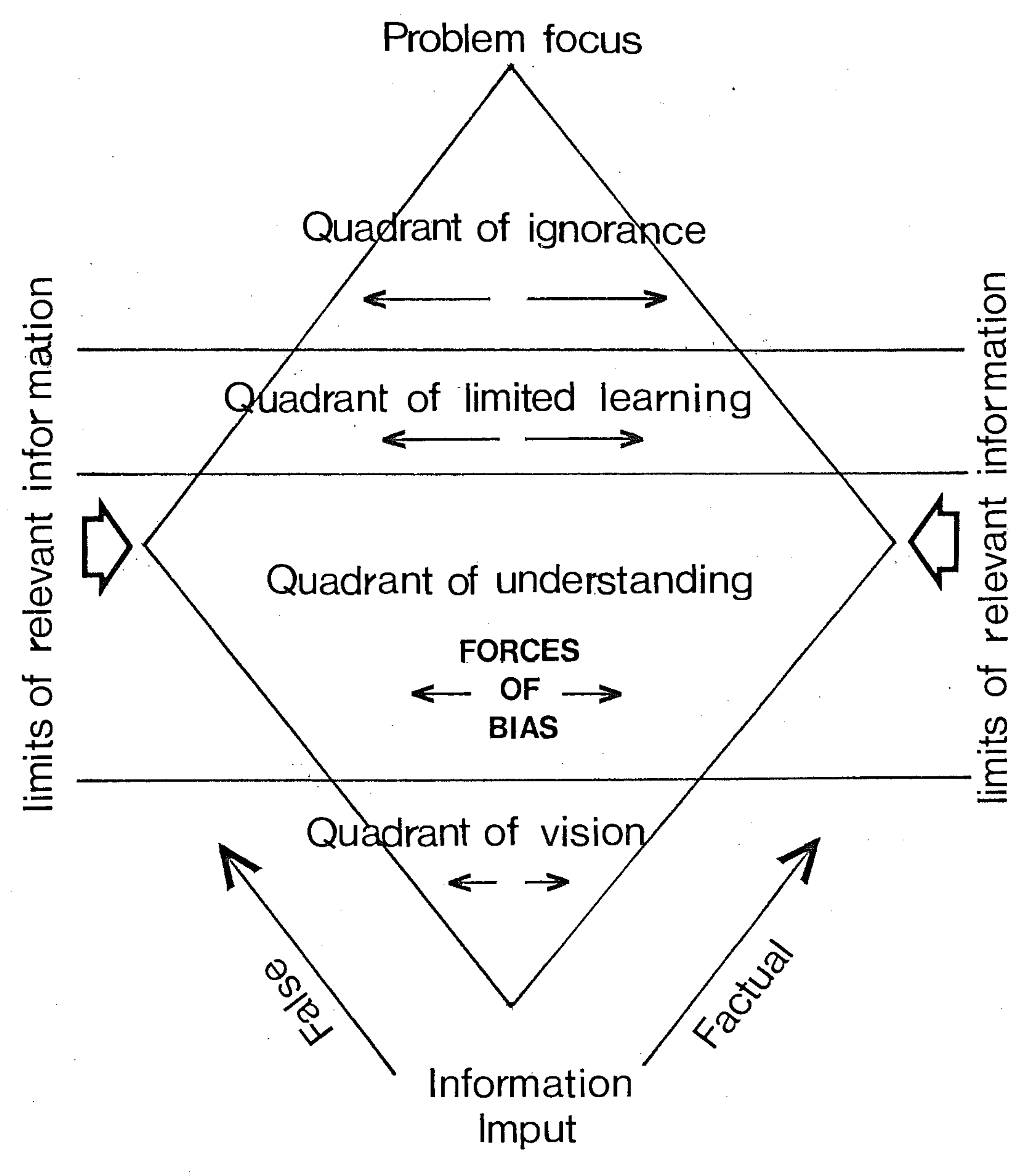
The subsequent controversy over a dioxin contaminant with teratogenic potential (Courtney 1970, MacLeod 1971, Leopold 1971) in a common right-of-way herbicide (2,4,5-T) inflamed public opinion (Toronto Globe and Mail 1971). Detailed investigation of environmental implications (Tschirely 1970) and of health implications (Johnson 1971) have now discounted hazards associated with registered uses of 2,4,5-T. Some rancor still exists (Vancouver Sun 1973a, 1973b) but in general the public outcry has been muted by the redirection toward inflationary trends in western economies and the growing realization that energy resources are not inexhaustable. Nevertheless the residue of this concern is now firmly embedded in regulations requiring the right-of-way manager to provide a more detailed and articulate description of proposed practices, especially on Federal or Crown land.

Human Perceptions

Humans apparently stand alone in nature in the ability to reason in the abstract, to take information and deduce relevance and consequence. From this process is derived our appreciation of circumstances and sets of circumstance. This might be termed our individual insight. In order to document this process, to better understand the needs of a communication program, a model, Figure 23, was developed to graphically illustrate that man attains varying levels of understanding characteristically modified by a variety of biases. In addition, perceptions are filtered by each individual's interpretative processes, and based on either factual or false sources, Complete or Incomplete.

The model is termed the Diamond of Individual Insight. Hypothetically an individual's perception of a problem or issue can be assessed within

Figure 23 Human Perceptions: Diamond of Individual Insight



Problem focus
Quadrant of ignorance
Quadrant of limited learning
Quadrant of understanding
FORCES OF BIAS
Quadrant of vision
limits of relevant information
limits of relevant information
False
Factual
Information Imput

the bounds of a diamond representing the individual's state relative to the body of knowledge on a particular subject. One apex of the diamond represents the focus of the problem, the broadest dimension the limits of relevant information, while the central axis from the point of focus through the centre of the figure represents a line of absolute objectivity. Individual knowledge regarding a particular topic is reflected by placement in the diamond. If the depth of knowledge is minimal, perspective of the total information on a subject is limited, and suggests placement in a "quadrant of ignorance." As knowledge increases the individual passes through the "quadrant of limited learning" to the "quadrant of understanding."

In any population there will be a few individuals approaching or in the "quadrant of vision." Here the individual has distinguished the limits of relevant information, synthesised and drawn conclusions from the body of knowledge and ordered those conclusions such that an issue may be judged relative to other issues. In a simple system with few complex issues a number of individuals will attain this "state." With complex philosophical, social or scientific issues only a few minds will attain this "state" in any century.

So far the explanation has dealt only with the ideal case when all facts are viewed with total objectivity. Deviations from the central axis may be represented as a reduction in objectivity. Wildly differing opinions exist on all subjects. Although the "correctness" of facts will influence individual perceptions, a number of important imprinted biases colour individual interpretations of information. These form every man's character to varying degrees. An understanding of this process which can radically distort communications effectiveness must underlie the preparation, execution and feedback mechanisms used to operate a vegetation management program.

The influences which tend to shape men's minds include: upbringing, level of formal education, ego, sense of fear, greed, past experience, reasoning, learned values, prejudice and righteousness, complacency and disinterest, expediency, and mental or social deprivation.

Upbringing and education form the basis of each man's catalogue of information. Innate ability, experience, and learning will shape his retention and colouration of facts. In adult life, reading, watching, talking, and employment play principal roles in the receipt of information. Information will be forgotten, discarded or retained depending on interest, form of presentation, and, for some, deductive reasoning. Pollock (1974) reports memory curves that show within two days people forget 20% of what they have learned, within four days 40%, nine days 60%, and in a month 75% is lost.

For the most part people will believe what they read or hear. And for the most part this information is provided by the media. However, only 12% of those surveyed in Canada (Davey 1970) felt that the press was very honest in its reporting and 59% expressed doubts about the quality of information they received. For Canadian news, individuals in the survey relied 48% on television, 19% on radio, and 29% on newspapers. About 50% felt that television was credible in presenting Canadian news compared with 17% for radio and 26% for newspapers. Fifty-five percent of those surveyed felt that newspapers required the most energy and concentration to understand.

It is not reasonable to draw specific conclusions from this data. However, the aggregate of these observations allied with our differing abilities to comprehend the intended meaning of words, aptly summarized in this conversation (Carroll 1871)

> "When I use a word, "Humpty Dumpty said, in rather a scournful tone, "it means just what I choose it to mean - neither more nor less."
>
> "The question is, "said Alice, "whether you can make words mean so many different things."
>
> "The question is, "said Humpty Dumpty, "which is to be the master - that's all."

has meant that many external public and on occasion government critics of utility operations have come armed with an array of dubious information with which to challenge the status quo. The opposing forces met head on and open confrontation often grew from corporate rebuttle, silence or inertia. Critics became more insistent and marshalled more "facts." Few, however, could grasp either the administrative or technical process of electrical utility operations which, even from within, are complex, technical, and often intimidating. Change has been slow but a pattern of dialogue has evolved. Belatedly, democratic reconciliation has begun to replace mistrust.

A recognition of the cultural, informational and educational, social and physiological factors which distort, alter or negate communication, should be borne in mind for both successful internal and external public communication in and out of the vegetation management group or its support services.

Corporate Responsibilities

Both private corporations and government managed utilities have, and are seen to have, a significant impact on the quality of the natural environment. This impact is generally seen as degrading environmental quality.

This perceived overall disbenefit must be weighed against the benefits which accrue from readily available electrical energy at modest cost. Moreover, an argument can be made that in some instances the initial disbenefits, after construction, of appearance and clearing impact are later mitigated in a properly managed vegetation program which reduces visual impact and improves wildlife habitat by encouraging a diversified vegetation canopy.

Corporate responsibilities in public communication are to clearly portray a corporate environmental ethic in a well reasoned, balanced style. It is important that advocacy of position be supported with clear purpose, evidence, and rationale. Public information and public education should evolve as a public "right." Electrical utilities provide a trusted service. The utility must not, by indifference or intent, betray that public trust.

Corporate responsibility in communication with government agencies must rest on a firm foundation of honesty and openness. Without this policy both motives and projects will be suspect. The process is simple; candor gains respect, and involvement aids agreement. The responsibility that the organization has in internal communication is more subtle. It serves, in addition to the purposes suggested in public and government communications, the added role of developing corporate morality and realizing individual worth. A corporate interest in positive self image, a clear understanding of individual, group, and corporate responsibilities and mission, and a feeling of contribution, support a healthy organization. Through a healthy, vital organization, comes responsive, responsible attitudes toward the totality of our environment.

Information Systems for the Public

Public Brochures

A great deal of misinformation about vegetation management has been carried in the press and similar sources, creating in the public mind a mistrust of such utility operations. Since public utilities are particularly vulnerable to external criticism, a well conceived public outline of vegetation management practices should be an essential constituent in any complete program. It should be a joint effort between the vegetation management group and a community relations group. It is unwise to leave preparation solely in the hands of a public relations oriented group who may place too great an emphasis on presentation and too little on content.

A two step approach has been utilized by some utilities (Ontario Hydro 1967c, 1971, British Columbia Hydro 1970, 1971). A simple pamphlet providing basic information on electrical system size, program rationale, methods, compliances with regulatory agency requirements and the degree of training and supervision given to field staff, provides a handout which can be used by field crew and field offices. This, or a similar brochure, can be considered as a "bill-stuffer" which would be sent to all customers or possibly to customers in a region or district which will require treatment projects that season.

A more substantial booklet can be prepared for public meetings concerned with new line location approvals or vegetation management practices specifically. As with the pamphlet, the booklet should address system size, but include a more detailed examination of the relationship between voltage, right-of-way widths, power demand and system growth. It should examine vegetation management rationale and discuss continuity of service, line security and protection policies. Task method alternatives should be recognized and the criteria which govern choice described in the context of vegetation management objectives. The implications for environmental, social, and occupational safety should be illustrated with examples, supported with economic and administrative verity. The training, supervision and inspection procedures which ensure compliance with internal policy and procedures and the mechanisms for adherence to regulatory structures should be clearly identified. Staff accountability should be reflected in a discussion on responsibilities which then leads into a review of staff expertise and ethics. Finally, statements of fact should be supported by references, further information sources noted, and the whole written in a non-technical prose and adult, mature style.

Project Notices

Since much public concern originates from ignorance as to vegetation management rationale, it is incumbent on the aware manager to initiate a process of public information. A two stage system is advisable in areas where vegetation management programs are relatively well known and accepted, and a three stage approach in areas which have been previously contentious or where projects are occurring for the first time.

In major ongoing established programs, project notices in the local press indicating task rationale, method(s), size, location, duration and contact points for further information, are good practice. If vegetation control measures present a public hazard, as in major cultivation, cutting or chemical projects, job site warnings may be posted. For minor operations, warning flags should be considered.

In the case of major projects in new or contiguous areas the addition of public information meetings should be considered. Task method alternatives, the benefit/risk and benefit/cost tradeoffs and the task rationale should be clearly presented in unbiased form. When possible, scientifically supportable answers should be prepared beforehand for known controversial issues. Factual, relevant handouts should be available. Community leaders with known concerns should be asked to participate by invitation. Adequate advance notice should be given for such meetings which should occur with sufficient leadtime to allow for project modification if necessary.

Individual Notification

Many regulatory agencies now appear to include adjacent landowner notification as a stipulation of permit approvals involving herbicide use on both owned or easement lands. In rural areas, where surface water sources are used for drinking water, vegetation management activities which may produce siltation or reduced flow for short periods should be indicated to the registered owner. Where an impact on stock watering or grazing is anticipated, farmers should be given advance notice. In urban areas, prior notice should be given to adjacent residents if noise from operations is likely to be a disturbance or if equipment such as gang-mowers present a potential hazard to young children and pets. In areas where multiple land use agreements are in force, adequate provision should be made to inform appropriate parties that projects are anticipated.

An argument against individual notification is often raised by field staff because of the difficulty of contacting property owners and in distinguishing between property owners and tenants. Obviously rules governing contract must be flexible, however the onus rests with senior management to explain the community relations purpose behind individual contact so that the logic is understood and appreciated at the local level.

Lack of attention to this simple though perhaps tedious duty has resulted in unnecessary and ill-informed press coverage of utility operations (Squamish Times 1973, Vancouver Sun 1973a).

Complaint Handling

Ditman (1969) indicates that complaints that are investigated and settled without delay enhance a utility's public relations policy and presumably, by inference, a company's public image. A complaint handling system is recommended. Turner (1967) notes that by far the greatest majority of complaints have developed from the application of herbicides and examines the legal implications. Where vegetation control is carried out on a bid basis with contractural agreements with applicators, it is observed that most contracts hold an indemnity running in favour of the utility but where drift damage has occurred, courts have applied a basic tenet of law which indicates that no one can contract against their own negligence. It is strongly recommended that financial responsibilities and insurance provisions be included in vegetation management contracts to protect the contractee.

Both in the case of contract work and with "in-house" staff, permanent or temporary, it is the utility which is seen to be the offending party. Complaint systems must be accessible and responsive to each individual complaint. Where complaints are the result of contract operations they should be dealt with by the contractor but with final resolution documented by letter to the vegetation management and legal support groups.

Evolving from a complaint handling procedure must be a claims handling procedure. A survey of Canadian utilities (Canadian Electrical Association 1976) indicates that of 14 utilities contacted, 13 had some method of handling claims although the survey replies, in some cases, appear to apply to post construction claims, not operating and maintenance damages. Moore (1967) noted that promptness in investigation and handling claims in a forest vegetation management program allowed positive proof to be collected that the project did not cause a number of alledged contaminations of water. Ditman (1969) records that an unnamed utility which investigated claims promptly, found that over 50% had no connection with that company's activities.

Turner (1967) and Ditman (1969) provide cogent thinking on the methodology for handling claims and the staff qualities and training required. Turner suggests that staff should have a penchant for walking, that the claims negotiator should travel to see, on location, a complaining party and once there, should be friendly and businesslike. Ditman suggests that personnel should be highly motivated, interested in exercising responsible business citizenship, fair, and thorough. Specialized consultants such as veterinarians, plant pathologists and agronomists are recommended where technical doubts arise.

