THE CHEMICAL INHIBITION OF WOODY PLANT GROWTH

RESUME OF FORESTRY DEPARTMENT INVESTIGATIONS IN ONTARIO HYDRO

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Abstract

The reason for investigation into growth inhibiting chemicals by Ontario Hydro is described. The dynamics of the problem of increased tree planting and the resultant effects on work load are followed. The history of the development and success, or otherwise, of these chemicals as used by this organization is given. Further, a report is made of the techniques and provisional findings of the work undertaken in the 1968/69 season.

I would like initially to explain the rationale behind this approach to the problems of woody plant growth inhibition as it applied to Ontario Hydro before elaborating on the results of 1969 research. I shall outline the general topics covered in this paper, describe each topic, their interrelationships and then outline the research techniques along with the data accumulated from the field research. I shall conclude by drawing a number of broad hypothesis from the first year observations taken from the work which was set out in the Spring and Summer of 1969 and reflect on the longitudinal implications of this work.

I wish briefly to discuss the reason for Ontario Hydro's interest in growth inhibitors. Electrical service carried by overhead wires is at present the most economical method of delivering electrical energy to our customers./1/ The general public, the urban planner and now the politician are greatly concerned with our environment. Roadside trees, be it street or garden trees, contribute in definite measure to shade, beauty and sentimental value. Values which should, and in the future, will have to be

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preserved. Large roadside trees which line our rural roads are valuable as wind-breaks and contribute to the beauty of the countryside. With the decimation of our Elm trees by Dutch Elm disease, greater consideration must be given to the continued maintenance of our desirable roadside tree species. However, since tree growth can interfere with the same and efficient operation of overhead lines, line clearance is a vital and continuing operation.

With the rising costs of labour, the extension of circuits in our growing electrical system and the subsequent rising cost of line clearance work, the Forestry Department has tried a number of approaches to offset these increasing maintenance expenitures. The emphasis has mainly been on mechanization involving the use of aerial power "buckets", small power saws, hydraulic or air operated pruners and other power tools. Continued emphasis has been placed on training with the expansion of courses to enlighten our field staff in the efficient use and maintenance of such equipment. Unquestionably, this is a logical time reducing approach, borne out by the fact that our line clearing costs have risen only some 26% in the period 1960-1968 while our labour costs have risen some 70% over the same period. However, we are rapidly approaching a time when the continual rising costs of labour and increased capital equipment costs will not be so greatly offset by these aforementioned methods./2/.

The cost of maintenance line clearing in Ontario is substantial and increasing. During 1968 the Forestry Department spent a considerable amount for maintenance line clearing operations. A total of some 489,977 trees were pruned at an average man-hour per tree of 0.93./3/.

The dynamics of increasing tree planting in Ontario

Despite continuing removal of dead or dying Elm trees, our number of trees treated per mile is not showing a significant decrease. Thus, it must be concluded that a large number of trees are, in fact, being planted by municipalities and home owners. Some research into these figures has been done by the Forestry Department with surprising results. It transpires that, based on the Canadian Dominion Bureau of Statistics' Report for the sale of nursery trees in Ontario for the year 1966, the following quantity of trees were retailed. Under the section on Deciduous Ornamentals and assuming that only fast growing species are

counted, a total of 17,785 or 85% of the trees shipped as "Liners", and 434,486 or 78% of the trees sent as "Other Sizes" could grow rapidly into the lines. The range of classifications is controlled by the Ontario Nursery Trades' Book of Standards. "Liners" are designated stock of 2 + 1 or 2 + 2 age up to 3 to 4 feet, while "Other Sizes" are saleable stock of over 4 feet and up to 8 feet, depending on the species and price paid./4/.

If the trees under "Other Sizes" are planted under a line with an initial clearance of 20 feet and it is assumed that only 10% of the total are planted close enough to the line to become problem trees, 43,448 could reach the line in four to five years, depending on annual growth. Of the "Liners", some 1,778 fast growing stems could eventually reach the line, although it would be difficult to predict how many years this would take, again assuming 10% of the total becoming problem trees. Of the 22% of the largest size trees and 17% of the "Liners" which could grow tall enough to reach the lines but not included above, it would be some 8 to 12 years before these plants would become problem size.

