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CLONAL FORESTRY:

IT'S IMPACT ON TREE IMPROVEMENT AND OUR FUTURE FORESTS

LA FORESTERIE CLONALE:

SON IMPACT SUR L'AMÉLIORATION GÉNÉTIQUE DES ARBRES ET NOTRE FORÊT FUTURE

WORKSHOPS

1. PRODUCTION AND UTILIZATION OF GENETICALLY IMPROVED SEED
2. ISOENZYMES IN TREE IMPROVEMENT
3. NORTH AMERICAN QUANTITATIVE FOREST GENETICS GROUP MEETING

ATELIERS DE TRAVAIL

1. PRODUCTION ET UTILISATION DES SEMENCES DE QUALITÉ GÉNÉTIQUE AMÉLIORÉE
2. ISOENZYMES EN AMÉLIORATION GÉNÉTIQUE DES ARBRES
3. RÉUNION DU "NORTH AMERICAN QUANTITATIVE FOREST GENETICS GROUP"

Canadian Tree Improvement Association / Association Canadienne pour L'amélioration des Arbres

TORONTO 1983

PROCEEDINGS

NINETEENTH MEETING
PART 2

COMPTE RENDUS

DIX-NEUVIÈME CONFÉRENCE
2e PARTIE

EDITORS / RÉDACTEURS
L. ZSUFFA
R.M. RAUTER
C.W. YEATMAN

PROCEEDINGS

OF THE NINETEENTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT

ASSOCIATION

PART 2:

SYMPOSIUM ON

CLONAL FORESTRY: ITS IMPACT ON TREE IMPROVEMENT AND OUR FUTURE FORESTS

TORONTO, ONTARIO

AUGUST 22 - 26, 1983

EDITORS: L. ZSUFFA, R.M. RAUTER, C.W. YEATMAN

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Its Impact on Tree Improvement and Our Future Forests

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1985

COMPTES RENDUS

DE LA

DIX-NEUVIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR

L'AMÉLIORATION DES ARBRES

2^{e} PARTIE:

COLLOQUE SUR

LA FORESTERIE CLONALE: SON IMPACT SUR L'AMÉLIORATION GÉNÉTIQUE DES ARBRES ET NOTRE FORÊT FUTURE

TORONTO, ONTARIO

DU 22 AU 26 AOÛT 1983

RÉDACTEURS: L. ZSUFFA, R.M. RAUTER, C.W. YEATMAN

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1985

PROCEEDINGS OF THE NINETEENTH MEETING OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

Enquiries may be addressed to the authors or to Mr. J.F. Coles, Executive Secretary, C.T.I.A./A.C.A.A., Room 147, Johnston Hall, University of Guelph, Guelph, Ontario, N1G 2W1.

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The Twentieth Meeting of the Association will be held in Quebec, Quebec, August 19-23, 1985. Speakers will be invited to address the topic of "Accelerated Genetic Gains through New Technologies". Canadian and foreign visitors are welcome. Further information concerning the 20th Meeting should be addressed to: Dr. Armand Corriveau, Centre de Recherches forestières du Laurentides, C.P. 3800, Saint-Foy, Québec. G1V 4C7.

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La vingtième conférence de l'association aura lieu à Québec (Québec) du 19 au 23 août 1985. Des orateurs seront invités à s'adresser au sujet de "l'accelération du développement de la génétique grâce à la nouvelle technologie". Tous sont les bienvenus. Pour d'autres renseignements concernant la vigtième conférence, s'adresser à: M. Armand Corriveau, Ph.D., Centre de recherches forestières des Laurentides, B.P. 3800, Sainte-Foy (Québec) G1V 4C7.

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ACKNOWLEDGEMENTS

On behalf of the Canadian Tree Improvement Association, I gratefully acknowledge the Faculty of Forestry, University of Toronto, and the Ontario Forest Industries Aassociation for their support towards the icebreaker, banquet and invited speakers at the Nineteenth Biennial Meeting.

We are grateful to the Ontario Ministry of Natural Resources for providing the competent assistance of Louis Zsuffa (program), Jim Hood (local arrangements) and support staff Brad Graham, Dan McKenney, and Celia Graham.

The Association is also indebted to Sam Foster of the North American Quantitative Forest Genetics Groups, to Bill Cheliak and George Buchert for their organization of the isozyme workshop, and to Ben Wang and Doug Skeates of the Tree Seed Working Group for enhancing the C.T.I.A. conference with their annual meeting and workshop, respectively.