Both authors stress the need for prompt handling of complaints and claims, with Ditman (1969) noting that lost time results in hardened attitudes. Turner strongly endorses the need to be comprehensive and suggests an eleven point procedure for claims: do not admit liability, beware of the way written communication may be construed by courts, be friendly, examine work records carefully to substantiate that utility personnel were actually operating where alleged damages occurred and make detailed field notes both of ~~approved~~ apparent damage and surrounding conditions, immediately notify insurance adjusters or ask permission to have damage inspected by expert opinion, obtain complete information or witnesses, take appropriate photographs, make sure operating records are up to date and finally, preserve whatever evidence would be pertinent to the case.

Ditman (1969) suggests that utilities require exact records of every complaint (real or imagined) to maintain an efficient claims program, presumably in order to establish trends and identify research needs. An example of a Complaint Investigation and Handling Form is given in Appendix L.

Complaint and claims handling then will directly reflect on public attitudes toward utilities and the vegetation manager charged with administrating an already contentious facet of operations. A utility should strive to handle public concerns with acumen and honesty.

Information Systems for Government

Municipal and Regional

A number of municipalities have bylaws which restrict or prohibit the use of herbicide within city limits despite such boundaries encompassing an area far removed from the concentration of population. The findings of various Commissions of Enquiry into the use of herbicides has tended to reinforce this trend (Mackenzie et al 1975, British Columbia Royal Commission, Environment Conservation Authority 1976, Public Hearings into the Use of Pesticides in Alberta). Vegetation control which requires herbicide use because of terrain or undesirable plant density within such boundaries may be possible if the Council concerned is approached with a well supported case. British Columbia Hydro have tried this approach with some success (Tatlow 1976).

With routine work, which does not require approval but which may cause public concern, planning should include the courtesy of informing Regional and Municipal governments. Such a strategy was undertaken by British Columbia Hydro and appears to have that Authority away from a period of confrontation (Tatlow 1976).

A two-level information system in writing is recommended. An initial letter once the project planning stage is complete and a record letter just prior to job startup provide an adequate communication mechanism. At the first stage, amps and rationale for the proposed project should be filed with a letter of intent. The success of this approach can be gauged from the response to an open information process adopted by British Columbia Hydro, Appendix M.

Regulatory Agencies

State or Provincial, and in some cases Federal regulating agencies require information on proposed programs and may actually operate a Permit and Approval System. In these cases adequate lead time is required for regulating agencies to inspect proposed projects and return approved permits. The applicant is advised to apply for such permits well in advance for two reasons; if there is any dispute on proposed areas or methods, time is required to resolve conflicts, and where projects are approved, but with hazard advisories or operating strictures, adequate time is required to transmit this information to field operations. This latter time requirement will depend on the proponents' internal communication's efficiency and the degree of decentralized authority vested in field staff.

In some instances work methods, especially those employing herbicides, are subject to routine or research monitoring. If extensive research-based surveillance is planned, the agency must be notified at a point which allows adequate lead time for their own logistics plan to be prepared.

The need for communication with agencies with power of regulation or approval must be understood by corporate management, vegetation managers, and by field staff. Good working relations with these agencies are essential to accomplish the objectives of management. Corporate staff must recognize that internal communication in other agencies is often poor and the onus for informing regulatory agencies at all levels rests with the proponent. On no account should either differences of technical opinion or personality conflicts be allowed to marr the corporate/regulatory agency communications process.

Resource Agencies

As with regulating agencies, resource agencies may wish to monitor vegetation management operations. In particular Fish and Wildlife Departments with a mandate for resource protection and Water Resource Departments with a mandate for water quality and human health have a constant concern about right-of-way disturbance. Since linear corridors cross many terrain and ecosystem types, it is important to provide accurate information on location and task methods proposed. Safety procedures for resource protection should be clearly identified and stated. Prior warning of right-of-way activities should be communicated to resource agencies at local and central levels. Working liaison with resource agencies is essential. Interpersonal confidence builds respect and cooperation.

As understandings of concern and responsibility interchange, so improves the work climate, job efficiency, and task accomplishment. If and when a problem does occur, resulting in environmental impact, the level of personal contact and individual trust developed will be amply reflected in the severity of censure.

Information Systems for Internal Corporate Operations

Field and Management Staff

The information gathering system in the field which provides the data for project decision is perhaps the most crucial element of internal communications. It is this mechanism which predicates the validity of vegetation management programming. Field reports may accrue from a combination of patrol reports, ground inspections and air photos. In special circumstances this "status" information may be supplemented with outage or trouble reports. Separate systems may exist for handling unscheduled work occasioned by line "incidents" but often control center information is not properly utilized unless electrical circuit reclosure has not been possible. This synthetic information and visual field inspection must however be interpreted by competent personnel using training, experience, and judgement to prepare the comprehensive program plans and implement key decisions. This will require a complex network of communications between many internal departments and trigger the communication processes which inform outside agencies and suppliers. This web of information links must function effectively and efficiently for a vegetation management program to accomplish its objectives.

Since a wide variety of technical and administrative information "bits" must move up, down and across the organization smoothly and without misinterpretation or misdirection, consideration should be given to colour coded forms and memo-heads which are used specifically for vegetation management programs. In order that this information is not confused with vegetation management information for other utility elements, right-of-way copy may be assigned an appropriate symbol or code.

No material discussion should be communicated verbally. Task methods, timing, job size, location and budget approval should be written in clear concise terms and reported to all staff levels responsible for the vegetation management project and to the support services which require documents initiating actions. Such documents as work orders and requisitions must have clear definition, destination, and data for completion. Approval should state authority, limitations and exact subject decisions and approval given.

The vegetation manager must be constantly vigilant for interruption in the orderly flow of internal information both in and out of the group. Internal information systems often have the two part purpose of communication and education. The content of one should not confuse the intent of the other. Care should be taken to draft all communications with forethought and with clear objectives in mind. Beware of the "memo mentality." Nothing written is worth writing if the reader will not, or cannot, understand it. It is better then, to use verbal communication guided by the rule that it is better if at all possible to talk to people in person rather than to talk by telephone.

One final item of internal communication, also important in fostering morale and team spirit, is the circulation of a group newsletter which combines personal interest, technical and corporate information in a style which will appraise staff of current activities of interest. Not only does this type of newsletter serve an important internal group communication purpose, but it also helps enhance corporate appreciation of a vegetation management group and addresses the important concern raised by Gilbert (1971) that internal public relations are as every bit important as those directed outside an organization.

Community Relations

Central office, regional and local level community relations officers should be appraised of both proposed annual programs and individual project scope. In this way site specific jobs may be set in perspective and information dossiers compiled for individual projects allowing advance preparation of question boards and press communiques. The simplicity or complexity of details should hinge on project size and past experience.

Complaint procedures and vegetation management staff contact points should be documented well in advance of job startup. At time of job initiation, the local vegetation management supervisor should inform the community relations network in writing, and outline the backup information available.

Where a previous history of community concerns indicates that local leaders or populace are opposed to particular vegetation management techniques, every effort should be made to provide informed counsel to identifiable groups, elected representatives or influential individuals. The emphasis should not be on convincing opponents of a particular point of view or justifying particular practices. Rather, a balanced, well supported picture of the alternatives and implications of choice should be provided. This may either be organized through the medium of a community relations group, if such exists as it does in most large utilities, or directly by local level management staff. If dependence will rest with community relations as a support service, it is incumbent on the vegetation managers to provide the detailed content and presentation on his program rationale. It must not be, or seem to be, anything other than an honest, frank presentation by those accountable for vegetation management (Hansen 1971). Community relations, as a group, should provide no more than the logistical support for this public information activity.

Support Staff

Information flow to support staff will take two forms; information updates, and action required. Information should be brief, formal and precise. Request communications to support staff should have a clearly stated purpose, required actions, and timeframe for implementation.

Particular care should be exercised in routing of internal communications. The principal impediment in effective written communications, after unclear content, is found in the inability of documents to promptly reach their desired destination. That destination should be viewed as the individual required to initiate action as a result of the communication and not as the department or managerial hierarchy. Wherever possible, a feedback check of initiated actions should be incorporated if those actions would not normally manifest themselves for some time but are critical to project success.

Appendix D Logistics

LOGISTICS

Introduction

Logistics are the Who, What, Where, When and Why indicated in the management model. These simple management questions become the preparatory key to determining the "go" field projects. Initial consideration of logistics becomes the transition phase between project planning and final project modification in the light of changing conditions over the elapsed period between planning and implementation. Seasonal weather fluctuation, unusual vegetation growth patterns, unplanned or unknown electrical system changes, previous project delays, delivery or availability problems, budget alterations and government restrictions are external causative factors in plan modification.

Once past the financial approval stage the individual program projects can be readied for implementation. Individual staff are assigned, the site specific task methods determined, and detailed maps, air photos or location plans finalized.

Timing and scheduling of equipment, supplies, staff and support services are now required. Tasks and emphasis will obviously change depending on the decision for "in-house" or contract work, but a mobilization phase should be viewed as essential in both cases.

Finally, the program manager should conduct a pre-project review to reexamine rationale. This should not require extensive time or effort, particularly if the planning and project development stages have progressed logically. Such a stage is suggested as a last reexamination step to ensure that individual projects meet the fundamental objectives of the vegetation management program and that this justifiability has not been clouded by subtle change as condition and content evolved.

Following the general audit of projects, appraisal and assignment of individual project requirements and notification of support services, the management theme must become largely field oriented for each project. Decision and authority levels now rest more directly with field foreman and their direct supervisors who are often not part of the Vegetation Management Group in a decentralized system. It is at this stage that a vegetation management program becomes most vulnerable. Procedures must leave little opportunity for misinterpretation while retaining sufficient flexibility to allow effective implementation. Project command must be vested in sensitive, well trained, alert staff. The managerial communication climate must be one of receptiveness and provide rapid, informed response to field problems.

In order to provide a framework for field project staff, four distinct stages of review are suggested in this chapter in order to identify potential problems and provide corrective solutions.

Project Pre-Job Conferences

A project is the logical combination of a number of tasks either of like nature or more commonly in a contagious geographical area. Projects should not be confused with programs which are broader based entities as in a vegetation management "program." A number of integrative planning requirements must be settled at the project pre-job stage. Since most utilities and/or contractors have limited resources in terms of men and machinery, it is necessary to set realistic limits on project size and to program the availability of staff and equipment well in advance. This is particularly true of those utilities working on a shared pool system for equipment or where equipment is multipurpose as in the case of timberskidder prime movers, used for tree trimming in winter and as spray vehicles in the summer. Equipment scheduling requires time for annual maintenance and testing. This is particularly true of large mechanical mowing or chipping equipment which may need magnaflux crack analysis to detect incipient metal fatigue and major overhaul, or spray equipment which may need pump testing, pressure and nozzle calibration.

Project pre-job conferences should document the necessary critical path (CP) planning or time horizons and the system responses needed. For example, chemical ordering, staff training and certification, and equipment availability must be determined. From this process, appropriate seasonal task method alternative choices, and proposed project sizes will come an assessment of time frame. Once the groundwork needs and timing have been established, it is possible to log and prepare the information entities discussed previously under communication. Depending again on program size and complexity, project pre-job conferences may be formal or simple discussions. It is unlikely that a single meeting will suffice and two stages appear to warrant attention. At the conceptual stage, when the basic source data is assembled which indicates need, a project plan should be established. At the formative stage, once the project is approved the more complete planning should evolve.

Pre-job conferences will normally involve the field crew foreman and the district level vegetation manager. Also included may be local level support staff if a project is of a continuing nature over a number of months. The local stores supervisor, safety officers and land representative may benefit from discussion of a project and conversely may contribute information on prevailing circumstances from their perspective. Formality of special meetings may not be necessary as local level department head meetings may act as an information vehicle for internal communication. Vegetation managers at all levels should impress upon other elements of their utility that vegetation management tasks are unique in the array of contacts and potential impacts involved in executing their mission. With the exception of those groups directly involved in new plant impact studies, no other group must react with such a broad spectrum of both internal and external contacts. Pre-job conferences are, then, an important aid in soliciting and synthesizing intimate local knowledge of prevailing conditions.

Job Site Setups

The economics of most tasks are governed in large part by labour costs. Effective working time on the job may seriously effect the unit cost, productivity obviously rising with the increased manhours available. Travel time is the most serious factor in eroding available manhours. It becomes evident that choice of locations for both major programs or site specific projects must be responsive to the desire for efficient management. Where possible an in-depth analysis of job start locations, union stipulations and work efficiency should determine the appropriate course. Outside contracts should be considered for jobs far removed from permanent staff home bases.

Efficiency of operations is also an important consideration in selecting job sites. Here, right-of-way width and mileage, terrain and availability of access, ground conditions, equipment capabilities, fuel consumption, vegetation density, size, and occurrence, are all important. Choice of task method alternative will also dictate various requirements which influence job site setup. Foliar herbicide applications require both chemical supplies and carrier, often water. Caches for herbicide and adequate provision of tanker supplies of water or identification of suitable water sources is necessary. In the case of mechanical equipment, particularly that used for brush cutting which often causes repetitive unscheduled down time, provision must be made for services and repair.

Supplies of fuel and like materials should be strategically located but care in placement and storage is needed to prevent theft. Likewise equipment should be parked away from ready sight to discourage vandalism. With contentious operations, notwithstanding their validity, equipment and personnel should be no more evident than necessary.

Environmental and aesthetic concerns should be considered in job-site selection. Disposal of containers and refuse should be carefully undertaken. Spills of fuel, oil, or herbicides should receive prompt attention and equipment and materials should be available in order to ensure that this is possible. (Where required in law or of sufficient size, spills should be rapidly reported to government agencies.) Parking of equipment and service vehicles should not impede access for emergency or routine service of other plant or personnel on the right-of-way. Parking of equipment at night should satisfy the criteria of safe distance for fire protection and discourage vandalism. Supplies should be secure from human, weather, or sildlife disturbance.

Finally, thought should be given to a job-site layout. Adequate spacing should exist between different stores and turnaround and access should satisfy simple time-study principles.

Work Site Pre-Job Conferences

These brief informal meetings, often referred to as "tailboard" meetings are intended as a final review before work proceeds. These are particularly important at the beginning of a new season when good work habits have been dulled by time and when unskilled additional staff are engaged for seasonal employment. Such meetings should ideally be held at the beginning of a new task or at any major new location and should involve the appropriate level vegetation manager, the crew foreman and the crew. An understanding of the objectives and method or methods to be employed, must be clear. Those environmental and work hazards likely to be encountered on the job should be discussed. Government stipulations and legal obligations should be reviewed. The balance between safety and productivity must be clearly stated.

Finally the public relations aspect of work quality, reasonable appearance, and pleasant manner should be stressed.

Assessment of Hazards

Assessment of hazards may be examined under four subheadings: Job Safety, Environmental Safety, Season, and Information Sources. Extensive literature exists concerning job safety and most utilities have a detailed Safety Code, carry out a program of safety training or accident prevention and are regulated by Federal, State or Provincial regulations. There are, however, a number of direct hazards which exist in right-of-way field operations which should be borne in mind.

Dangerous ground conditions prevail in many areas since transmission lines traverse wide varieties of topography. Extremes of ground condition, including adverse slopes, rock, swamp, and areas subject to pot-holing are all potentially unsafe both for the employees and equipment. Dangerous equipment is an inherent hazard in many vegetation control operations. Tools or equipment intended for cutting, spraying, grubbing, or crushing undesirable plants are by their very nature, hazardous. Every effort should be made to ensure equipment is safe in design. Any equipment is of course only as efficient and safe as the owner and operator wishes to maintain it (Gardner 1975). Protective clothing appropriate to certain hazardous operations were once poorly available and little used. With the advent of extensive regulations, the pendulum has swung the other way with workers almost burdened with precautions. Recent statistics and occupational health findings by the Occupational Health and Safety Administration (OHSA) in the United States and the Workman's Compensation Boards (WCB) in Canada, however, strongly endorse the need for employee protection from noise, cutting, crushing and falling accidents. The provision of first aid supplies, training and evacuation procedures should be prerequisite for all tasks, especially in isolated locations. Staff should not undertake, or be required to undertake, hazardous operations on their own.

Great care is required in geographic areas where stinging or biting insects, poisonous snakes and poisonous or puncturing vegetation are known to infest rights-of-way. Crews should be given adequate warning and be alert for such hazards and to be particularly careful where dangerous wildlife may occur especially during the period when young are reared. During hunting season, "Work in Progress" signs should be posted on right-of-way access and staff cautioned to wear high visibility jackets.