Under the section of Coniferous Evergreens, some 199,266 or 49% of the total trees under "Other Sizes" are fast growing and 25,746 or 32% of the "Liners" are fast growing. Thus, it could be expected that some 19,926 trees of the largest size classification could grow into the line in some 6 to 8 years, and of the "Liners", some 2,576 could grow quickly into the wires. The balance of both types could take from between 10 and 18 years to become problem trees. Again, these figures are assuming that only 10% of the overall totals would become nuisance trees.

Under the section on Deciduous Shrubs, various species account for some 1,344,185 plants which could grow to line height, and of these some 50% approximately are fast growing. Thus, 6,720 approximately would possibly grow into the wires in under 10 years, assuming that only 1% of these shrubs are planted close to overhead services./5/6/. Moreover, the trend is for a continual upswing in the number of trees planted because of increasing awareness on the part of the general public. This upswing would appear to be annually about 5.4% of the figures given here. This planting and its projected influence on rural line clearing work loads is presented graphically in the Appendix. I might add at this point that

Maple, Ash, Poplar, Willow and Pines comprise the bulk of the species noted. Therefore, one might conclude that the basic tenant of utilities promoting compatible trees for urban planting for both aesthetic and financial reasons would appear to be valid on both a long and short term basis.

Because of these potential increases in the number of trees and tree-trimming costs, the use of chemicals to inhibit the growth of trees near wires can offer potential savings. Many chemical companies are at present searching for chemical means of slowing vegetative growth. If the rate of growth can be decreased to the extent that regrowth as a percentage of follow-up pruning is decreased, or so that the frequency of trimming could be reduced, the cost of maintenance line clearing, it follows, would also be reduced.

Savings

Before considering possible savings, one must remember that tree growth inhibition falls into two main areas - that which concerns the complete growth retardation of the growing crown with a sprayed application. for example, with MH30, and that which concerns the application of fortified tree wound dressings, such as asphalt, with naphthalene acetic acid, which reduces the number of adventitious buds which break and become fast-growing suckers after pruning. Potential savings with the former type of application are, in the literature available, considered to be extensive once a suitable chemical or combination of compounds is available. Even at the present state of the art, P.G. & E. in California have had extension of their pruning cycles of up to two years, concurrent with significant "reductions" in sucker growth. In the former type of application, the general concensus of opinion amongst user Companies seems to be that there is a reduction of 40% to 60% in growth from resprouting and reductions in pruning time spent in each tree of between 5 to 15%.

Extensive work is being undertaken by Chemical Companies to develop desirable growth inhibitors. It is being calculated that utility companies in the United States spend approximately $125,000,000 per year for line clearance, a sum which indicates an area where expenditures are at least as great, if not greater, than the area of brush control.

Potential savings for a utility company in line clearing through

the use of growth inhibition is a difficult factor to arrive at, stemming mainly from the unavailability of information from reliable long-term research projects, involving applied field utilization, of substituted auxins In the case of Ontario Hydro, where our present man-hours per tree are 0.93 for pruning, calculation indicates that through the use of a fortified tree wound dressing it will be possible to effect time-savings of some 19%, equivalent to 0.2 manhours per tree./7/. Since research and development is not yet completed, it is envisaged that implementation of growth regulator applications on an Ontario-wide basis will not be possible until 1971. If this target is practical and there appears at this time no reason to be pessimistic, actual savings would not be apparent until 1975 since the majority of our work is run on a four-year pruning cycle. At that time there will be a calculated reduction from our projected work load in number of trees and our 0.20 time saving of some 81,600 manhours, equivalent to approximately 40 men. These resources, it is believed, will be used to further offset increasing work loads in relation to a compatible tree planting program which is to be promoted about that same time in Ontario. Projected benefits from using a fortified tree wound dressing are shown graphically in the Appendix.

History of Growth Regulators in Ontario Hydro

A sketch of the history in Ontario Hydro of growth regulators would perhaps serve to clarify where our present research started. During the past ten years a number of inhibiting chemicals have been evaluated experimentally to determine their utility in Ontario Hydro tree trimming operations.