R.M. Rauter, Chairman

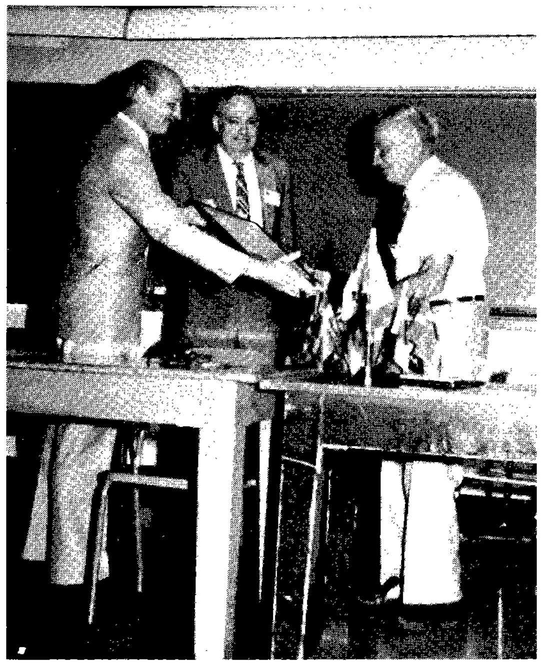
REMERCIEMENTS

De la part de l'Association canadienne pour l'amélioration des arbres je suis très reconnaissant à la Faculté de Forestérie à l'Université de Toronto, et à la "Ontario Forest Industries Association" d'avoir participé au "bris-glace", au banquet et aux discours au dix-neuvième conférence biennal.

Nous témoignons de la gratitude pour l'excellent appui de Louis Zsuffa (programme), Jim Hood (arrangements locaux), et Brad Graham, Dan McKenney et Celila Graham (auxiliaires) du ministère des Ressources naturelles de l'Ontario.

L'association sait gré à Sam Foster des "North American Quantitative Forest Genetics Groups", à Bill Cheliak et George Buchert d'avoir organisé l'atelier sur les isoenzymes, et à Ben Wang et Doug Skeates du Groupe de travail sur les semences forestières d'avoir contribué au conférence de l'A.C.A.A. en tant que hôtes du conférence annuel et de l'atelier.

R.M. Rauter, Président



Dr. V. Nordin, Dean of the Faculty of Forestry, University of Toronto and Mr. W.T. Foster, Deputy Minister, Ontario Ministry of Natural Resources, presents Dr. C. Heimburger with a plaque in recognition of his outstanding contributions to the knowledge and advancement of forest genetics and tree breeding.

M. V. Nordin, doyen de la faculté de foresterie à l'Université de Toronto et M. W.T. Foster, adjoint ministre, ministère des Ressources naturelles de l'Ontario donnent une plaque à M. C. Heimburger en témoignage de reconnaissance de ses excellentes contributions aux connaissances sur l'amélioration génétique des arbres et donc au développement de celle-là.

APPRECIATION/RECONNAISSANCE

DR. CARL C. HEIMBURGER

The Canadian Tree Improvement Association, the Faculty of Forestry, University of Toronto, and the Ontario Ministry of Natural Resources were proud to extend a special honour to Dr. Carl C. Heimburger at its 19th Biennial Meeting. Dr. Heimburger was presented with a diploma certificate and a special plaque in recognition of his outstanding contributions to the knowledge and advancement of forest genetics and tree breeing.

It was through Dr. Heimburger's foresight and enthusiams that tree breeding got its foundation in Canada in the 1930's. Dr. Heimburger continued to make historical progress in tree breeding, conducting most of his work in Ontario at the former Southern Research Centre in Maple.

Dr. Heimburger's contributions are acknowledged in Canada and throughout the world. He is particularly noted for his work in poplar breeding and white pine hybridization.

M. CARL C. HEIMBURGER

L'Association canadienne pour l'amélioration des arbres, la Faculté de Foresterie à l'Université de Toronto, et le ministère des Ressources naturelles de l'Ontario ont eu le grand plaisir de rendre honneur à M. Carl C. Heimburger au dix-neuvième conférence biennial. On a donné à M. Heimburger un diplôme et une plaque spéciale pour témoigner de notre reconnaissance de ces contributions extraordinaires aux connaissances sur l'amélioration génétique des arbres, et à son développement.