Fire hazards are present on almost every right-of-way operation. Gasoline powered engines require care and adherence to the rules governing safe handling of gasoline. Fueling large equipment under transmission lines is not recommended. Where unavoidable, equipment must be grounded. Dormant herbicide operations using fuel oil as a carrier requires explicit safeguards against fire (McPhail 1967). Oil-soaked protective clothing and equipment constitute both a fire hazard and unsafe footing. Good housekeeping and anti-skid materials can reduce these hazards greatly. The potential for burns from hot equipment, hydraulic oil and breaktime fires should be recognized.

Environmental safety, unlike job safety, is concerned with the impact of the job on the surrounding area rather than on the worker himself. Of primary concern are those elements of the environment particularly sensitive to disturbance and which have little or no capability for recovery. It is possible that, despite all the planning design, impact analysis, reports, promises and public relations, to then destroy, perhaps irreparably, areas of unique vegetation, the stability of some soils and the purity of some water courses.

Transient effects are also possible but may visit substantial hardship on wildlife or adjacent landowners.

A legitimate concern often voiced is the impact of maintenance on drinking water quality and on fish bearing waters. Care should be taken to document and protect water resources on the right-of-way.

The hazards associated with removal of vital wildlife habitat, disturbance on the right-of-way during nesting and ungulate calving (Wan 1975) and herbicide operations which may injure or destroy bees (Hachey 1975), sensitive crops, Table VIII, or enhance the palatability of poisonous vegetation to livestock (Stahler 1950, Lynn 1952, Grigsby 1952, Frank 1957, MacLean 1970a, 1970b) should all be considered prior to and during the execution of projects.

Information sources for the assessment of work hazards may also be separated into those appropriate to job safety and those primarily concerned with environmental protection. Job safety practices should be contained in the task Safety Practices Manual discussed in the section on Support Documents. In addition, training workshops and safety meetings should promote worker safety awareness. Safety newsletters and accident statistics should be readily available.

Environmental safety should be embodied in the guidelines and task methods employed. Where necessary, clear standards should be prepared, circulated and understood by field staff both permanent and temporary. Where contract staff are engaged, contract documents must clearly stipulate requirements for environmental protection. Since many vegetation management programs, and in particular those employing herbicides, are reviewed by various regulatory agencies, it may be that hazard information is provided in the Permission to Spray (Heskin 1975).

TABLE VIII HAZARDS : CROP AND HORTICULTURAL PLANTS SUSCEPTIBLE TO HERBICIDE SPRAY DRIFT

TOBACCO

TOMATOES

GRAPES

BEANS AND PEAS

ALL CLOVERS

PEPPERS

CARROTS TURNIPS CAULIFLOWER CABBAGE SUGAR BEETS

CEREAL CROPS - OATS BUCKWHEAT AND FLAX

ANNUAL FLOWERS

ORNAMENTAL SHRUBS

ORCHARD TREES - CHERRIES PEACHES AND PEARS

Brush burning operations must observe the appropriate Forest Service rules and should be considered as a serious risk. Fire fighting equipment should be carried or available when appropriate.

Radio contact with control dispatches should be maintained whenever there is potential for fire, serious bodily injury, emergency evacuation, or where electrical service interruption may occur from reclearing operations. In this latter case, every effort should be made to have lines deenergized if a conductor strike is possible. Lastly there are two additional important sources of information concerning environmental safety. The utility should maintain updated historical profiles and possibly aerial photography as discussed in the section on Historical Profiles. Further, the easement agreements and multiple use agreements, which will increasingly become a function of right-of-way management, should contain details of potential hazards.

A factor which has a profound influence on the degree of hazard associated with utility rights-of-way maintenance in that of seasonability. Winter operations, though posing less risk of environmental impact, increase the potential for worker injury, while other hazards are heightened during spring or summer periods. Projects should be planned with worker safety as a prime consideration and adequate provision made for response in emergencies.

Appendix E Research and Development

RESEARCH AND DEVELOPMENT

Introduction

In order to sustain a viable vegetation management program it is necessary to establish a research and development capability. Irrespective of program size, program improvement should be a basic objective. New practices, equipment, materials, scientific knowledge, data management systems, and administrative hardware are constantly reported in the literature. Applicability of new information in light of program needs should be examined and where appropriate, field tested (McPhail 1971).

It should not be implied that program improvement should only respond to external knowledge. The scale of internal research and development may range from the innovative vegetation manager reading a few articles and initiating a moderate field trial based on his own and other utility experience, to an advanced research program of basic and applied projects conducted jointly between a vegetation management group and a research support service.

Although research and development are suggested as essential ingredients in a vegetation management program, it should not be conducted as an aside to daily responsibilities, as a favour to suppliers or in a haphazard manner. It must be an integral part of program planning, have clearly identified objectives and respond to rigorous protocols. Documentation of existing conditions, application of the method and materials, collection and interpretation of results, and use in the context of program improvement should be supported by statistically and economically sound procedures. Every effort should be made to establish research and development projects on a term appropriate to the study concern and to dedicate the staff and resources to both follow through and follow up. All too often vegetation management research projects are started and ongoing evaluations not considered. Despite the continuous nature of vegetation growth and even where research conclusions are implemented, adequate provisions are not made to follow the validity of these findings over a period of years on a system wide basis. In this way it is possible for practices or materials of dubious merit to become established and enjoy continuing use with little scrutiny. If a diversity of task method alternatives and geographic locations do not exist, it is not possible, even with accurate records, to evaluate a method by comparison with others. It would seem that poor record keeping and inadequate monitoring of existing vegetation management methods after introduction are largely responsible for the static, conservative nature of many utility vegetation programs.

Five separate areas of right-of-way vegetation management investigation are recommended: Materials, Machinery, Methods, Multiple Use and those which do not directly fit these categories - Miscellaneous.

Materials

Applied research to establish efficiency, degradation, and environmental impact of the range of new selective and non-selective herbicides registered for right-of-way application has not been undertaken on a consistent basis amongst utilities. In some cases, development work carried out by chemical companies in conjunction with utility users has not been followed up or has been undertaken using inadequate research protocol and statistical design (Gardner 1975).

Variability, as a result of application technique, season, soil type, target species and density, ambient meteorological conditions, formulations and rate has not been adequately documented.

Routes of entry into the environment, long and short term consequences, metabolism, degradation rates and potential for selecting resistant bio-types remains to be quantified for many chemicals. Little or no recent work has been carried out by utilities into the many drift control agents, stickers and adjuvants (Woodgerd 1976). Penetrating agents and translocation modifiers require further study, as do the variants of formulation and carrier, in terms of both effectiveness and environmental impact. In particular, the impact on non-target organisms as a result of broadcast right-of-way herbicide projects should be clearly documented and published. Effect on pollinators, aquatic organisms, and enhancement of toxic properties in browse species (Grigsby 1952, Lynn 1952) are candidate topics often raised and apparently remain unanswered (Horstman 1977). Narrow spectrum herbicides, seedicides (Day 1967), product combinations and split applications should be investigated. With the exception of Krenite (Dupont 1975, Stevenson 1975, Niehuss 1974, Chappell 1976) it appears that no concerted effort has been made to assess the potential of growth regulators to replace herbicides in some programs.

On the other hand, sufficient information is not yet available about selective retention or establishment of desirable vegetation on rights-of-way. Chemicals which enhance woody shrub seed germination, suppress transpiration and evaporation loss while moving large trees, fertilizers, soil amendments, and materials which retard or prevent erosion, warrant further investigation.

Insufficient emphasis has been given to accomplishing the transition from initial research to field practice (Crafts 1967). Materials technology outpaces the vegetation manager's abilities to test and assess products. Manufacturer's field plots and regulatory agency efficacy testing cannot substitute for large field scale trials for the unique rights-of-way circumstance. Utility research cooperatives, pooling resources and expertise to answer common problems in similar bioclimatic regions should replace the present emphasis on independent and consequently uncoordinated research. Interested utilities should consider formation of a centralized right-of-way management information library system (ROWMILS).

The final responsibility for the safe introduction of synthetic chemicals into the environment rests with the user. Inappropriate or unsafe use can negate all effort at developing a "safe" compound. Carvell (1973) suggests that the controversy over herbicide use (often fought in the forum debating utility practices) has curtailed the agrochemical industries' involvement in herbicide development. It would seem good practice to ward against eventual denial of all chemical tools for vegetation management by developing products and practices which refute unfounded scientific and public criticism.

Machinery

Heavy equipment and hand tools specifically designed for vegetation management have undergone rapid development in the last decade. Hydraulics, hydrostatics, and metallurgy have allowed new applications of energy and light-weight materials. Present day timber skidders and chainsaws are two eminent examples.

Herbicide application equipment has been developed or adapted by utility companies and their contractors. Basic requirements for such equipment are that it minimizes drift, whether application is liquid, pellet, or powder, and that it maintains accurate delivery rates evenly at the target area. These premises are generally true irrespective of ground or aerial application, broadcast or spot treatment. With the notable exception of Amchem (Microfoil boom, Directa Spray Nozzles) few chemical companies have addressed the problem of application equipment.

Efficiency of equipment will be reflected in ability to traverse various terrain types with load capacity appropriate to project size, except where equipment is developed explicitly for level ground application, as in roadside truck mounted boom sprayers. Equipment should be versatile, yet developed with its expected work clearly in mind. Demountable units require intensified development, allowing the prime mover to be adapted for a variety of purposes. McPhail (1976) suggests that there is a need to develop air cushion vehicles for soft ground, while Baribeau (1976) expressed a need for improved equipment to apply pellets and mechanical brush cutters which will work all year round. Peters (1976) notes a need for snowmobile mounted seeding equipment.

Equipment safety research would appear important, but is not discussed in the utility vegetation management literature. The continuing emphasis on mechanical cutting by machine or hand tools with their attendant danger of operation injury bears further investigation at least to develop a data base on frequency and type of injury specific to right-of-way operations.

Development of criteria for work study analysis of equipment productivity, and for assessing durability and down time appear necessary to allow equatable comparison of equipment within or available to the utility industry. Design and experience sharing should find a concrete vehicle for expression between and within companies as suggested in the management information library.

In summary, lack of uniform research, identification of needs, and few mechanisms for directly sharing information characterize the present weakness in equipment or tool research and development for utility vegetation management operations.

Methods

A wide variety of methods have been developed to meet individual needs in the field of utility vegetation management. Despite the existance of possibly 3,000 utilities in North America with rights-of-way carrying high or extra high voltage transmission lines, barely a handful of authors have consistently published their experiences and documented their method failures and successes.

A more detailed understanding is required of the benefit/risk and benefit/cost techniques of appraising vegetation control methods. Criteria are required for comparison of task methods and for comparison of technique alternatives within task methods. "Cost" effectiveness must be judged over decades rather than over years, and tested against the objectives of management, as well as against an economic scale.

Administrative and vegetation management theory is, in general, poorly elucidated. The application of sophisticated game plans, strategies, and right-of-way management plans must attend the future of right-of-way development. Automation of data acquisition and synthesis, computerization of data handling, storage and retrieval, and utilization of low impact technology will dominate the field of research and development into new methods. Such an embrace must not, however, ignore the apparent inability of existing systems to adapt quickly and new technology to make the quantum leap from genesis to application. Overcoming man's reticence to respond to innovation must be recognized as an integral step in the search for, and application of new methods.

Multiple Use

Much has been written about the benefits of multiple us of rights-of-way (Carvell 1973, Randell 1973, Young 1970). Much remains to be written. The compatability of differing utilities within the common corridor concept requires functional and aesthetic validation. The incompatability between conflicting multiple use values, as in wildlife habitat enhancement but unrestricted hunting access, require documentation and resolution. Physical impact of some multiple use as in recreational vehicle erosion on right-of-way integrity require more detailed examination.

The productive capacity of rights-of-way to produce food and fibre (Popovinnkoff 1976) will become increasingly apparent before the beginning of the 21st century as energy input analysis will demand a higher yield of return for resources expended.

Miscellaneous

Some basic biological, social and managerial research needs are evident from an assessment of existing vegetation management programs. Too little is yet known about successional development on rights-of-way after initial clearing and the most appropriate maintenance practices which should subsequently follow. The relationship between restoration planting after clearing and subsequent maintenance requires clearer definition. The seed production and establishment of native species and the appropriateness of various species has been barely started.

Interaction with the public and inter and intra utility communications requires improvement. Mechanisms to facilitate improved communications are yet ill-defined despite rapid advances in media technology.

Intensified regional planning will require right-of-way incorporation into detailed land use plans as urban centres expand. Right-of-way managers will require a broader spectrum of skills and understanding. The era of the generalists and integrationalist will and is replacing the era of the narrow specialists and individualists. This should not indicate an erosion of the creative and innovative toward the insensate, rather the emphasis will be for excellence of concept with greater universiality of application.

The vegetation manager of the future will require training and experience far broader than at present. An integration of biological and social sciences must form a fundamental educational grounding on which to build an array of Managerial Skills. Considerable research remains in order to establish the market needs for vegetation and right-of-way managers and the basic curriculum appropriate to their training for the future.

Appendix F Non-Electrical Right-of-Way Maintenance Tasks

Re-clearing

Bulldozing

Scarifying

Stump Removal

Burning

Seeding

Right-of-way inspection and policing of easements

Multiple land user supervision

Erosion observation, control and maintenance

Stream observation, control and maintenance

Rubbish collection and disposal

Sign placement and maintenance

Fence and building grounding

Fence and gate construction and repair

Danger tree determination and removal

Woody 'brush' cutting - machine

Woody 'brush' cutting - hand

Woody 'brush' spraying

Woody 'brush' chemical treatment - other

Water crossing construction and maintenance

Water crossing repair

Helicopter landing site clearing and maintenance

Road crossing screening

Road crossing pruning

Selective cutting maintenance

Chipping of debris

Recreational facility servicing

Tower inspection

Tower painting

Insulator washing

Noxious weed spraying

Noxious weed chemical treatment - other

Grass cutting - machine

Grass cutting - hand

Grass growth control - chemical

Insect and rodent control

Pole treatment

Liaison with property owners

Applied research and development
- material
- equipment
- techniques

Appendix G Example Task Method Breakdown

Task - undesirable 'brush' growth control

Location - transmission rights-of-way

Method - selective herbicides

- Herbicide categories -

selective	growth regulator	non-selective

Task requires - selective woody growth control = Selective Herbicide

Technique used -
dictated by: environmental consideration, safety, public pressure, aesthetics, crop proximity, time of year, density, % and height of undesirable vegetation, accessibility and topography, equipment availability and operator skill, experience, cost

Dormant	Stem Foliage	Pellets

Specific chemical choice -
dictated by: weed species, label recommendations, Provincial recommendations, cost, packaging, toxicity, climate, applicator training, equipment available, chemical characteristics, past research and experience

Type -
dictated by:
formulation, active ingredient %, need for additives or carrier, odour, effect of temperature, efficacy, resistance, solubility, experience

active ingredient %, size, type of carrier, shape

Rate -
dictated by: label recommendations, Provincial recommendations, own research and experience, cost, density of undesirable species, % of resistant species, % control desired

Application technique used -
dictated by: weed density, size of area, topography, line protection priority, equipment and operator skill

- Application categories -

Dormant	Stem Foliage	Pellets
Spot	broadcast or spot	broadcast or spot

Application method -
dictated by: weed density, availability of equipment, operator skill, the preceeding criteria

Spot	broadcast			broadcast		
	air	or	ground	air	or	ground
hydraulic sprayer, mist blower, knapsack sprayer -mechanical or hand backpack dribble bar hand sprayer	thickened of microfoil boom		hydraulic sprayer invert emulsion sprayer	centrifical venturi		mechanical or hand centrifical throw bar spreader mist blower

Appendix H Bonneville Power Manual on Right-of-Way Inventory

BPA Manual on R/W Inventory

Functions and Implementation

A total management system requires a total inventory. To assure ourselves of a full understanding and uniform application of the inventory method for the entire Bonneville Power System, a standard procedure has been devised which will satisfy the needs and conditions of the system and each Area.