Initially, maleic hydrazide (MH30) was examined during 1955 and 1956. Two considerations were viewed in the evaluation of results - the amount of retardation and the amount of plant injury as evidenced by foliaged distortion, and from death of stem tips. The latter was readily visible through observation; the former, i.e. amount of retardation, presented a greater problem for the species treated, primarily Acer saccharum Marsh and Fraxinus americana L. were affected quite differently amongst the various individual trees. Treatments were both aqueous and oil solutions of varying P.P.M. concentrations of MH30, 2,3,5 Triiodobenzoic acid, Alpha naphthyl methyl thiopropionic acid, and 2,3,6 Trichlorobenzoic acid. These were applied with a Knaprack sprayer as overall sprays with complete

coverage of the stems and leaves. All of the chemicals, except MH30, were initially dissolved in alcohol and then diluted (1:7) with water. Five to ten replicates were made for each species. In order to study the effects of pruning, the terminal growth of some stems was clipped before spraying. During 1957 further studies were made similar to those previously conducted, with the addition of Tetrachlorobenzoic acid. A basal banding technique was added to the methods evaluated.

The work on growth retardation performed in field treatments from 1955 to 1959 indicated that certain chemicals could inhibit new tree growth and perhaps prolong the pruning cycle. However, the data was not complete enough, at that time, to permit recommendations but suggested that more intensive work could provide the basis for suitable retardation methods. Moreover, it was stated that chemical applications must first be proven to be effective in retarding growth for at least one season without subsequent growth proliferation. The chemicals must be safe and not discolour tree foliage and economical methods of application had still to be devised. The report written at that time concluded, "At present the chemical retardation of tree growth is a long look into the future but a promising one"./8/.

Little activity follows this initial period of investigation as the technical difficulties and the ecomomic justifications did not appear to warrant further work. It was not until 1965 that any further research is noted, when the compound Hadracin and again the Benzoic acids were evaluated. However, problems caused by formative effects on leaves, chemical formulations, and the lack of personnel discouraged full-scale evaluation.

Thus, it is not until 1968 when a greater proliferation of chemicals and a more pressing economic climate coupled with increasing research amongst American utilities, do we start in earnest to develop, evaluate and, more important, resolve to implement the use of growth regulants, if their benefits could be proven.

Requirements for a Woody Growth Regulator

I would like now to suggest a number of requirements for a woody growth regulating chemical. Since 1949, a number of potential growth

inhibiting chemicals have been promoted. Because of the complexity in screening retardant chemicals, the extreme species specificity of those found promising and the unknown factors of effective concentrations and the long-term effect of chemical applications on woody plants, little data of a useful nature has been published. However, the major chemical companies are continually searching for newer and better compounds suitable for utility and agricultural purposes. Chemicals showing promise must meet several requirements. They should:

I - Reduce new sprout growth, that is, reduce apical dominance of interfering growth and retard lateral sprout formation from adventitious buds,

II - Be non-toxic to the plant on repeated application,

III - Exhibit little or no formative effects on woody growth or leaf cover, specifically avoiding malformation of foliage or the appearance of non-green pigments,

IV - Be harmless to people, animals and adjacent plants,

V - Be economically justifiable, providing suitable growth retardation, ease of application, reasonable cost of chemical and be effective at any season of the year and on any species of tree./8/.

Ontario Hydro Research Program in 1969/70

The last section of this paper deals with those areas which perhaps require more intensive research and development and a contribution from field research towards this requirement. Two main techniques have been practiced on a commercial scale. One method is to spray the growth retarding chemical onto the foliage just before or after the start of the growth phase. This spraying can be done on the unpruned tree but best results are obtained by spraying after pruning. The main shortcoming of foliar spraying is that the spray operation, in the case of Ontario, has to be carried out over the relatively short period of each year before the unfolding of the leaf and before any appreciable woody growth has occurred. Over this short period a large amount of spray equipment and

extra labour would be required which would be difficult to justify.

A tree paint retaining growth retarding chemicals which can be applied to a cut surface at the time of pruning appears to be a more attractive method of retarding growth in northern latitudes at this time. No extra operation is involved as in foliar application. Chemical costs and blending of the chemical into tree paint are small compared with the costs of overall pruning operations. Therefore, the emphasis of research has been initially placed on cut surface application of growth retardants, with some consideration given to such allied treatments as bark application or foliar treatments.