C'était grâce à la prévoyance et au enthousiasme de M. Heimburger que les canadiens ont commencé à s'intéresser à l'amélioration des arbres dans les années 30. M. Heimburger a continué à réaliser des progrès historiques en ce qui concerne l'amélioration des arbres; il fait la plupart de son travail à Maple, en Ontario, à l'ancien Centre de recherche du Sud.

Les contributions de M. Heimburger sont reconnues au Canada et à travers le monde. Ses travaux sur l'amélioration des peupliers et sur l'hybridation des pins blancs sont les mieux connus.

C.T.I.A. EXECUTIVE AND GUEST SPEAKERS

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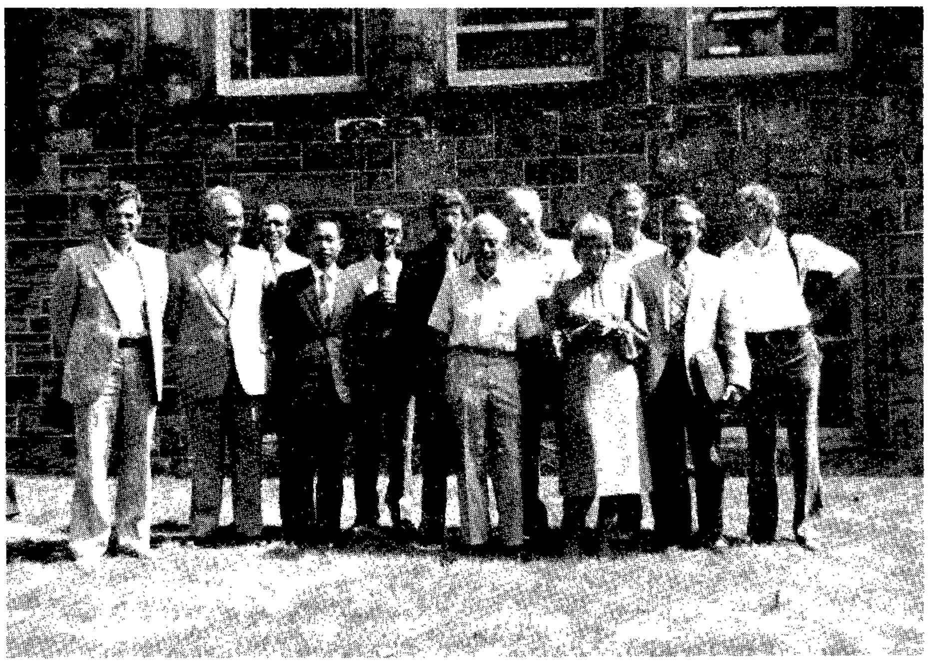

Dr. L. Zsuffa, Dr. A. Franclet, Dr. G. Vallée, Dr. K. Ohba, Dr. J. Bonga
Mr. J. Hood, Dr. C. Heimburger, Dr. W. Libby, Miss R.M. Rauter,
Dr. D. Fowler, Dr. B. Dancik, Dr. J. Kleinschmit.

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KEYNOTE ADDRESS

WILLIAM J. LIBBY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA
U.S.A.

KEYNOTE ADDRESS

POTENTIAL OF CLONAL FORESTRY

W.J. Libby
Professor, Departments of Genetics
and of Forestry and Resources Management
University of California
Berkeley, California
U.S.A. 94720

Keywords: Deployment strategy, Diversity, Maturation, Selection, Silviculture

INTRODUCTION

To most people, the word "clone" is not a neutral word.

To some, the images are wonderful and even magical, full of the promises of modern molecular biology.

To others, the word is ominous, leading inexorably to visions of that worst of all monocultures: large, dreary, and biologically unstable monoclonal plantations.

RECENT HISTORY

In Canada, clonal forestry was pioneered during the 1940's by Carl Heimburger, largely with poplars. Here and in most other parts of the world, the idea of a clonal forest of conifers was rarely addressed until about a decade ago. Except for a few species, most of which were hardwoods, the biological problems kept clonal forestry from serious consideration. Among those biological problems, now largely solved or understood, are maturation state, cutting environment, cutting condition, problems associated with other ways of cloning, and survival and growth of propagules.