The Inventory Program and its adaptation to the ADP system makes possible a multitude of uses. Some of these uses are:

(1) Budget preparation.
(2) Planning and Programming.
    a. Scheduling.
    b. Determining method or techniques from "what's there".
    c. Furnish data for contracts.
(3) Location of problem areas.
(4) Use in developing multiple right-of-way uses.
(5) Provide answers to statistical questions such as how much where (ownership, vegetation, critical areas, etc., by Line, District, Area).
(6) Miscellaneous facility data.
(7) Summary data for reports such as "Environmental Impact Statements".
(8) Detailed analytical studies such as growth predictions resulting in identification of problem areas.

It is recognized that the compilation of this inventory is no small task. It will involve many hours of field work, office time and computer time. It will require new tools to improve and expedite the process. To satisfactorily serve the purposes of the inventory the Right-of-Way Maintenance Specialists will have photos, type maps and computer data available to be used in combination.

Continual updating of the right-of-way inventory including the addition of new facilities is a basic requirement. The concepts which have been developed were devised with this need in mind.

The updating procedure is designed to not only provide a view of the current status of the rights-of-way but also a historical record. Only with such a record can we fully analyze the effectiveness of the Right-of-Way Management and Maintenance program.

No specific procedures will be established as to the collection of inventory data. Photos and maps are to be used to a great extent and field work generally to confirm photo and map interpretation. Recording of data for computer application will be precise and performed by a predetermined procedure. Each Area will establish a priority for the order in which rights-of-way will be inventoried. The same priority will be used to set up a schedule for the necessary photography. Mapping procedures will be standardized and are set forth in Section II. Definition of terms is found in Section IV.

To make the inventory, recording the data, flexibility for data use and ready availability of data, the procedures for taking the inventory are controlled for computer application. In the process of development, coordination and uniformity with other systems was of particular concern. As a result, some format has been adopted from BLM and USFS procedures.

During the early stages of development of the inventory system the hope had been to control the data by the tract identification as used by the Branch of Land. After much study and interchange of ideas it was determined that "tract identification" created a degree of inflexibility that was not compatible with the desired uses of the inventory. The decision was made that the basic unit to be inventoried will be the "span", the starting point being a structure and ending at the next structure ahead-on-line. The unit is fixed in that it is always one span but flexible in that it accommodates both the variable widths of the rights-of-way and the variable lengths of the spans. The section on "treatment data" is patterned after the program developed by the Portland Area. In addition to the computer application of the inventory system, certain other procedures have been developed for office and field use of the program.

The major tools of the inventory program are the photos, graphic aids such as maps and the computer program.

A. Graphic data will be recorded in several ways. Data considered to be permanent can be recorded on the working photo maps. Reproduction of these will be made for field use whether it be for gathering of inventory data, for BPA crew use in assignment of right-of-way work or for use by Contractors in vegetation control work.

   Scale of the photo maps will be retained at the present scale of 1" to 400'. Photo maps are compiled on the basis of providing a pictorial facsimile of the right-of-way and therefore are not photogrammetrically correct. The error in scale is negligible over short distances and can generally be ignored.

   Plan and Profile maps are still of utmost value as information is contained on them not available on the photo maps.

   Data to be mapped will consist of vegetation types, species land use, critical areas, water courses and restricted areas. A full tabulation of inventory data to be recorded in graphic form is included in Section I. Mapping keys and symbols are illustrated in Section III. Certain data will be identified on the map in the identical manner that it is recorded for the computer program and is included in the description of the computer program.

B. Photography suitable to serve the inventory system is the key to the program. After serious consideration of the available photography, the decision was to use the 1" to 1000' color which is presently being developed. This type has versatility for other uses now in progress. These are DT analysis, photo-maps and reconnaissance of possible parallel new constructicn. The present priority of scheduled photography for DT analysis complements the needed photography to initiate the inventory program.

It is also possible to reduce cost of photography by incorporation of existing black and white photos into the inventory process. Some equipment will be necessary to provide the means of transferring photo data accurately and rapidly to the base maps.

C. Computer application provides the means of extracting inventory data in a usable form. To assure the uniformity of data collection, recording and interpretation for management purposes all data has been strictly coded and defined. Slightly modified has been the coding developed by the Portland Area for the segment of treatment data. The inventory listing in Section I has been developed on a broad scale so as to encompass the multitude of situations that exist within the system. By the proper selection of the specific data an accurate inventory will result with little error for interpretation.

There has been some testing and thorough review of the cards on which the data will be recorded. A sample is attached in Section II, which also includes the coding which will be used to record the inventory data.

The program is designed to extract for compilation any particular data desired by line, district, Area, or any combination, up to system totals. Section I contains definitions of all terminology used in the inventory system. This includes that used for mapping and computer programming. These definitions should preclude any misunderstanding of the terminology meaning or misuse of the terminology.

To maintain uniformity of the system contact between Areas and the computer programmer will be through the Branch of Maintenance, Right-of-Way Management Specialist. Proposals for changes, additions or deletions will be submitted to the Branch for consideration and implementation. The entire Inventory program will be published as a separate chapter of the Right-of-Way Management Standards handbook.

One of the principal features of the inventory system will be the capability of providing an historical record. This will be of particular use in evaluating the effectiveness of the vegetation management.

In the following sections the various functional aspects of the inventory system are described.

BPA Manual, R/W Inventory

Section I. Sets out the inventory data in the order that it appears on the computer coding form. Under each numbered data items are shown the numerous categories of data that will be specifically identified. The last page of this section is a copy of the coding form. This section also includes a brief description of each data item.

Section II. The data again is listed in the order in which it appears on the coding form. In this section the exact coding of all data is shown. Coding requires a very specific vocabulary to be applied in a very legible manner.

Section III. Contains all the necessary mapping data; keys, symbols and aids. Most of this data is self-explanatory.

Section IV. Sets out the mapping procedures that will provide the reliable data source necessary to the success of the inventory program.

Section V. Briefly sets out procedures and guidelines for the proper use of the inventory data sheet.

Appendix I Daily Vegetation Control Record

DATE
REVISION

USE OR APPLICATION OF HERBICIDE
DAILY VEGETATION CONTROL RECORD

PAGE 1 OF 1
INDEX

D75-251

REGION ____________
DISTRICT ____________
LOCATION ____________
FROM/TO ____________
LINE ____________
STATION ____________
OTHER ____________

PREPARED BY INDUST. ENGRG.

NO.	ITEM	REMARKS
A	ENVIRONMENT DATA	
1	TARGET SPECIES AND DENSITY	____ ____% ____ ____% ____ ____% ____ ____% ____ ____% ____ ____%
2	TOPOGRAPHY	____ TERRAIN ____ SLOPE
3	PREDOMINANT SOIL TYPES	____ ____ ____
4	PREDOMINANT SOIL MOISTURE	____
5	DRAINAGE FEATURES	____ ____ ____
6	WATER BODIES	____ ____ ____
7	STIPULATED PRECAUTIONS FROM PERMIT FOR THIS DATE	____
8	HAZARDS FROM PRE-JOB CONFERENCE FOR THIS DATE	____
B	CLIMATIC DATA	0900 HRS. / 1200 HRS. / 1500 HRS.
1	WIND SPEED	____ MPH ____ MPH ____ MPH
2	WIND DIRECTION	____ DIR. ____ DIR. ____ DIR.
3	HUMIDITY	____% ____% ____%
4	TEMPERATURE	____ MAX. °F
5	PRECIPITATION	____ BEFORE/AFTER ____
C	HERBICIDE DATA	HERBICIDE NO. 1 / HERBICIDE NO. 2
1	HERBICIDE NAME COMMON OR PRODUCT CHEMICAL	____ ____
2	PCP REGISTRATION NUMBER	____ ____
3	CARRIER NAME	____ ____
4	HERBICIDE TO CARRIER RATIO	____ ____
5	TOTAL MIXTURE APPLIED	____ ____
6	TOTAL ACRES TREATED	____ ____
7	RATE/ACRE OF MIXTURE APPLIED	____ ____
8	ACTIVE INGREDIENT PER ACRE	____ ____
9	APPLICATION METHOD	____ ____

REMARKS:

DATE ____________
SUPERVISOR'S SIGNATURE ____________
APPLICATOR'S SIGNATURE ____________
APPLICATOR'S CERTIFICATE NO. ____________

BCH & PA OPERATIONS ENGINEERING DIVISION — STRUCTURES DEPARTMENT

D75-251

USE OR APPLICATION OF HERBICIDE REPORT GUIDE

NO.	ITEM	REMARKS
A	ENVIRONMENT DATA	
1	TARGET SPECIES AND DENSITY	NAME MAJOR SPECIES AND PERCENT TO BE CONTROLLED.
2	TOPOGRAPHY	RECORD TERRAIN IN AS FLAT, ROLLING OR MOUNTAINOUS. RECORD SLOPE AS LEVEL, MODERATE OR SEVERE.
3	PREDOMINANT SOIL TYPES	RECORD AS ROCKY, GRAVELLY, SANDY, CLAY, LOAMY OR PEAT.
4	PREDOMINANT SOIL MOISTURE	RECORD AS WET, DAMP OR DRY.
5	DRAINAGE FEATURES	NAME ALL RIVERS AND STREAMS IN OR NEAR TREATED AREA.
6	WATER BODIES	NAME ALL SLOUGHS, PONDS, LAKES IN OR NEAR TREATED AREA.
7	STIPULATED PRECAUTIONS FROM PERMIT FOR THIS DATE	RECORD ALL INSTRUCTIONS, CAUTIONS AND SUGGESTIONS. FROM B. C. PESTICIDE COMMITTEE OR FEDERAL E. P. AGENCY.
8	HAZARDS FROM PRE-JOB CONFERENCE FOR THIS DATE	RECORD ALL HAZARDS FROM PRE-JOB CONFERENCE NO NOTED IN ITEM A7, STIPULATED PRECAUTIONS.
B	CLIMATIC DATA	
1	WIND SPEED	RECORD WIND SPEED IN MPH. AT TIMES SPECIFIED.
2	WIND DIRECTION	RECORD WIND DIRECTION AT TIMES SPECIFIED.
3	HUMIDITY	USE STANDARD WET BULB METHOD.
4	TEMPERATURE	RECORD MAXIMUM TEMPERATURE FOR THIS DATE.
5	PRECIPITATION	RECORD AS HEAVY. MEDIUM. LIGHT AND CONTINUOUS OR SHOWERS. AND IF BEFORE OR AFTER APPLICATION.
C	HERBICIDE DATA	
1	HERBICIDE NAME	
	COMMON OR PRODUCT	RECORD COMMON NAME OR PRODUCT NAME FROM CONTAINER.
	CHEMICAL	RECORD FORMULATION AND PERCENT ACTIVE INGREDIENT BY WEIGHT.
2	PCP. REGISTRATION NUMBER	RECORD PEST CONTROL REGISTRATION NUMBER.
3	CARRIER USED	ALSO INCLUDE ANY STICKER, EMULSIFIER OR SPREADING AGENT.
4	HERBICIDE TO CARRIER RATIO	RECORD RATIO OF ACTIVE INGREDIENT TO CARRIER USED.
5	TOTAL MIXTURE APPLIED	RECORD TOTAL AMOUNT OF HERBICIDE MIXTURE APPLIED.
6	TOTAL ACRES TREATED	RECORD TOTAL ACRES TREATED.
7	RATE/ACRE OF MIXTURE APPLIED	CALCULATE RATE PER ACRE OF MIXTURE APPLIED.
8	ACTIVE INGREDIENT PER ACRE	CALCULATE ACTIVE INGREDIENT PER ACRE TREATED.
9	APPLICATION METHOD	RECORD APPLICATION METHOD AND EQUIPMENT USED.

Appendix J Policies and Procedures for Use of Pesticides

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY POLICIES AND PROCEDURES	PAGE 1 of 5	NUMBER EO-E1
	DATE 1 March 1976	

Subject: USE OF PESTICIDES

For further information apply to: Vegetation Management Supervisor
Structures Department
Operations Engineering Division

POLICY

Herbicides used by B. C. Hydro will accord with policy set by B. C. Hydro Directors and pertinent legislation.

This Policy applies to Contractors employed on authorized work as well as all B. C. Hydro staff.

NOTE: Provincial legislation may be changed as a result of the findings of the Royal Commission of Inquiry into the Use of Pesticides in British Columbia.

PROCEDURE

1. All proposed pesticide treatments, irrespective of size of program and whether undertaken by B. C. Hydro staff or a contractor, must be submitted on the appropriate form. Submissions, including maps clearly showing the location of the proposed treatment should be sent to the Interdepartmental Pesticide Committee and Environment Canada for prior approval. See Appendix A.

   In order to reduce the delay in processing applications, proposals should be forwarded to the regulatory agencies as soon as program needs are recognized. Programs applied for but not completed in the calendar year for which application was made must be applied for again the following calendar year.

This requirement includes:

A. Foliar application of herbicides on a broadcast or spot basis.

B. The use of pelletized herbicides, either on a broadcast treatment or scattered touch-up basis.

C. The use of either liquid or pellet soil sterilants.

D. The use of dormant sprays or treatments on exposed cut stumps.

E. The use of chemical mowing agents (desicants) for grass control.

F. The use of selective herbicides to control broadleaf weeds and grass in landscape plantings.

G. Insecticide treatments and treatments intended for the control of birds and vermin.

2. Only those pesticides registered under the Pest Control Products Act are authorized for use by B. C. Hydro personnel or by contractors. A schedule of Approved Chemicals and Formulations may be obtained from Vegetation Management.

3. Where it is necessary to carry out the work by contract the contractor shall be accredited under the Pharmacy Act of the Province of British Columbia.

4. Accurate records of all pesticide treatments should be made on form D75-251, (Appendix B), obtainable from Vegetation Management. In addition, a program summary sheet should be completed and any discrepancies between the size of the program applied for through the regulatory agencies, and the size of the program carried out should be clearly indicated. Surplus herbicide on hand should be clearly noted.

These summary sheets should be forwarded to the Vegetation Management Section as each program is completed.

5. Each herbicide application shall be supervised by a B. C. Hydro employee (or a contractor's employee) who holds a valid Non-Agricultural Non-Forestry Vegetation Control Pesticide Applicators Certificate. Other classes of certificates are not permitted except a Landscape and Garden Pest Abatement Certificate for insect control or weed control in landscaping.

The certified applicator must be present during the execution of the work. He must also be conversant with permit recommendations from both the Interdepartmental Pesticide Committee and Environment Canada for that specific job.

6. Each Provincial Regional District in which herbicides are to be used should be informed by letter early in the year of the herbicide program for the coming season. At the same time request a meeting between Hydro officials and their representatives, at their convenience, to provide further information on the program: its extent, timing, procedures, and rationale.

Wherever possible an attempt should be made to contact adjacent land-owners prior to commencement of the spraying to inform them that this work will be carried out. Care should be taken to determine if prior agreements have been made with Properties Division on easement property which specifically precludes the use of herbicides for brush control. Where disagreements arise which cannot be resolved at the Regional Divisional level, the matter should be referred to the Vegetation Supervisor. The Local or Regional District Councils, the Fish and Wildlife Office and the appropriate health unit must be informed of proposed programs not less than one month prior to intended start up date.

Particular care must be taken with stem foliage programs adjacent to susceptible crops and ornamental vegetation. Where possible it is recommended that dormant application be substituted for foliar application where the possibility of drift damage exists. The following is a partial list of susceptible plants of economic importance in British Columbia.

(a) Orchard trees, cherries, peaches, pears, etc.
(b) Grapes
(c) Tomatoes
(d) Peas and beans
(e) Carrots, turnips, cauliflower, cabbage and beets
(f) All clovers
(g) Annual Flowers
(h) Ornamental shrubs and trees.

7. Conditions of Spraying:

A. Water: Under no circumstances should herbicide drift, spillage, or leakage be allowed to enter into potable water. Extreme caution should be exercised in spraying low-lying areas which may fill with water during heavy run-offs. Specific recommendations for the protection of streams and other water bodies are normally contained in the recommendations from the regulatory agencies, which must be closely followed.

B. Wind: Extreme care should be exercised during any type of spray operation to ensure that no drift of spray solution is allowed off the area being treated. With any foliar spraying where susceptible crops or ornamental vegetation are nearby, any breeze, whether steady or gusting, shall be treated as hazardous. It shall be the responsibility of the applicator to exercise extreme caution under these conditions, and if considered necessary to suspend operations using aqueous or oil carriers. The adjustment of spray gun nozzles must always be maintained to produce a minimum of fine particles, and tank pressures should not exceed those which will cause fogging of the spray mix.