As can be seen by the flow chart in the Appendix,/9/ the research program is split between the Forestry Department of Operations Division and the Chemical Section of Research Division. The responsibilities for the program fall mainly on this writer and Dr. W.R. Effer. This co-operative program is, by the very nature of the number of chemicals involved, the rates required, and the tree species and replicates desired, a large and long-term project. The investigations in Ontario Hydro, therefore, are two-fold. The initial screening of chemicals and basic research which is conducted under the supervision of Dr. Effer and the field trials of more promising compounds under this writer's supervision. Dr. Effer is going to explain his work so I shall not encroach on his time save to say that we have a continual flow of information and data backwards and forwards, enabling us to benefit very quickly from current research.

The field trials of fortified tree wound dressings and a number of other substances have been conducted on four main species, picked because they represent the highest percentage of pruning time on our maintenance program. They are;

a) Salix species, specifically yellow and black Willow, Salix alba and Salix nigra,

b) Populus species, Aspen, large toothed Aspen and Balsam Poplar, Populus tremuloides, Michx., P. grandidentata, Michx. and P. balsamifera L.,

c) Fraxinus species, both White Ash and Black Ash, Fraxinus americana L. and Fraxinus nigra Marsh., and finally

d) Acer species, Sugar Maple, Silver Maple and Red Maple, Acer saccharun, Marsh. Acer saccharinum L. and Acer rubrum L. respectively.

Treatments

A minimum of three replicates per treatment per application date have been completed. Controls with either no treatment or our standard stores tree wound dressing have been set out during the trials, in the approximate ratio of 1 set of replicates to each control. The evaluative techniques used have been as follows:

I - On the Poplar and Birch up to two-thirds of the growing crown was removed with a single horizontal cut. The resultant cut surface was then treated. This method parallels our field operation of topping which often results in a considerable proliferation of sucker growth. Measurements were made on two tagged laterals and sucker growth recorded some two and five months after treatment.

II - Maple and Ash with a total height of from 40 to 60 feet had one large limb removed with a power saw from an Asplundh lift. These treatments would normally be at a point two-thirds of the way up the tree. In the larger trees it was possible to accomplish more than one cut from the aerial bucket.

III - The Willows and a number of Chinese Elm were treated in a similar manner. Measurement was made in this case of sucker growth, distance above or below cut, condition of the suckers and rate of occlusion. The callus growth was recorded in tenths of an inch. Wherever possible, a drop crotch pruning method was adhered to throughout since this has been the normal work method in our line clearing operations since the origination of the Forestry Department. The size of limbs removed would vary from 2 inches minimum to 10 inches maximum.

IV - The fourth method utilized has been the treatment of stumps specifically cut to chest height from suckering species of

about 30 to 50 feet in height. The object here was to determine the relative retardation effect of a number of chemicals in relation to separate untreated controls, or in some cases a concrescence of stems where one side would be left untreated.

Three main sites have been utilized, two on Ontario Hydro property at Delphi in the Georgian Bay Region of Ontario, at South River in Northeastern Ontario, and a third site on Department of Highways' property at Elmvale in Central Ontario. These three sites encompass the tree species that are mentioned in the section before in the sizes that parallel the conditions found on our lines. Location of these sites is given in the attached Appendix.

The various treatment techniques were devised to enable the research data to be correlated in a quantifiable way so that it may be treated statistically. An example dealing with the data collected from Pinus Resinosa, Ait., Red Pine can be found in the Appendix. In all cases the chemicals have been applied in close co-operation with the respective chemical companies. Wherever possible, Forestry crews have been seconded for the work, the trimming and tree wound dressing applications being done by them. Each individual treatment has been tagged, recorded and, in many cases, photographed. The reason for this intensive process is a) to forestall criticism that the work does not simulate true working conditions and b) to provide an accurate record of the results.

Despite considerable expenditures in time and effort amongst various utilities, very little scientific data would appear to have been published. Rather, very general papers outlining the advantages of possible use of these chemicals have appeared from time to time in publications, save for the Battelle Institute Research which is very comprehensive.