Maturation State

It was logical to select outstanding trees as cutting donors for clonal trials and for use in forest plantations. Trees of at least half rotation age seemed likely to provide better information for selection than younger trees; thus mature trees were generally used as sources of cuttings. It only took a few rooting trials to learn that cuttings from mature trees did not root very well. Furthermore, those cuttings that did root didn't grow very well. But few of those hopeful early cloners realized that the maturation state of their cuttings was the problem. Even fewer thought that maturation state could be controlled, or better yet, manipulated. It now seems clear that maturation can be slowed, perhaps arrested, and maybe even reversed.

Cutting Environment

We have learned much about the physical environment of detached cuttings, and we now can modify that environment so that cuttings are maintained in a healthy condition prior to their rooting. We know (with less certainty) that many elements of that environment, such as bottom and top temperature, also affect the rooting event.

Cutting Condition

We have learned much about the physiological states of cuttings, and we have particularly gained experience with various plant-growh regulators that promote or otherwise affect rooting.

Diseases

We are beginning to learn about various important pathosystems and their interactions in various rooting environments. The low rooting percentages common in many early experiments were not so much rooting failures as pathogen successes.

Other Ways of Cloning

Grafting was occasionally used in order to produce genetic uniformity for various experiments, and even for large-scale propagation. Cost, stock-scion incompatibility, and variable rootstock effects have largely ruled out these uses. Grafting is still appropriately and effectively used for seed-orchards, breeding-orchards, gene archives, and in some urban-forestry operations. Organ- and callus-culture techniques have progressed from exotic science to become increasingly reliable alternatives to the more classical rooting of cuttings. Encapsulated embryoids may soon be the method of choice.

Survival and Growth

Much of the early skepticism with regard to the practical usefulness of rooted cuttings (stecklings) was based on their poor survival and early growth in field conditions. We are gaining experience with the after-care of newly-independent stecklings. Increasingly, we can produce healthy stecklings that survive as well and grow as well as the best nursery-produced seedlings.

In short, while we still need to know the answers to a lot of biological questions to do clonal forestry well, these biological questions are no longer of a disqualifying nature, such that they block further consideration. We can now begin to think seriously about other kinds of questions. Questions concerning the economics of clonal forestry, and policy questions related to clonal forestry, are and will be important. However, in this paper, I am going to focus on opportunities and strategies.

DO WE NEED A WHOLE NEW DESIGN?

A favourite analogy has to do with the strategies followed by three major U.S. aircraft builders following World War II, with respect to the civilian passenger market[1]. In the 1930's, Lockheed was producing their two-engine "10" and "14"' series, and Boeing came out with their "247" in 1933. Beginning in 1936, Douglas had the DC-3, which for years was thought by many to be the best and most reliable airplane in service. The four-engine Boeing Stratoliner appeared in 1940, and then further civilian development paused for World War II. Near the end of that war, Allied air crews got their first looks at German jet aircraft.

Following the war, piston engines continued to be used on civilian airliners for more than a decade. Douglas' wartime four-engine DC-4 was soon replaced by its popular DC-6. Boeing upgraded its Stratoliner to a Stratocruiser. In the early and mid-1950's, Douglas followed the DC-6 with a series of DC-7's, culminating in the large, long-range DC-7C. Lockheed added two engines and a tail to evolve its 10A Lodestar to its Constellation, and then to its wonderful Superconstellation. These 1950's models were about as good as big piston-engine airliners ever got.

Responding to much pressure and direction from Eastern Air Lines' Captain Eddie Rickenbacker, in 1959 Lockheed produced the Electra, the first U.S. civilian airliner with jet engines. The Electra looked like a fat DC-7, with turbojets mounted where the piston engines used to be. (Perhaps that was comforting to those who were used to the DC-7, and thought it was wonderful.)

Meanwhile, Boeing had been gaining experience with a jet-powered military tanker, which was designed to take advantage of the jet and to meet its requirements. By 1959, they had modified it for civilian passenger use, and entered that market with the 707. A year later, Douglas brought out the DC-8. It looked a lot like the 707. Since 1960, no new major long-haul airliner has looked anything like the wonderful and successful DC-3 or DC-7, and most have looked rather like the 707.

I now suggest, perhaps inappropriately, that those forestry enterprises that attempt to use stecklings or culture-origin plantlets or embryoids in a forestry system designed for seedlings will be creating something about as successful as the Electra. Further, those that persist with the tried and true seedling as the propagule of choice will be about as competitive as a 1983 airliner salesman with a lot full of new DC-7's.