C. Height of Vegetation: Vegetation which is greater than 10 ft. in height shall not be chemically treated unless specific authorization has been obtained from the Divisional Manager or Head Office. Under no circumstances should vegetation over 10 ft. in height be sprayed and left standing in areas readily accessible to the general public. In addition, no dense vegetation greater than 3 ft. in height shall be sprayed on road sides.

As an alternative, vegetation should be mechanically cut and deciduous stumps treated to prevent re-suckering. Wherever practical, vegetation at road crossings in forested areas should not be sprayed in order to encourage natural screening of the right-of-way.

D. Permissible Spray Temperature: The effectiveness of translocated herbicide applications to control vegetation is dependent upon ambient temperature. In addition there is an increased risk of fire and volatization from herbicides at high temperatures. Listed below are the temperature ranges permissible for various types of spraying:

(i) Brush control:

- stem, foliar spraying	10°C to 27°C
- dormant spraying	-13°C to 30°C

(ii) Weed control:

	- lawn areas	10°C to 30°C
	- rights-of-way	10°C to 30°C
	- stump treatment - summer	10°C to 20°C
	- winter	-13°C to 20°C
(iii)	Insect control	5°C to 27°C

E. Storage: All pesticides should be stored in locked buildings, appropriately identified with a Chemical Storage Warning Notice. Buildings should be preferably dry, well-ventilated, fire-proof and frost-proof. Liquid herbicide concentrate should be stored in a separate area from wettable powders and pelletized formulations and drift control agents. Inflammable liquids of petroleum origin, such as solvents, diesel fuel, etc. should not be stored with pesticides. Wooden buildings should not be used for the storage of herbicides or their carriers.

F. Personal Hygiene: Although herbicides used by B. C. Hydro (with the exception of Gramoxone) are not considered to be hazardous to humans, every effort must be made not to contaminate clothing or equipment. Great care should be exercised with Gramoxone to ensure that no chemical comes in contact with other than the target area. Once sprayed this chemical is de-activated on contact with soil or vegetation.

If any pesticide is spilled on skin or clothing, the clothing should be removed and contaminated skin washed with soapy water. Avoid contaminating natural water sources. Clothing must be thoroughly cleaned before re-using. Where possible, arrange the program for each day to work up-wind of spray operations, working away from the area last treated.

G. Disposal: Under no circumstances should surplus herbicide, storage containers or packages be disposed of in such a way as to present a hazard to fish, wildlife, or human beings. Final spray operations should be arranged so that spray mix is appropriately used up. Small quantities of surplus herbicides, contaminated mop-up material, and surplus containers should be buried under 18" of soil in a location well away from ground water or drainage channels.

H. Safety: In addition to Items 5(a) Protection of Water, and 5(b) Drift Control, it shall be the specific responsibility of the licensed applicator on the job to supervise the following:

(a) Herbicide mixes shall be prepared at the rates applied for in the application to the regulatory agencies. Permission to use rates less than the specified rate must be cleared by the appropriate program supervisor. Under no circumstances should rates greater than the label recommendations for the herbicide in question be applied.

(b) No equipment shall be used on a weed control program where that equipment is not functioning in a reliable and safe manner.

(c) At no time shall herbicide concentrate or spray mix be decanted into any container other than one marked to specifically show its contents and bearing the appropriate hazard symbols.

(d) At no time shall spray equipment, herbicide or spray mix be left unattended in such a way that unauthorized personnel may have access to them.

(e) In the case of an operational mishap such as spills, overspray or potential environment damage, contact the Environmental Protection Service at 666-6711, or in the case of an emergency, call 666-6100 which can be reached 24 hours a day.

Manager, Operations
Engineering Division

Assistant General
Manager, Electrical Operations

General Manager

Appendix K Example Vegetation Management Job Description

62029 (front)
rev. 10-74

STEWARD
job identification data

title	total points	rating classification
TECHNICIAN - VEGETATION MANAGEMENT	365	63

group	occupation code	date
Engineering and Operations	330027	July 14, 1975

branch	department
Operations	Forestry

division (region)	section or unit
System Maintenance	Vegetation Management

title of immediate supervisor	occupation code
Senior Forester - Vegetation Management	723401

title of all jobs directly supervised	occupation codes

JOB FUNCTION

Assist others in the section by carrying out field assignments and performing a variety of technical analyses and evaluations on matters pertinent to vegetation management, such as, outage data, experimental line-clearing work, workload survey data, development of work practices and equipment, biological vegetation control and herbicides and growth retardants. Attend meetings and equipment demonstrations as requested. Prepare technical lesson material and act as back-up instructor in connection with the forestry training program. Assist in research and development of specialized tools, materials and equipment and participate in discussions with internal and external sources pertinent thereto. Participate in evaluations of contractors' resources and assessment of work done by them.

THIS DOCUMENT REPLACES THAT DATED APRIL 4, 1974, CODED 330027 AND TITLED TECHNICIAN - VEGETATION MANAGEMENT.

JOB DESCRIPTION

62030 (FRONT)
REV. 9-65

SHEET 1

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS	RATING CLASSIFICATION

1. Analyse outage data to determine from a forestry standpoint the reasons for outages from data gathered from Outage Reports and on-site investigations. Extract all pertinent data and analyse to determine reason for outages, such as, size and specie of vegetation doing the damage, and past maintenance practices. Associate with past outages in the area concerned to assist in identifying if outage is caused by a repetitious or unique fault. Prepare reports on findings and submit to appropriate section personnel for further study. Maintain all pertinent outage record data by region and area for reference purposes.

2. Participate in establishing line-clearing experiments and follow up on the evaluation of same to determine the value and benefits of extending line-clearing cycles, pruning techniques and the like. Receive assignments from Supervisor or other section personnel indicating area of concern, locality and other general data. Study assignment and decide on method of approach and schedule. Visit regional and field personnel to discuss and agree on suitable experimental sites and gain their cooperation. Coordinate the activities of field personnel and equipment and other staff services, such as Management Services Department, Safety Department, Customer Service Division and other concerned personnel. Initiate experiment and stay with it until either complete, or running smoothly. Visit areas from time to time to assess progress and keep assignment originator informed. Assess experiment upon completion considering such aspects as economics, outages, customer acceptance, public safety and prepare a report covering findings and recommendations. Submit to originator of assignment for review and further processing.

3. Participate with field personnel in the survey of workload to establish the manpower and equipment requirements to fulfill the area forestry needs. Receive assignments from Supervisor or other section personnel with a general outline of requirements. Study assignment and lay out sample plot locations on map. Contact field personnel to discuss program, obtain their concurrence and arrange for the necessary personnel and equipment. Visit field location and supervise and assist field personnel in surveying workload. Tabulate workload data in a suitable format and forward to assignment originator for review, analyses and finalizing.

JOB DESCRIPTION

62030 (FRONT)
REV. 9-65

SHEET 2

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS	RATING CLASSIFICATION

4. Instruct, as required, Forestry Tradesman both in the classroom and the field in specialized subject matter, such as, workload surveys, experimental line-clearing work, herbicide application and the like. Assist in the preparation of training material, present lectures, demonstrate various techniques and use of specialized tools and equipment. Act as back-up man to regular forestry instructor.

5. Assist others in the section, as assigned, in the research and development of specialized tools, materials and equipment pertaining to forestry operations and in the development of work practices and procedures pertinent thereto. Contribute from a practical standpoint, based on field trials and experience with similar equipment, any modifications that would result in an efficient, reliable, safe and economic operation. Arrange for assistance of field personnel during field trials and take over the field testing and development phase of the program. Work with Transport and Work Equipment Department personnel and suppliers' representatives on design and modifications.

6. Participate with others in the section, as assigned, in research and development work involving herbicides, growth retardants and biological brush control. Receive a general outline on the type of assignment, locality involved and other essential information. Study assignment, gather the necessary data and in conjunction with regional or area personnel select a desirable test plot. Arrange with area personnel for the application of chemical if a large area is considered and if a small area is chosen, in conjunction with assignment originator, mix and apply as necessary and tag and/or record species treated. Cooperate with chemical suppliers on matters associated with above. Inspect area after a predetermined time to assess the effectiveness of the program. Prepare report on findings and submit to assignment originator for consideration and further action.

7. Attend internal and external meetings associated with the section's activity and report on outcome of meeting. Attend forestry equipment demonstrations to become familiar with new equipment and make recommendations as required.

62030 (FRONT)
REV. 9-65

JOB DESCRIPTION

SHEET 3

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS	RATING CLASSIFICATION

8. Investigate field complaints, suggestions, new developments, etc, with regard to hand tools, small power tools, chippers, aerial lifts, pesticide application equipment, materials, etc. Work with appropriate Ontario Hydro personnel, suppliers and/or other outside contacts to resolve quality and supply problems to department's benefit.

9. Assist in the evaluation of contractors' resources and assessments of their work. Follow up on contract jobs to ensure standards are met. Recommend to Supervisor action needed to remedy substandard work performed by contractors.

10. Advise section head on field practicality of proposed policies and practices, of safety rule changes and matters dealing with the equipment, tools and materials of the trade. Participate in regional audits and provide input from a standpoint of quality of work, quality of tool and equipment maintenance, adherence to safety rules and general overall crew performance.

11. Perform other duties as required.

62028 (FRONT)
REV.12-65

JOB SPECIFICATION

SHEET 1

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS 365	RATING CLASSIFICATION 63

	DEG.	PTS.
EDUCATION - Requires a knowledge of business practices and procedures and a knowledge of forestry trades to assist in coordinating, collecting, analysing, evaluating and maintaining appropriate data associated with vegetation management covering such subjects as experimental line-clearing work, research and development involving herbicides and growth retardants, workload surveys and the like. Requires a knowledge of communicative skills, oral and written, to prepare clear concise reports, to converse intelligently with internal and external contacts, to prepare lesson material and instruct Forestry Tradesman. This knowledge is considered to be normally acquired in and equivalent to a Grade XII education in a secondary school plus additional short specialized training courses in appropriate subject.	4	72
EXPERIENCE - Requires experience in forestry or associated work to become familiar with the use, operation and maintenance of tools and equipment essential to forestry work, the use and application of herbicides and growth retardant chemicals, and the proper treatment of trees and underbrush pertaining to line clearing. Requires experience in analysing and evaluating a variety of subject matter pertinent to forestry management and preparing written reports on findings. Requires experience in preparing training material and instructing in methods, techniques and procedures. Requires experience on the job to become familiar with Ontario Hydro forestry methods and procedures, geographical locations, responsibilities of Head Office, regional and area personnel, internal and external contacts and to become generally familiar with the duties involved. A period of up to eight years is considered necessary to gain this experience.	8	91
DIFFICULTY OF SOLUTION OF WORK PROBLEMS - Difficulties are often encountered in deciding on a suitable site for line-clearing experiments and arranging for workload surveys. Requires gathering all essential data, analysing and assessing all requirements, discussing	3	45

CONTINUED ON SHEET 2

62028 (FRONT)
REV.12-65

JOB SPECIFICATION

SHEET 2

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS	RATING CLASSIFICATION

	DEG.	PTS.
various alternatives with regional and area personnel and based on findings, experience in handling similar circumstances, and a knowledge of the requirements decide on a course of action that will meet the needs, modifying as required to meet extenuating conditions.		
PHYSICAL FATIGUE - Requires performing some duties while seated at a desk with frequent visits to field locations requiring many periods of standing and walking, walking over rough terrain, handling reasonably heavy apparatus and testing, using and demonstrating forestry equipment.	3	14
MENTAL FATIGUE - Requires concentration for periods of varying duration, often in excess of one hour, while analysing outage data, while participating in line-clearing experiments and workload surveys and evaluations of same, in the development of equipment and work practices and in the application and development of herbicides and growth retardants.	3	20
RESPONSIBILITY FOR INDEPENDENT ACTION - Assignments are received from Supervisor or others in the section with a general outline in the requirements, locality and contacts involved. Requires studying assignments, gathering and reviewing all essential data, contacting internal and external sources and following assignments through to completion according to guidelines received and departmental policies. Requires keeping assignment originator informed of progress and seeking their guidance on unusual problems or matters not often encountered of a significant nature. Work is checked through discussions from time to time and the submission of reports on findings and recommendations.	3	40
RESPONSIBILITY FOR SUPERVISION - Requires assigning and checking work of personnel on loan from time to time while performing field forestry assignments.	2	14

CONTINUED ON SHEET 3

62028 (FRONT)
REV.12-65

JOB SPECIFICATION

SHEET 3

TITLE	CODE NUMBER	DATE
TECHNICIAN - VEGETATION MANAGEMENT	330027	July 14, 1975
	TOTAL POINTS	RATING CLASSIFICATION

	DEG.	PTS.
NUMBER SUPERVISED - Direct - 0 Indirect - 0	1	6
CONTACTS - Requires collaborating with regional and area personnel while investigating field complaints and on the utilization of appropriate equipment and manpower when arranging for the implementation or assessment of work programs, such as, workload surveys, equipment development and experimental programs. Requires contact with Transport and Work Equipment personnel and with representatives of government agencies and suppliers to discuss design, legislation, quality and delivery of vehicles and equipment and attempt to reach agreement on changes to meet Head Office and field requirements. Requires contact with contractors when evaluating their resources and assessing their work.	3	24
RESPONSIBILITY FOR ACCURACY - Errors in analysing outage data or while participating in the setting up and evaluation of forestry experiments, development and work survey programs may be difficult to detect in the early stages resulting in senior personnel utilizing such data in establishing programs across the province and reaching conclusions that could be erroneous. Such errors when discovered could result in embarrassment and loss of time of senior personnel in reassessing their programs, upsetting field and Head Office work schedules and could have a harmful effect on field personnel's acceptance of forestry programs.	3	25
WORKING CONDITIONS - Requires frequent trips by automobile or truck to field locations to participate in field activities and examine results for forestry requirements resulting in exposure to varying weather conditions, the handling of toxic substances and exposure to highway travel and field hazards. Requires occasional travel by commercial aircraft and occasional small fixed-wing aircraft and helicopter flights to assess results of forestry experiments when large areas are involved. Such visits require driving approximately 10,000 miles per year and absence from home averaging four to five nights per month.	3	14

CONTINUED ON SHEET

Appendix L Chemical Damage Investigation Report

Alberta

CHEMICAL DAMAGE INVESTIGATION REPORT

AGRICULTURE
Plant Industry Laboratory

File No. ....
Date Received ....
Acknowledged ....

1. **Investigator**

Name .... Title ....
Organization .... Address ....
Postal Code .... Telephone Number .... Date of Investigation ....

2. **Client**

Name .... Address ....
Postal Code .... Telephone Number ....

3. **Legal Location of Affected Area**

Section .... Township .... Range .... West of ....

4. **Chemical Suspected to Have Caused Damage**

Name .... Date Applied ....
Insecticide .... Fungicide .... Herbicide .... Unknown or other ....
Industrial fume .... Name and location of suspected industry ....

5. **Details of Crop Affected**

Name of crop .... Variety .... Acreage ....
Commercial crop? Yes ... No ... Other vegetation affected ....
Age of affected crop: Years .... Months ..... Weeks ..... Days .... Height: Feet .... Inches ......
Symptoms ....
Part of Plant affected: Lower leaves .... Upper leaves .... Roots .... Stems ....
Entire plant .... One side of plant only .... (indicate N, S, E, W)
Suspected duration of crop damage: Months ..... Weeks ..... Days ....
How much vegetation is affected: Throughout entire field .... Only in a specific portion of the field ....
Crop grown in same field: Last year .... Two years ago ....

6. **Physical Characteristics of the Soil**

Texture: Light .... Medium .... Heavy ...... Moisture: Moist .... Wet .... Dry ....
Drainage: Good .... Fair .... Poor .... Surface: Loose .... Crusted .....

7. **Weather Immediately Prior To and Immediately Following the Observation of Damage**

High temperature: Before .... After .... Low temperature: Before.............. After ....
Sunny or overcast: Before .... After .... Estimated wind velocity: Before .... After ....
Humidity high or low: Before .... After .... Rainfall: Before .... After ....