One of the problems which takes almost as much time as the actual treatments is trying to locate sufficient numbers of trees to utilize for the experiments. In the future, provision has been made for this type of work to be carried out at Pickering Generating Station, near Toronto. An 'L'-shaped parcel of 15 acres has been set out and some 10 acres planted. 600 Silver Maple, 350 White Ash, and 82 Basswood in the sizes 5 ft. to 8 ft. have been established. Some 6,000 seedlings have also been started. It

is intended that large Poplar and Willow along with some more seedlings will be planted in the Spring of 1970./10/.

Progress in this type of research can be very slow if the resources available, limit the time of testing to the growing season of each year. It has, therefore, been proposed that greenhouse space be acquired so that initial screening of chemicals and other operations can be carried out on smaller potted trees. After a cold period of approximately three months, these trees will be transferred to the greenhouse and dormancy broken in January, perhaps with the help of supplementary light. Preliminary data could then be obtained which can be applied to the larger nursery trees at the beginning of the normal growing season.

With these greenhouse facilities, it will be possible to carry out the sequential steps of screening of small stock, further evaluation of selected chemicals on nursery stock and field testing on full-size trees. Running concurrently with these steps, investigation will be made into such aspects as carrier formulation, rate of diffusion of compounds into the tree and reasons for variation between species.

Discussion of Results

The chemicals used in this study are detailed in the Appendix. Briefly, the active components are - formulations of CF125 and naphthalene acetic acid in various carriers, research materials submitted by the Amchem Company, our standard stores tree wound dressing, manufactured in Ontario by Sturgeon Ltd., and a spar varnish. This latter treatment provided some interesting data. It was included more out of interest as to the comparable benefits of any bitumen type tree wound dressing as against a protective paint.

The results of these first-year evaluations, a point which must be stressed as second-year growth may completely negate initial apparent advantages in the case of sucker control, are briefly as follows:

CF 125 - Foliar Treatments

This material was tried as a foliar spray on Poplar, some 15 to 20 feet in height. Suitable foliage cover was obtained with a hand sprayer. Concentrations of 50, 100,

and 200 P.P.M. in an aqueous solution were evaluated. 50 P.P.M. gave a 30 to 50% reduction in height growth and a 60 to 80% reduction in side growth. The greater concentrations were less successful. However, this experiment was conducted on a relatively small number of trees. An extension of this work will be undertaken in 1970 to disprove or validate these initial observations.

CF 125 - Banding and Cut Treatments

CF 125 will translocate rapidly upwards in all species to a maximum of 20 feet from point of application. However, there appears to be little lateral or radial movement, a point which may enable specific applications to be made for controlled effect on one side of a tree. The higher concentrations or a combination of these and their carriers are phyto-toxic to all species. Further, severe cambial damage is apparent where a half per cent or greater of this compound is applied to an open wound.

CF 125 - Reduction of Sucker Growth

The compound is active in reducing adventitious bud break and thus the number of suckers forming in close proximity to cuts. However, the downward movement of the chemical is limited and frill growth is exhibited at marginal levels of active concentration below the cut. There is some indication that growth may have been stimulated at this point.

CF 125 - In an Aerosol Can

An aerosol spray paint with one-quarter per cent active material is effective in promoting wound occlusion. Moreover, it indicates that rapid release of the compound is stimulating the callus tissue growth to an extent not shown with other carriers. This rapid release may defeat the purpose of prolonged growth inhibition as against a more controlled release from a "plastic" bitumen type carrier.

CF 125 - Conifer Applications

It has been shown that severe needle bunching is apparent on first and second laterals from the point of treatment on Red Pine. This needle bunching eventually results in dieback and terminal shoot mortality. On Spruces a 100 P.P.M. foliar treatment causes the growing leader to become completely disorientated. Where noticeable contortion is not a problem, this material may have a function as a short-term growth modifier instead of using a herbicide. Therefore, in summary, the material shows considerable promise, although extensive work on foliar treatments, concentration and carriers is indicated.

Naphthaleneacetic Acid Treatments

A 1% formulation in both an aerosol and a tree wound dressing have been tested. Translocation upwards from the point of application appears to be limited to some 10 to 20 inches and below the cut from between 4 and 6 inches, depending on the size of branch. Some radial movement was indicated. The formulation in the aerosol asphalt travelled further and is thought to have caused some minor leaf epinasty on Willow.