Please Complete Reverse Side of This Form

8. **Chemical Applied** (a) to this crop or soil (b) to last year's crop (or soil in previous years)

Name of chemical(s): (a) .... (b) ....

Type of chemical(s): Insecticide (a) ... (b) ... Fungicide (a) ... (b) ... Herbicide (a) ... (b) ... Nematocide (a) ... (b) ...

Date(s) of application: (a) .... Time .... am/pm (b) ....

Rate(s) of application: (a) .... (b) ....

Reasons for chemical usage (pest involved) and results observed:

(a) .... (b) ....

9. **Method of Seeding the Crop**

Disc drill .... Hoe drill .... Disc plow .... Broadcast .... Depth of seeding ....

10. **Has This Field Been Soil Tested?**

Yes ... No ... If "Yes", give date .... Report number ....

11. **Fertilizer(s) Applied to This Field**

Date(s) of application: This year .... Last year ....

Drilled in:	This year:	Type	Rate	Last year:	Type	Rate ....
Broadcast:	This year:	Type	Rate	Last year:	Type	Rate ....
Incorporated:	This year:	Yes	No	Last year:	Yes	No ....

12. **Have Neighbours Sprayed Recently** (or had any spraying done for them)

Yes ...... No ...... Date(s) .... Wind direction and velocity on that date ....

Crop sprayed .... Chemical used .... Type of equipment ....

13. **Sketch** affected field and surrounding area. Relate the damaged area to topography, drainage pattern, roads, transmission lines, railway lines, wooded areas as well as adjoining crops. Include locations of sprayed areas in the vicinity of the affected field. Indicate "North."

I certify that the information I supplied for this report is correct to the best of my knowledge.

....
Client

We certify that the observations detailed in sections 5, 6 and 13 of this report are in agreement with the situation on the date of the investigation.

.... Client

.... Investigator

Appendix M Community Relations Correspondence on Vegetation Management

The Corporation of the Village of Sechelt

TELEPHONE
885-2043

P.O. BOX 129
SECHELT, B.C.
V0N 3A0

June 24, 1975

Mr. E. Hensch,
B.C. Hydro,
Box 159,
Sechelt, B. C.

Dear Mr. Hensch:

Thank you very much for your letter of June 10th pertaining to vegetation control on the R/W. It was received with great pleasure by the Village Councilors, who were most appreciative of the steps being taken to control the spraying, and of your trouble in communicating your intentions so fully.

Yours truly,
(Per M. G.)

T. W. Wood

Village Clerk

TW/mg

RECEIVED
BRITISH COLUMBIA HYDRO
AND POWER AUTHORITY
JUN 25 1975
E.S. 27/6/75
SECHELT, B. C.

cc/ N.S. Kent
G.L.T. Morrill

SUNSHINE COAST REGIONAL DISTRICT
TELEPHONE: 885-2261/2

OFFICE OF THE SECRETARY-TREASURER

BOX 800, SECHELT, B.C.
VON 3A0

July 9, 1975

B.C. Hydro & Power Authority
Box 159
Sechelt, B.C.

Attention: Mr. E. Hensch

Dear Mr. Hensch:

Re: Spraying of B.C. Hydro Transmission Right-of-Way

The Sunshine Coast Regional District Board wishes to express their appreciation for the before hand information regarding the above spraying.

There have been no complaints received by the Regional District to date which indicates the public notification has been of value.

We look forward to your continued co-operation.

Yours very truly

A.G. Pressley

(Mrs.) A. G. Pressley
Secretary-Treasurer

AGP/sje

Copy Sent to: Messrs: N. S. Kent
G. L. Morrill

RECEIVED
BRITISH COLUMBIA HYDRO AND POWER AUTH...
JUL 10 1975
E.S.
SECHELT, B.C.

Literature Cited

Abbott, R.E. and J.F. Moore. 1964. Chemical Brush Control Cuts, Costs and Outages. Electric Light and Power. May, pp. 70-74.

Abbott, R.E. 1973. Transmission rights-of-way and the environment. Arborist's News 39(1):35-36.

Alberta Environment. 1977. Environmental Impact Assessment Guidelines. Alberta Environment. 14 pp.

American Society of Mechan Engineers. 1968. Gas Transmission and distribution piping systems. USAS B31.8:77-78.

Anon. 1968. Right-of-way management policy guides contractor services. Electrical World. April, pp. 58-61.

Anon. 1969. Rooting out the ugly is the utility activity today. Electrical World. Feb., p. 30 & 35.

Anon. 1975. Right-of-way alternatives are complex. Electrical World. August, pp. 40-42.

Anon. 1977. Blackout hits New York. Edmonton Journal July 12, 1977.

Arner, D.H. 1960. Effects of right-of-way techniques on vegetation. 25th American Wildlife Conference Transactions. pp. 378-383.

Arner, D.H. 1966. Utility line right-of-way Management. 31st American Wildlife Conference Transactions. pp. 259-268.

Asbaugh, F.A. 1968. Convert rights-of-way from woody to herbaceous cover. Electrical World. April, p. 63.

Bagge, C.E. 1968. Working Committee on utilities: Report to Vice President and to President's Council on Recreation and Natural Beauty. U.S. Superintendent of Documents. 126 pp.

Barclay - Estrup, P. 1971. Herbicides, a critical look at their use in forest management. Canadian Field Naturalist 86:91-95.

Baribeau, J. and J. Rivest. 1970. Programming and evaluating R/W brush control by aerial photography. Proc. Northeastern Weed Science Soc. 24:247-249.

Baribeau, J. 1976. Reply to Questionnaire as to Utility Practices Right-of-Way Section. Canadian Electrical Association. Montreal.

Baribeau, J. 1977. Infrared reconnaissance with aerial photos. Personal communication.

Barrons, K.C. 1969. Some ecological benefits of woody plant control with herbicides. Science 165:465-469.

Beck, R.B. 1973. Environmental issues and the electrical utility. Arborist's News 48(2):59-63.

Bennet, M. 1974. Evaluating data collection costs: Emphasis on remote sensing "Plan B. Research Paper," Michigan State University.

Bernstien, D.A. 1974. Are reforestation surveys with aerial photographs practical? Photogrammetric Engineering Vol. XL. No. 1:69-73.

Blansjaar, P.W. et al. 1972. A computer controlled precision comparitor-densitometer. Paper to Commission VII, XIIth Congress of the Int. Soc. for Photogrammetry. 12 pp.

Bramble, W.C. and W.R. Byrnes. 1955a. Progress Report on the Effects of Certain Brush Control Techniques and Materials on Game Food and Cover on Power Line Right-of-Way. Penn. St. Univ. Agr. Exp. Sta. Report 125. 4 pp.

Bramble, W.C. and W.R. Byrnes. 1955b. Effect on Certain Common Brush Control Techniques and Materials on Game Food and Cover on a Power Line Right-of-Way. Penn. St. Univ. Agr. Exp. Sta. Report 135. 7 pp.

Bramble, W.C. and W.R. Byrnes. 1957. Progress Report No. 4. Effects of certain common brush control techniques and materials on game food and cover on a power line right-of-way. Proc. Northeast Weed Control Conf. 11:219-226.

Bramble, W.C. and W.R. Byrnes. 1958. Use of a power line right-of-way by game after chemical brush control. Pennsylvania Game News 29(9): 19-25.

Bramble, W.C. and W.R. Byrnes. 1967a. Ecological aspects of brush control - a long term study on a Pennsylvania right-of-way. Proc. Northeast Weed Control Conf. 21:406-412.

Bramble, W.C. and W.R. Byrnes. 1967b. Biological aspects of brush control - long term study on a utility rights-of-way. Purdue Univ. Agr. Exp. Sta., Lafayette, Indianna. Res. Bull. No. 835. 12 pp.

Bramble, W.C. and W.R. Byrnes. 1969. Fifteen years of ecological research on a utility right-of-way. Proc. Northeastern Weed Control Conf. 23:270-278.

Bramble, W.C. and W.R. Byrnes. 1972. Development of game food and cover on a sprayed right-of-way. Ind. Veg. Management 4(2):8-10.

Bramble, W.C. 1974. Songbirds on the right-of-way. Ind. Veg. Management 6(3):12-14.

Bramble, W.C. and W.R. Byrnes. 1976. Development of a stable, low plant cover on a utility right-of-way. In: Proc. of 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 168-174.

B.C. Hydro. 1970. Brush control along hydro power lines. Information Services. British Columbia Hydro and Power Authority. 1 p.

B.C. Hydro. 1971. Brush control along hydro power lines. Information Services. British Columbia Hydro and Power Authority. 8 pp.

B.C. Hydro. 1975. Clearing Transmission Line Rights-of-Way. Policies and Procedures EN.7. Transmission Design Department. Clearing Section Engineering Division. British Columbia Hydro and Power Authority. 3 pp.

Buell, M.F. et al. 1971. Invasion of trees in secondary succession on the New Jersey Piedmont. Bull. of the Torrey Botanical Club 98(2): 67-74.

Burgraff, F.B. 1971. Power to the people. Planning News. New York State Planning Federation 35(4):1.

Canadian Electrical Association. 1975. Environmental Guidelines. CEA Task Force on the Environment. Canadian Electrical Association. Montreal. pp. 32-36.

Canadian Electrical Association. 1976. Questionnaire as to Utility Practices. Right-of-Way Section. Canadian Electrical Association. Montreal. 40 pp.

Canadian Forest Service. 1975. A place for aerial photography in regeneration surveys? Forestry Report 4(3):6.

Canadian Standards Association. 1970. Standards for joint use of Electrical Utility Rights-of-Way. C 22.3, No. 1., p. 2.

Carroll, L. 1871. Alice through the looking glass. Kinapport Press.

Carvell, K.L. 1973. Phase I Report of Edison Electric Institute: Environmental Effects of Herbicides Research Project. Edison Electric Inst. Publication 72-903. 61 pp.

Carvell, K.L. 1975. Environmental impact of herbicides on electric transmission lines rights-of-way. Jour. of Arb. 1(7):129-130.

Carvell, K.L. 1976. Effects of herbicidal management of electrical transmission rights-of-way on plant communities. Proc. 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 178-180.

Carson, R.L. 1962. Silent Spring. Houghton Mifflin Co., Boston.

Cavanaugh, H.A. 1970. Utilities and the environment. Electrical World. June, pp. 53-72.

Cavanaugh, I. 1977. Personal communication with working tables. Energy and Minerals Section. Manufacturing and Primary Industries Division. Statistics Canada.

Cavanaugh, J.B. et al. 1976. Wildlife use and management of power line rights-of-way in New Hampshire. In: Proc. 1st National Symp. on Environmental Concerns in Rights-of-Way Management. Mississippi State University. pp. 275-285.

Central Electricity Generating Board. 1972. Overhead or underground and The Facts. Estates and Wayleaves. Bulletin No. 8. Central Electricity Board, London, England. pp. 1-3.

Central Electricity Generating Board. 1973. Comparison of Costs of overhead lines and underground cables: 1971-2. CEGB Annual Report 1973.

Chandler, C.C. 1972. Applications of remote sensing in forestry. Sixth session, North American Forestry Commission, FAO. Washington, D.C. 20 pp.

Chappell, W.E. et al. 1976. The use of plant growth regulators in rights-of-way maintenance. In: Proc. 1st National Symp. on Environmental Concerns in Rights-of-Way Management. Mississippi State University. pp. 183-188.

Clements, F.E. 1916. Plant Succession. Carnegie Institution of Washington.

Clement , R.C. 1973. Future right-of-way maintenance - A public view. Arborist's News 38(2):13-15.

Cloninger, H.H. 1970. The grass grows greener. Transmission and distribution. Feb., pp. 32-33.

Cody, J.B. 1975. Vegetation Management on Electric Transmission Lines: A State of the Knowledge Report. Applied Forestry Research Inst., State Coll. of Env. Sci. and Forestry, Syracuse. 56 pp.

Coffey, W.J. 1954. Brush control - Materials and methods. Proc. North. Cent. Weed Cont. Conf. 11:106-109.

Colwell, H.E. 1971. How the 2,4,5-T controversy has affected Appalachian Power Company's right-of-way vegetation management program. Proc. Northeastern Weed Science Soc. 25:395-397.

Conover, H.S. 1969. Public Invited to Share Transmission Right-of-Way. Transmission and Distribution. January, p. 31.

Coupe, J. 1974. Summary of transmission right-of-way seeding by B.C. Hydro in 1974. Internal Report Operations Division, British Columbia Hydro and Power Authority.

Courtney, K.D. et al. 1970. Teratogenic evaluation of 2,4,5-T. Science 168:864-866.

Cowles, H.C. 1899. The ecological relations of the vegetation of the sand dunes of Lake Michigan. Bot. Gaz. 27:95-391.

Crafts, A.S. 1967. Vegetation Management and the Welfare of Society. Symp. Proc. Herbicide and Veg. Management in Forests, Ranges, and Non-Croplands. pp. 1-7.

Cran, H.J. 1969. Preservation of desirable species through selective use of herbicides. Proc. Northeastern Weed Control Conference 23: 294-297.

Damman, A.W.H. 1971. Effect of vegetation changes on the fertility of a Newfoundland forest side. Ecol. Manag. 41:253-270.

Davey, K. 1970. Report of the Special Senate Committee on Mass Media. Queens Printer. Ottawa, Canada.

Day, B.E. 1967. The future of vegetation management. Symp. Proc. Herbicides and vegetation management in Forests, Ranges, and Non-Croplands. Oregon State University. pp. 298-303.

Department of Interior as reported in Transmission and Distribution, 1970. Transmission and Distribution. Dec., pp. 58-60.

de Wilde, R.C. 1976. Innovations in Right-of-Way Seedings. Newsletter, Utility Arborist Association 7(3):8-10.

Ditman, W.D. 1969. Pesticides Complaints Require Prompt Attention. Transmission and Distribution. Jan., pp. 36-38.

Dolton, R.L. 1974. Right-of-way clearance can be economical and environmentally sound. Electric Light and Power. T/D Edition, Jan., pp. 42-43.

Dreyfuss, H. 1968. Electric Transmission Structures. Edison Electric Institute. EEI pub. no. 67-61. 79 pp.

Dupont. 1975. New from DuPont: Krenite brush control agent. Technical Information and Spray Guide. DuPont de Nemours and Co. Ltd. 5 pp.

Edmonton Journal. 1977. Blackout Hits New York. July 12th.

Environmental Conservation Authority. 1976. The Use of Pesticides and Herbicides in Alberta. Report and Recommendations. 207 pp.

Egler, F.E. 1947. Effects of 2,4-D on woody plants in Connecticut. Jour. of Forestry 45(6):449-452.

Egler, F.E. 1949. Pesticide effects on Connecticut vegetation 1948. Ecology 30(2):248-256.

Egler, F.E. 1950. Herbicide effects on Connecticut vegetation. Bot. Gaz. 112(1):76-85.

Egler, F.E. 1952. Herbicide effects in Connecticut vegetation. Jour. of Forestry 50:198-204.

Egler, F.E. 1953. Our disregarded rights-of-way - Ten million unused wildlife acres. Trans. N. American Wildlife Conf. 18:147-158.

Egler, F.E. 1954. Vegetation management for rights-of-way and roadsides. Smithsonian Inst. Annual Rep. for 1953. pp. 299-322.

Egler, F.E. 1958. Science, Industry and the abuse of rights-of-way. Science 127:573-580.

Egler, F.E. 1966. Pointed perspectives: Pesticides in our ecosystem. Ecology 47:1077-1084.

Electrical Research Council. 1967. Electric Transmission Structures. A design research program. Edison Electric Institute, EEI Pub. No. 67-61, 4 pp.

Electrical World. 1975. Utilities still biting the bullet. 26th Annual Forecast on the Electrical Industry. Electrical World. Sept., pp. 35-50.

Encyclopedia Britannica. 1976. Electrical and Electronics Engineering "The First Practical Application". Encyclopedia Britannica. Chicago University Press. p. 536.

Energy Policy Staff. 1968. Considerations Affecting Steam Power Plant Selection. U.S. Office of Science and Technology. 66 pp.

Energy Policy Staff. 1970. Electric Power and the Environment. U.S. Office of Science and Technology. 77 pp.

Environment Canada. 1974. Power line clearing guidelines for the protection of Fishery Resources in the Pacific Region. PAC/T-74-6. pp. 1-9.