Reduction of suckers NNA will also reduce the degree of suckering in those species where suckering appears in the first growing season after pruning. Results, however, vary from tree to tree. Rate of occlusion is slightly enhanced, the aerosol being more effective in this respect.

Aerosol Treatments

Aerosol treatments were not significantly different from the tree wound dressing. Much of the comment made under this packaging method for CF 125 seems also to apply in the case of N.A.A. The asphalt formulation appeared to weather well in the first season.

Conifer Applications

The tree wound dressing was shown to be a more effective method of retarding lateral shoot elongation. Some needle

discolouration was noted but there were no phyto-toxic effects evident.

Summary

This material is available in a number of commercial forms. It will reduce sucker growth and to a lesser degree promote wound healing. In present form, the potential for concentration variations have been exhausted in the conclusions drawn from the work at Bettelle Institute. The material perhaps would offer more pronounced control with a different carrier or in combination with another substituted auxin. Effects differ noticeably between individuals of a single species. This compound would appear to be a useful standard on which to base the effectiveness of future chemicals.

Amchem Research Materials

Of the four materials submitted, two appeared to control suckering. None promoted wound occlusion to a significant extent. One of the two not referred to above appeared to cause cambiam dieback. One of the more attractive materials caused no needle discolouration on Red Pine, as was shown with the other three. This material was also the most effective substance of all those tested, in reducing Red Pine shoot elongation without producing needle epinasty.

Summary

Interesting materials, the chemical contents of which have not been disclosed by this, the first company to market a commercial formulation of NAA.

Spar Varnish

This material promoted callusing to a greater extent on a uniform basis than any of the other treatments. Moreover, the number of suckers were, on average, significantly less than on the controls. It is probable that the vigour

required for healing naturally diminishes the likelihood of adventitious bud break. Further research into the mechanisms involved may provide an interesting study.

Sturgeon's Tree Wound Dressing

This material is successful in sealing a wound. It would appear to inhibit the natural process of callusing. No apparent growth inhibition was noted on a uniform basis. This material may be a suitable carrier for active components in a fortified tree wound dressing.

Thoughts for the Future

Apart from some published data in the field trials with NAA, there appears to have been little or no work on the more fundamental aspects of woody growth control to date. Thus, I feel that consideration should be given to the following points if this group of chemicals, which has increasing importance in the light of criticism of present-day herbicides, is to provide the various users with a flexible, efficient and financially attractive chemical tool:

I - This group of chemicals should fall under the jurisdiction in Canada of the Federal Department of Agriculture and the Food and Drug Directorate who are responsible for administration of the Pest Control Products Act. This will require registration of these compounds, although there will, I have no doubt, be some chemical company resistance to this idea since registration can be a lengthy and also costly proposition. In the long run, this requirement can only enhance the position of this group of compounds and in the short term promote more intensive basic research. It is probable that, as this group of materials grows in importance, it would eventually fall under a modified section of the Act, but this is not to say that we should sit back and wait for that time.

II - Much greater research must be initiated into the diffusion and/or vollatilization of these compounds from their

respective carriers. I suggest that the aerosol can method of application, although attractive from a packaging and usage standpoint, is mainly fulfilling a customer requirement, while ignoring the resultant chemical release and translocation mechanisms compared with those of a heavy tree wound dressing.

III - More intensive work is required into the importance of species, age and size of tree along with the size and placement of cuts in relation to potential growth inhibition or, in the case of foliar treatments, the elongation of meristematic tissue.

IV - The factor of growing conditions, i.e. light regime, soil condition, moisture and latitude will affect response. The degree of such effect requires study to provide data on the optimum areas and times of application of these substances.

It must only be a matter of time before chemicals are available, not only for the control of sprouting and complete foliar treatments, but for grass retardation and in some instances to replace herbicides. Auxin control of plant growth mechanisms is, however, fraught with difficulties. The mode of action in many plants is little understood. Much of the research is less than scientific. Substances that affect growth being tested in biological and numerical permutations that are staggering in number in the hopes of finding a usable combination. Many of the chemicals so far developed and now used in woody growth research were first developed for horticultural or agricultural purposes. The short-term financial gains in these two fields are, of course, considerable and much of the research money in this field is devoted to this end.

The combination of basic research, chemical company development, commercial pressure and diligent work by all interested parties will, in the foreseeable future, I am sure, produce a group of chemicals which will, in the years to come, help to shape our environment to be a better place in which to live.

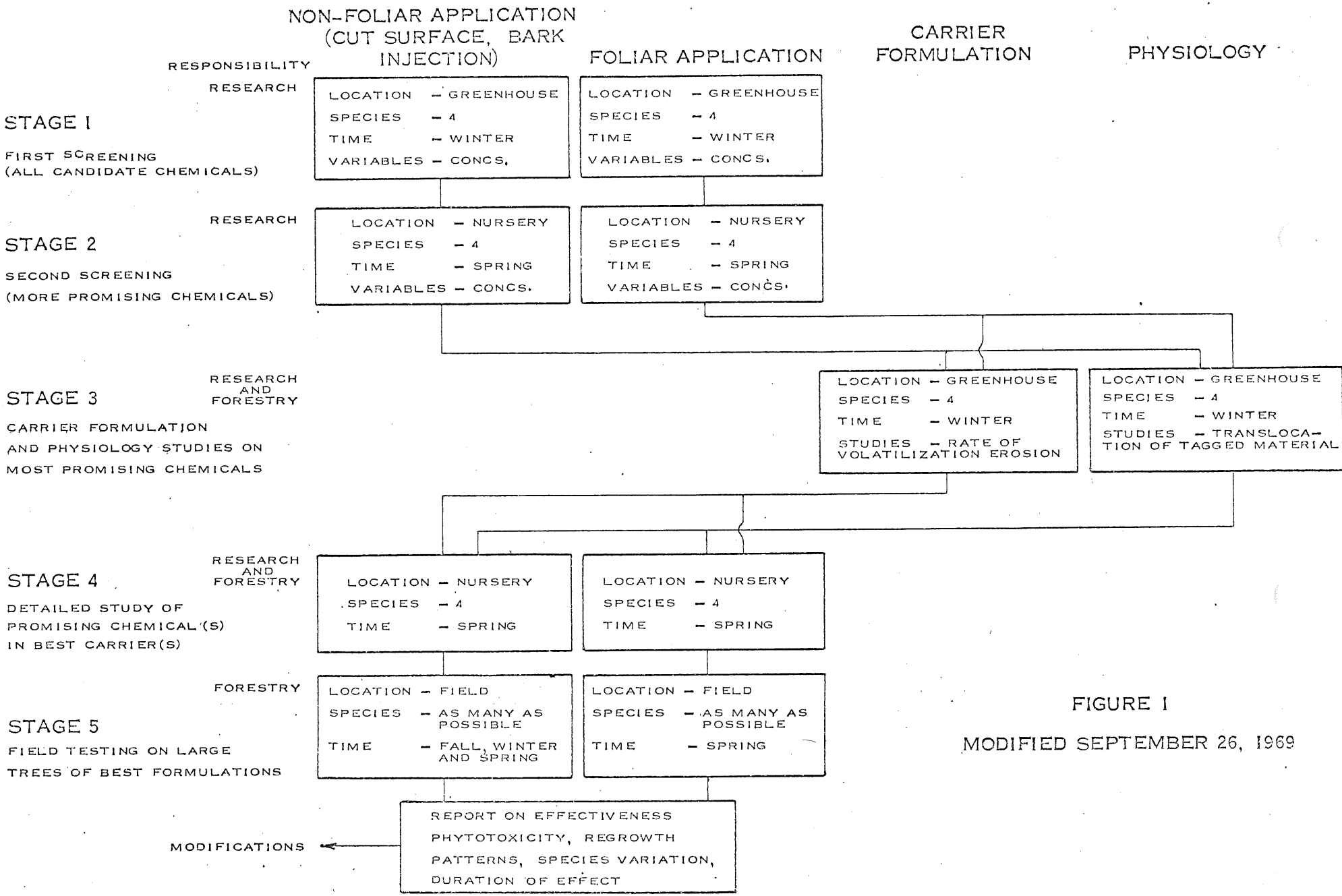

FIGURE 1

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Growth Control in Trees

A Collection of Studies on the Retardation of the Growth Characteristics of Trees with Synthetic Auxins

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