Environment and Land Use Secretariat of British Columbia. 1976. Guidelines for Environmental Assessment of Utility Corridors. Environment and Land Use Secretariat. British Columbia. 2nd Draft.

Ewald, G.A. 1968. Transmission R/W swath eliminated. Transmission and Distribution. May, pp. 42-45.

Farmer, J.D. 1970. Right-of-Way Management Program - a challenge for the 70's. Industrial Vegetation Management 2(1):4-7.

Federal Power Commission. 1970. Electric power transmission and the Environment. U.S. Federal Power Commission. 22 pp.

Federal Power Commission. 1971. The 1970 National Power Survey. Guidelines for the growth of the electric power industry. U.S. Federal Power Commission. 951 pp.

Fisheries and Environment Canada. 1977. A guide to the Federal Environmental Assessment and Review Process. Environmental Assessment Panel. Fisheries and Environment Canada. 10 pp.

Fleming, E.A. 1974. The utlization of satellite imagery for map revision. Proc. International Soc. for Photogrammetry. Comm. IV. 6 pp.

Fleming, E.A. 1975. Canadian mapping use of Landsat imagery. Proc. 10th International Symp. on remote sensing of environment 2:1451-1456.

Foster, M. 1975. Challenges for electrical energy in Canada. Proc. Canadian Electrical Assoication 85:140-145.

Francisco, D.C. 1973. TVA's three dimensional program. Weeds, Trees and Turf 12(6):14,46-47.

Frank, P.A. and B.H. Grigsby. 1957. Effects of herbicidal sprays on nitrate accumulation in certain weed species. Weeds 4:206-217.

Gardner, M.R. 1971. The development and current status of right-of-way management in Ontario Hydro. Right-of-Way. Dec., pp. 20-24.

Gardner, M.R. 1974. Decimal Thesauraus and Filing System. Office of the Environmental Advisor. British Columbia Hydro and Power Authority. 36 pp.

Gardner, M.R. 1975. Industrial herbicide use in B.C. now and in the future - A user's perspective. Minutes, Canada Weed Committee Western Section. Dec. 2-4:32-38.

Gardner, M.R. 1976. Central Interior Division vegetation management workload analysis - Distribution. British Columbia Hydro and Power Authority. 130 pp.

Gardner, M.R. 1977. Basic principles for right-of-way management in the urban environment. In: Trees and Forests for Human Settlements. Centre for Urban Forest Studies. Univ. of Toronto. pp. 234-244.

Gilbert, W.H. 1971. Public Relations in Local Government. Inst. for Training in Management Administration and International City Management Association. 206 pp.

Giles, R.H. et al. 1976. POWER: A high voltage transmission corridor location system. In: Proc. of 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 44-48.

Girard, C. 1974. Etudes multispectrales "In Situ", Comparison avec enaegistrements ultispectraux = Des applications en Agromonie, Institute National Agronomique. France. pp. 39-49.

Goodland, R. 1973. Ecological Perspectives of Power Transmission. In: Power Lines and the Environment. Cary Arboretum. pp. 1-35.

Goodwin, R.H. and W.A. Niering. 1962. What is happening along Connecticut's roadsides? Conn. Arboretum Bull. 13:13-19.

Gratkowski, H. 1967. Ecological considerations in brush control. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. Oregon State University. pp. 124-140.

Grigsby, B.H. and C.D. Ball. 1952. Some effects of herbicidal sprays in hydrocyanic acid content of leaves of wild black cherry. Proc. Northeastern Weed Control Conference 6:327-329.

Gross, F.H. 1969. Why a right-of-way management plan? Industrial Vegetation Management 1(2):6-8.

Grove, A.R. 1956. Right-of-way management - a growing problem. Virginia Wildlife 17(8):10-11.

Gysel, L.W. 1962a. Vegetation changes and animal use power line right-of-way after the application of a herbicide. Down to Earth 18(1): 7-10.

Gysel, L.W. 1962b. Vegetation and animal use of a power line right-of-way in southern Michigan: Quart. Bull., Mich. Agr. Exp. Sta. 44(4): 697-713.

Hansen, J. 1971. The public relations of public spraying. Industrial Vegetation Management 3(1):9-11.

Hachey, B. 1975. Presentation of the Alberta Bee Keepers' Association. In: Proceedings of the Public Hearings into the Use of Pesticides and Herbicides in Alberta.

Halliday, D. 1967. Physics, Parts I and II. Wiley. pp. 688-763.

Harper, R.L. 1969. Right-of-way beautility - economical or extravagent? Proc. Northeastern Weed Control Conf. 23:279-282.

Harvard University. 1977. Laboratory for Computer Graphics and Spacial Analysis. Harvard University LAB Log. Graduate School of Design. pp. 1-9.

Heskin, B.A. 1975. Correspondence to G.L. Morill, Superintendent Metro-Transmission B.C. Hydro and Power Authority regarding: Approval for Pesticide Application, Pemberton and Sechelt. Pollution Abatement Branch. Environmental Protection Service, Environment Canada.

Hoffer, R.M. 1969. Ecological Potentials in Spectral Signature Analysis. In: Remote Sensing and Ecology. University of Georgia Press.

Hoffer, R.M. 1967. Interpretation of remote multispectral imagery of agricultural crops. Report of the Laboratory of Remote Sensing. Vol. 1. Purdue University Ag. Exp. Sta. Rev. Bull. No. 831. 26 pp.

Horstman, L. 1977. Current Pesticide Uses In Alberta: Fish and Wildlife. Concerns and Recommendations. Alberta Recreation, Parks and Wildlife. p. 82.

Howlett, B. and F.J. Elmiger. 1968. Power lines and scenic values in the Hudson River Valley. Hudson River Valley Commission of New York. 23 pp.

Howlett, B. 1973. An Environmental Study to Select Hydro Transmission Corridors for the Solandt Commission. Prepared by Bhi Ltd. Queen's Printer. Ontario. 132 pp.

Howlett, B. 1976. Environmental Selection of Transmission Line Routes with Maps and Computers. In: Proc. of the 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 35-41.

House et al. 1967. Assessment of Ecological Effects of Extensive or Repeated Use of Herbicides. U.S. Department of Commerce. Publication AD 824-314. 369 pp.

Institute of Sciences and Technology. University of Michigan. 1970. Scanner Data for 70 Mile Flight Line. Indianna. Collected for Research Sponsored by the Indianna State Highway Committee.

Jenkins, B.C. 1955. Wildlife habitat development with herbicides in Michigan. Proc. Annual North Central Weed Control Conf. 12:58.

Jenkins, C.F. and G.E. Fisher. 1970. Study of vegetation control on power line rights-of-way. Report prepared for the Northeastern Utilities Service Company by the Centre for the Environment and Man. Inc. Hartford, Conn. 41 pp.

Jensen, H. et al. 1977. Sidelooking Airborne Radar. Scientific American 237(4):84-95.

Johns, H.R. 1967. Programmed Right-of-Way Maintenance. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. pp. 265-272.

Johns, H.R. 1969. Programmed Right-of-Way Maintenance Eliminates Weed Worries. Telephony. April, pp. 46-49.

Johns, H.R. 1976. Regulatory Aspects of Management of Rights-of-Way. In: Proc. of 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 190-204.

Johnson, L.B.J. 1965. "Beauty for America." Proceedings of the White House Conference on Natural Beauty.

Johnson, J.E. 1971. The public health implications of wide-spread use of the phenoxy herbicides and picloram. Bio-Science 21(17):899-905.

Kahn, H. 1976. The Next Two Hundred Years, A Scenario for America and the World. Morrow & Co. p. 79.

Keever, C. 1950. Causes of Succession on Old Fields of the Piedmont, North Carolina. Ecol. Monographs 20(3):231-250.

Kimmins, J.P. 1975. Review of the Ecological Effects of Herbicide Usage in Forestry. Pacific Forest Research Center Info. Report, B.C. - X - 139. Canadian Forest Service. 44 pp.

Kingsbury, J.M. 1964. Poisonous plants of the United States and Canada. Prentice-Hall. 626 pp.

Klein, W.H. 1970. Mini-aerial photography. Jour. of Forestry 68(8): 475-478.

Langley, P.G. 1969. New multi-stage smapling techniques using space and aircraft imagery for forest inventory. In: Proc. of 6th Inter. Symp. on Remote Sensing of the Environment. Univ. of Mich. pp. 1179-1192.

LARS. 1968. Remote Multispectral Sensing in Agriculture. Volume I. Laboratory for Agricultural Remote Sensing Annual Report. pp. 18-25.

LARS. 1970. Chapter 5, Biogeophysical Research Programs. Report of the Laboratory for Agricultural Remote Sensing. pp. 52-86.

Lawrence, W.H. 1967. Effects of Vegetation Management on Wildlife. In: Proc. Symp. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. Oregon State University. pp. 88-93.

Lee, Y.T. 1974. Monitoring forest management operations. The Canadian Surveyor 28(2):135-142.

Legge, A.H. 1974. Development and application of an ecologically based remote sensing system. Paper presented at the International Society for Photogrammetry. Banff, Alberta.

Leith, R.H. 1974. Control of brush by grassing of transmission rights-of-way. Proc. South Weed Sci. Soc. 27:234-235.

Leth, W.C. 1967. Responsibility of Society to Land Managers. In: Symp. Proc. Herbicides and Vegetation Management in Forest, Ranges and and Non-Croplands. Oregon State University. pp. 281-286.

Lewis, A.J. and H.C. MacDonald, and D.S. Simonett. 1969. Detection of Linear Cultural Features with Multipolarized Radar Imagery. In: Proc. Symp. on Remote Sensing of Environment. Volume 2. University of Michigan. pp. 879-893.

Lincicome, R.A. 1964. Right-of-Way Brush Control is a Multimillion-Dollar Headache. Electrical Light and Power. May, pp. 58-61.

Loncia, R.A. 1976. Wildlife Management on Rights-of-Way: Results of a National Survey. In: Proc. 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 307-314.

Loose, R.P. 1975. Maintenance techniques to reduce the visual impact of transmission lines. American Public Power Association and Northwest Public Power Association Engineering and Operations Workshop. 10 pp.

Luther, R. 1973. Transmission and Distribution Policies and Practices in England, Norway and France with particular reference to Environmental Considerations. NUSCO Electrical Engineering Special Report. p. 12.

Lynn, G.E. and K.C. Barrons. 1952. The Hydrocyanic acid (HCN) content of Wild Cherry leaves sprayed with a brush killer containing low volatile esters of 2,4-D and 2,4,5-T. Proc. Northeastern Weed Control Conf. 6:331.

MacConnel, W.P. and J.J. Joslyn. 1967. Controlled tree plantings enhance rights-of-way. Electrical World. June, pp. 32-33.

MacConnel , W.P. and J.J. Joslyn. 1968. Growing Christmas trees on a power line right-of-way. Proc. Northeastern Weed Sci. Soc. 22:329-333.

MacLean, G.J. and J.H. Davidson. 1970a. Poisonous Plants, a major cause of livestock disorders. Down to Earth 26(2):5-11.

MacLean, G.J. and J.H. Davidson. 1970b. Diagnosis of Disorders in Pastured Livestock. Industrial Vegetation Management. pp. 11-15.

MacLean, A. and A.H. Baintree. 1971. Seeding Forest Rangelands in British Columbia. Canada Department of Agriculture. Pub. 1463. pp. 1-14.

Mackenzie, C.J. et al. 1975. Royal Commission of Enquiry into the Use of Pesticides and Herbicides. Final Report of the Commissioners. May 1970. Queens Printer. British Columbia.

Madison Gas and Electric. 1973. EDAP Environmental Decision Alignment Process. Produced by Landscapes Ltd. Madison, Wisconsin. 246 pp.

Mann, R.A. 1963. Stump treatment after initial clearing of rights-of-way for newly constructed lines. Proc. South Weed Conf. 16:318-322.

Mann, R.A. 1968. Brush control - endless task over 14,000 miles of line. Electrical World. January, pp. 19-22.

Marjerrison, M. 1973. Aesthetic Clearing of transmission line right-of-way. Bonneville Power Administration. Portland, Oregon. pp. 1-15.

Martin, A.C. 1940. American Wildlife and Plants. Dover. 487 pp.

Mayer, T.D. 1976. An evaluation of chemically-sprayed electrical utility transmission line rights-of-way for actual and potential wildlife use. In: Proc. 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 288-294.

McCloskey, M. 1971. The Energy Crisis: Issues and a Proposed Response. Env. Affairs 1(3):587-588.

McPhail, R.A. 1967. Safety precautions in spraying operations. Annual Accident Prevention Conference. Ontario Hydro, Toronto. 6 pp.

McPhail, R.A. 1972. Selective Spraying Cuts Costs. Hydroscope. Ontario Hydro. July 25, pp. 2-3.

McPhail, R.A. 1971. Current research in the vegetation management program of a large Canadian electrical utility. Ontario Hydro. Toronto. pp. 1-11.

McPhail, R.A. 1976. Reply to Questionnaire as to Utility Practices Right-of-Way Section. Canadian Electrical Association. Montreal.

MacPhail, R.A. 1977. Personal Communication.

Medicky, E.J. 1976. Right-of-Way Development and Maintenance. Journal of Aboriculture 2(3):53-58.

Middleton, J.B. 1965. Right-of-Way Beautification - Small Tree and Shrub Screens. Penn. Electric Company, Johnstown, Penn. 2 June.

Middleton, J.B. 1966. Screen plantings to enhance Penelec R/W road crossings. Electric Light and Power. May, pp. 80-82.

Middleton, J.B. 1969. Efforts to remove the "ugly" from transmission rights-of-way. Proc. Northeastern Weed Control Conf. 23:283-290.

Middleton, J.B. 1970. Restrictions on Herbicides Feared. In: Transmission and Distribution. Feb., pp. 32-33.

Middleton, J.B. 1977. Low cost of power line right-of-way maintenance for beauty and use. Proc. Northeastern Weed Science Society 31:302-305.

Miller, J.E. 1975. Evaluating line clearing crews. Paper presented at Utility Arborist Association Annual Meeting. Detroit, Michigan. 11 pp.

Moore, S.T. 1967. Public Relations and Forest Management. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. Oregon State University. pp. 295-297.

Morgan, M. 1974. EHV and the Environment: The tip of the iceberg? Electric Light and Power. T/D Edition. August, pp. 21-24.

National Academy of Science. 1968. Principles of plant and animal pest control. Weed Control. Volume 2. Natl. Acad. Sci. Pub. 1597. pp. 305-317.

National Environmental Policy Act. 1971. Environmental Impact Statement Guidelines. U.S. Federal Register 36(79)Part II:7724-7729.

National Energy Board. 1974. Environmental Impact Assessment Guidelines. In: Environmental Information Requirements Respecting Certificate Applications for International Power Lines. (Second Draft) National Energy Board Canada. 14 pp.

Neidig, W.J. 1973. Initial Clearing for Transmission Line Rights-of-Way for Today's Environment. Proc. International Shade Tree Conference 49:93-95.

Nelson, M. 1975. Power Lines and Rights-of-Way. Aware 52:9-12.

Newton, M. 1967a. Response of vegetation communities to manipulations. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. Oregon State University. pp. 83-87.

Newton, M. 1967b. Vegetation Management - A System of Operation. In: Symp. Proc. Herbicides and Vegetation Management in Forest Ranges and Non-Croplands. Oregon State University. pp. 8-11.

Niehuss, M.H. 1974. Ammonium Ethyl Carbamoylposphorate: A new plant growth regulator. Proc. British Weed Control Conf. 12:1015-1022.

Niering, W.A. 1953. A shrub community. Ecology 36(2):63-73.

Niering, W.A. 1955. Research projects on herbicides: practical applications of interest to property owners, sportsmen, foresters, and public utilities. Conn. Arb. Bull. No. 8:14-17.

Niering, W.A. 1958. Principles of sound right-of-way vegetation management. Economic Botany 12(2):140-144.

Niering, W.A. 1961. The Connecticut Arboretum Right-of-Way Demonstration Area - Its Role in Commercial Application. Proc. Northeastern Weed Control Conference 15:424-433.

Niering, W.A. 1968. The effects of pesticides. Bio-Science 18(9):869-874.

Niering, W.A. and F.E. Egler. 1955. A shrub community of Viburnum lentago, Stable for 25 Years. Ecology 36(2):356-360.

Niering, W.A. and R.H. Goodwin. 1974. Creation of relatively stable shrublands with herbicides: Arresting "succession" on rights-of-way and pastureland. Ecol. 55(4):784-795.

Niemann, B.J. and B.H. Murray. 1974. PERMITS methodology. Landscapes Limited, Madison, Wisconsin. 96 pp.

Norris, L.A. 1971. Chemical Brush Control: Assessing the hazard. Jour. of Forestry 69(10):715-720.

Novikoff, A.B. 1945. The concept of integrative levels of biology. Science 101:209-215.

Odum, E.P. 1969. The strategy of ecosystem development. Science 164: 262-270.

Odum, E.P. 1977. The emergence of ecology as a new integrative discipline. Science 195:1289-1293.

Oetting, R.B. 1971. Right-of-way resources of the prairie provinces. Blue Jay 29:179-183.

Olenik, C.J. 1977. The wonderful power of selectivity to power line rights-of-way. Proc. Northeastern Weed Science Society 31:306-311.

Ontario Hydro. 1963. Data for talks on chemical brush control line clearing operations and conservation. Operations Division. Forestry Department. Ontario Hydro. 23 pp.

Ontario Hydro. 1967a. Forestry reference manual. Volume 1. Line clearing. Operations Division. Forestry Department. Ontary Hydro.

Ontario Hydro. 1967b. Forestry reference manual. Volume 2. Spray practices. Operations Division. Forestry Department. Ontario Hydro.

Ontario Hydro. 1967c. Power lines and vegetation control. Operations Division. Forestry Department. Ontario Hydro. 15 pp.

Ontario Hydro. 1971. Maintaining Hydro Rights-of-Way. Operations Division. Forestry Department. Ontario Hydro. Publication 71-0040.

Ontario Hydro. 1974. Specifications for the selective cutting and restoration of new 500, 230, 115 and 44 kV Transmission Line Rights-of-Way. System Maintenance Division. Ontario Hydro. 6 pp.

Ontario Hydro. 1976. Environmental Assessment Act. S.O. 1975. C 69 Part II, Section 5, Subsections 1 to 3 and Section 6, Subsections 1 and 2.

O'Riordan, J. 1975. Procedure for the Development and Assessment of Electric Power Projects in British Columbia. Environment and Land Use Secretariat. British Columbia. 5 pp.

Oswald, E.T. 1974. Evaluation of ERTS imagery for vegetation interpretation in B.C. The Canadian Surveyor 28:147-154.

Oswald, E.T. 1976. Terrain Analysis from Lands at Imagery. Forestry Chronicle 52(6):274-282.

Paris, L. 1969. Future of UHV transmission lines. IEEE Spectrum 6: 44-51.

Pass, A. 1970. Georgia Power Aids Wildlife. Georgia Game and Fish 8:17.

Patterson, J.H. 1974. The Use of Herbicides in Alberta. In: Biocide Use in Alberta. Part 3. Information Bulletin No. 5. Environment Conservation Authority. Alberta. pp. 11-13.

Piemeisel, R.L. and E. Carsner. 1951. Replacement control and biological control. Science 113:14-15.

Piemeisel, R.L. 1954. Replacement Control: Changes in Vegetation in Relation to Control of Pests and Diseases. Botanical Review. Volume 20(1):1-32.

Pollock, T. 1974. Eliminating misunderstanding by getting the most out of words. Telephony. Sept.

Popovinnkoff, R. 1975. Reply to Questionnaire as to Utility Practices. Right-of-Way Section. Canada Electrical Association. Montreal.

Pound, E.D. and Egler, F.E. 1953. Brush control in southeastern New York: Fifteen years of stable tree-less communities. Ecology 34: 63-73.

Punhani, A.L. 1971. Statistical Analysis of Smother Crop Experiments in 1970-71 Using A Completely Randomized Design. Report No. 71-102-H. Ontario Hydro. 14 pp.

Patrick, R.W. 1970. Need for Environmental and Aesthetic Feasibility Studies. Right of Way Dec., pp. 27-34.

Randell, W.E. 1973. Multiple Use Potential Along Power Transmission Rights-of-Way. In: Power Lines and the Environment. The Cary Arboretum. pp. 89-113.

Rehder, J.B. 1972. The applicability of remote sensing to detection, identification, and monitoring of power transmission rights-of-way within selected areas of the TVA region. Final report sponsored by NASA and TVA. Monitoring Agency Report No. 18. 14 pp.

X Richards, N.A. 1973. Old Field Vegetation as an Inhibitor of Tree Vegetation. In: Power Lines and the Environment. The Cary Arboretum. pp. 78-88.

Robbins, G. 1968. Trees screening right-of-way help utilities win easements. Electrical World. Nov. 18th. p. 69.

Roberts, H.A. 1969. A wildlife manager's view of herbicide use on the right-of-way. Proc. Northeastern Weed Control Conf. 23:291-293.

Robinette, G.O. 1973. Energy and Environment. Kendall/Hunt Publishing Co. Dubuque. pp. 111-218.

Robinson, J.P. 1973. Reduce guesswork in T-line ROW clearing. Electric Light and Power. T/D Edition. Dec. pp. 51-53.

Roche, B.F. 1967. Selective vegetation control to favour attractive and non-objectionable cover. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges, and Non-Croplands. Oregon State University. pp. 259-264.

Rosemarin, C.S. 1976. The Transmission Line Aesthetic Impact Evaluation Process and Its Implementation in a Comprehensive Planning Scheme. In: Proc. of 1st National Symp. on Environmental Concerns in Rights-of-Way Management. Mississippi State University. pp. 58-68.

Roy, C. et al. 1970. Transmission and Distribution Rights-of-Way Selection and Development. Consumer's Power Company. Jackson, Michigan.

Schaal, H.R. 1972. Constraint Maps: The newest tool in right-of-way selection. Transmission and Distribution 24(4):26-31.

Schaal, H.R. 1973. Environmental Impact Analysis for Overhead Transmission Lines. IEEE Power Engineering Society. Conference Paper C 73 381-1. 3 pp.

Schlosser, M.S. 1974. Television scanning densitometer. Photogrammetric Engineering. Vol. XL, No. 21:199-202.

Scott, W. 1972. HV and EHV transmission planning. Energy Int. 9(7):27-30.

Shah, K.R. 1975. Seminar Notes on Analysis of Electrical Radiation Effects and Alternatives to OH Transmission in Transmission Line Route Selection. Commonwealth Associates. New York.

Shoecraft, B. 1971. Sue the Bastards. Franklin Press. Pheonix. 460 pp.

Shuler, E.B. 1968. Experience plus ingenuity cut R/W clearing costs. Electrical World. April, pp. 50-51.

Simonson, G.H. et al. 1973. The comparative evaluation of ERTS-1 imagery for resource inventory. In: Land Use Planning, Interim Report for Period March-August 1973. NASA, Goddard Space Flight Centre.

Slatt, C.J. 1969a. The Bonneville Power Administration's View of Right-of-Way Beautility. Proc. Northeastern Weed Control Conf. 23:262-269.

Slatt, C.J. 1969b. Vegetation Control - A Challenging Concept in R/W Management. Transmission and Distribution. August, pp. 92-94.

Slatt, C.J. 1973. Bonneville Power Administration's Right-of-Way Inventory System. Staff Handbook. Bonneville Power Administration. Portland. Sections I to V.

Smart, E.W. et al. 1976. Computer Interpretation of Soil Data for Rights-of-Way Management. In: Proc. of 1st National Symp. on Environmental Concerns in Rights-of-Way Management. Mississippi State University. pp. 72-75.

Smith, P.F. 1976. Environmental considerations in right-of-way management. Proc. 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 8-11.

Smith, V.K. 1969. Right-of-Way is Site for Soil Conservation Program. Transmission and Distribution.

Smyth, J.R.G. 1972. Parameters and intervals for 35 mm aerial photography. Division of Forests, Ministry of Natural Resources, Ontario.

Solandt, O.M. 1974. The Solandt Commission. Report to the Ontario Provincial Secretary for Resource Development. Solandt Commission. Queen's Printer. Ontario. 93 pp.

Sorensen, R.W. 1976. Computerized program for right-of-way vegetation management. Jour. of Arboriculture 2(6):101-105.

Spencer, D.A. 1975. Corridors that streak across the land. Jour. of Arboriculture 1(9):1973-1975.

Spoehr, A. 1956. Cultural differences in the interpretation of natural resources. In: Man's Role in Changing the Face of the Earth. University of Chicago Press. pp. 93-102.

Squamish Times. 1973. Regional district chairman blasts spraying. The Times Squamish, Alta Lake, Pemberton. Aug. 8.

Stahler, L.M. and E.K. Whitehead. 1950. Indirect effects of herbicides. Proc. North Central Weed Cont. Conf. 7:110-112.

Stanley, H. 1971. The electric power crisis, its impact on workers and consumers. U.S. National Rural Electric Cooperative Association. p. 5.

Stevenson, G.R. 1975. Krinite for the control of deciduous brush or conifers. In: Research Report. Canada Weed Committee Eastern Section. Exhibit 35A. p. 273.

Stewart, R.A. and E.A. Fleming. 1974. Mapping activities: Skylab and ERTS Imagery. Proc. 2nd Canadian Symp. on Remote Sensing. pp. 217-223.

Sup. R. 1976. Mohawk AN/AAS - 14 Airborne infrared detector. Support R. United States Army Tactical Command Training Manual. 72 pp.

Sullivan, M.C. 1975. The use of remote sensing in transmission line route selection. Jour. American Society of Photogrammetry. 41st Ann. Proc. pp. 308-321.

Tansley, A.G. 1929. Succession: The Concept and Its Values. Proc. Int. Congress Plant Sciences 1926. pp. 677-686.

Tansley, A.G. 1935. The use and abuse of vegetational concepts and terms. Ecology 16(7):284-307.

Tatlow, R. 1976. Hydro says spraying an economy measure. Times of Squamish and Alta Lake and Pemberton 20(10):1-3.

Taylor, R.B. 1975. Hydro and the Future. Electrical Business. May, p. 11.

Tillman, R.E. et al. 1971. A computer software system for integration and analysis of grid-based remote sensing data with other natural resource data. Journal of American Society of Photogrammetry XLIII(6):739.

Tillman, R.E. 1973. Wildlife management - power line rights-of-way. In: Power Lines and the Environment. The Cary Arboretum. pp. 127-132.

Tillman, R.E. 1976. The Southern Tier Interconnection: A Case Study. In: Proc. of 1st National Symp. on Environmental Concerns in Rights-of-Way Management. Mississippi State University. pp. 222-230.

Toronto Globe and Mail. 1971. Defoliant has many worried. February 13th.

Tschirely, F.H. 1969. Defoliation in Vietnam. Science 163:779-786.

Tschirely, F.H. 1970. 2,4,5-T Risks and Responsibilities in the Use of Herbicides. Proc. Northeastern Weed Science Soc. 24:223-228.

Turner, S.W. 1967. Legal responsibilities of pesticide users. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges, and Non-Croplands. Oregon State University. pp. 287-294.

Tweddle, B.A. 1971. Evaluation of Spraying Versus Grooming and Mowing in Transmission Line Rights-of-Way Brush Control. British Columbia Hydro. 17 pp.

Ulrich, E.S. 1976. Selective Clearing and Maintenance of Rights-of-Way. In: Proc. 1st National Symp. on Environmental Concerns in Right-of-Way Management. Mississippi State University. pp. 206-276.

Urban Renewal Administration. 1963. Preserving urban open space. U.S. Superintendent of Documents. pp. 20-26, 32-33.

U.S. Department of the Interior and Department of Agriculture. 1970. Environmental Criteria for Electric Transmission Systems. U.S. Department of the Interior. 55 pp.

U.S. Forest Service. 1965. Forest Service Policy R-9. In: Vegetation Management for Rights-of-Way. U.S.D.A. Forest Service, Eastern Region. p. 3.

U.S. Forest Service. 1966. Vegetation management for Rights-of-Way: Selective Maintenance for Improved Wildlife Habitat and Scenic Values. Eastern Region, U.S. Forest Service. 39 pp.

U.S. Forest Service. 1975. National Forest Landscape Management. Volume 2. Chapter 2, Utilities. Forest Service. U.S. Department of Agriculture Handbook. U.S.D.A. Forest Service. pp. 19-115.

U.S. Office of Science and Technology. 1970. Energy Policy Staff. Electric Power and the Environment. Transmission Lines and Utility Corridors 4:21-25.

Vaartnou, H. 1977. Testing grasses and legumes for revegetation of disturbed areas in Alberta. Final Report of Research 1973 to 1976. Prepared for Alberta Agriculture and Alberta Environment. 109 pp.

Vanden Born, W.H. et al. 1974. Brief presented by Industrial Vegetation Management Committee to the Environment Conservation Authority of Alberta. 33 pp.

Vancouver Sun 1973a. B.C. Hydro's use of pesticide sprays blamed by father of deformed child. Vancouver Sun. October 3rd.

Vancouver Sun 1973b. Squamish-Lillooet area. Hydro spray unnecessary. Vancouver Sun: July 30th.

Wagner, J.F. 1971. Creating Wildlife Habitat on Utility Rights-of-Way. Industrial Vegetation Management 3(1):15-17.

Wagner, A.J. 1977. Facing the energy future: Let's have some guidelines. Right of Way. March, pp. 22-25.

Wan, M.T. 1975. Impacts of Chlorophenoxy Herbicides on a Coastal Forest Environment of British Columbia. Pollution Abatement Branch Environmental Protection Service. Pacific Region. Canada Dept. of Environment. Surveillance Report, EPS; 5-PR-75-4. 35 pp.

Webster's Dictionary. 1976. Webster New Collegiate Dictionary. Management. p. 697.

Wenger, J.S. 1974. Corridor: A new system for environmental impact analysis. IEEE Conf. Paper. IEEE Power Engineering Soc. Winter Meeting. New York.

Western Systems Coordinating Council. 1971. Environmental Guidelines. Environment Committee. Western Systems Coordinating Council. Los Angeles, California. pp. 25-26.

Wetsch, A.F. 1968. R-O-W aesthetics call for selective tree control. Electrical World. April, pp. 45-47.

Wetsch, A.F. 1967. Brush and stump control on new rights-of-way. In: Symp. Proc. Herbicides and Vegetation Management in Forests, Ranges and Non-Croplands. Oregon State University. pp. 248-258.

Whiteside, T. 1970. Defoliation. Ballantine Books. New York. 168 pp.

Wilson, H.R. 1970. Possible effects of an increase in vegetation control costs. Memorandum to R.A. McPhail, Forestry Department, Ontario Hydro. 8 pp.

Wilson, T.G. 1972. Teratological potential of 2,4,5-T. Proc. 25th Annual Meeting, Southern Weed Sci. Soc., Dallas, Texas.

Wilson, W.C. 1973. Aesthetic clearing of transmission time right-of-way. Paper presented at IEEE Summer meeting and EHV/UHV Conference, Vancouver, B.C.

Wobber, F.J., Orville R. Russell and Daniel J. Reely. 1975. Multiscale aerial and orbital techniques for management of coalmined lands. Photogrammetria 31(4):117-133.

Woodgerd, S.M. 1976. Agricultural spray adjuvants. Agrichemical Age 19(7):20-21,23.

Wodehouse, R.P. 1945. Hay fever plants. Chronica Bot. Press. 364 p.

Working Committee on Utilities. 1968. Report to the Vice President and to the President's Council on Recreation and Natural Beauty. Washington, D.C. 146 pp.

Young, H.J. and R.S. Thorsell. 1970. Environment, economics and electric utility rights-of-way. Right of Way. October, pp. 41-43.

Zimmermann, R.H. and K.J. Duker. 1977. An automated land use information system: Needs, possibilities, recommendations, and problems. Photogrammetric Engineering and Remote Sensing 43(6):754.

Zsilinszky, V.G. 1972a. Resource Surveys with miniature cameras. In: Proc. 12th Congress of International Society for Protogrammetry. pp. 1-15.

Zsilinszky, V.G. 1972b. Camera mounts for 35 mm mono and multi-spectral photography. In: Proc. 1st Canadian Symposium on Remote Sensing. pp. 441-450.