But, what are the probable design changes that will produce 707-like clonal forestry?

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[1] The material on aircraft in this section, of which I know little, is from Wigton, D.C., 1963, From Jenny to Jet, Floyd Cramer, Los Angeles

BE CAUTIOUS WITH FANTASIES

I opened this talk speaking of promises of modern molecular biology and fears of unstable monocultures. I believe both are largely fantasies.

Molecular Biology Fantasies

As exciting as molecular biology is, there are several reasons that led me to believe that it will not soon provide much to forestry that is radically new. The first and most obvious reason is its expense. But clever people may solve the problems of expense.

A more serious problem is that plants produced by the more radical techniques of molecular biology will be totally new. And being totally new, they must be very carefully tested. Thus, the promise of faster entry of new clones to production forestry through molecular biology appears to me to be a fantasy, and perhaps a dangerous one. Because propagules for forest plantations must successfully occupy a variety of sites for very long periods, the tests of radically different trees should be conservative;i.e., they should be conducted on many sites for many years, exposing such trees to both the foreseen and unforeseen conditions that occur on operational plantation sites. It is the need for this conservative and long-term testing that will increase both the time and the expense of entering radically-engineered new clones.

In contrast, one may use clones whose histories include conventional selection from populations known to be adapted to plantation sites, followed by breeding, clonal testing, and further selection. Such clones are at least as reliable as seedlings from those same populations. They may be rapidly entered in large-scale use, with considerable assurance that most of them will not fail. This is not to say that radical new clones will never be used. It merely suggests that their use will (should) be neither soon nor cheap.

The safest technique and thus probably the most useful genetic-engineering technique for forestry, will be genetic surgery..... i.e., the insertion of single desirable genes (operons) into clones that are already outstanding in most other respects. At present, this technique is not operational with forest-tree species. Furthermore, few sufficiently outstanding recipient clones of forest trees are available..... perhaps the poplar clone I-214 is one such.

Large Monoclonal Fantasies

The fear of inexorable, large, unstable, monoclonal plantations is, I think, fear of a fantasy. Large monoclonal plantations are neither necessary nor likely components of clonal forestry. If they occur at all, they are best viewed as rather nasty management errors, and such errors may be avoided by education and/or regulation.

Well, none of the above leads obviously to our 707-like forestry.

SO WHAT IS TO BE REDESIGNED?

Production Options

With greater per-tree (or per-unit-area) productivity being acheived by genetic means, managers have the option of reducing the amount of land managed for harvest, or of increasing the total production on the previous land base. These options occur with any form of successful tree-improvement, but clonal forestry appears to offer the greatest genetic leverage.

Orchards

Classical tree-improvement has typically relied on seed-orchards to produce select stock at production levels. Seed-orchards also feature sexual recombination of the select genotypes, a mixed blessing at best. As clonal programs come on-line, seed-orchards will be replaced by much smaller and less demanding breeding-orchards, to satisfy the need for continued advanced breeding. It is appropriate to emphasize here that continued breeding will be as essential a component of clonal forestry as it is for classical tree-improvement. But for most clonal forestry, production-level multiplication of clones will be done in hedge-orchards, or by using young stecklings still in the nursery as donors, or by *in-vitro* propagation.

Returning to the airline analogy, piston-engine airliners still serve on local low-volume runs. Here the analogy breaks down. Seed-orchards are sensitive to economies of scale, and one can rarely justify a seed-orchard for local low volume demand. (In contrast, a relatively few hedges will satisfy such a special demand, and they can easily be included in a larger hedge-orchard.) Seed-orchards are site-demanding, can be labour-demanding when cones ripen, should be free of pollen contamination, and can have other annoying management problems. You may wish to take pictures of these wonderful old components of seedling-based forestry. If so, do it soon, for they will disappear soon after reliable clonal programs become available.

Nurseries

If clonal forestry employs plantlets or stecklings, nurseries will be substantially redesigned in their early operations and little affected in their later ones. Seed-handling equipment will be replaced by mechanized methods of sticking cuttings. If plantlets are employed, we will need new techniques and facilities to acclimatize the delicate plantlets from culture conditions to harsher field conditions. Compared to a seedling, a recently rooted steckling needs more attention to the early form of its roots, using either containers or root pruning for this purpose.

Once the stecklings or plantlets are well established, husbanding of their continued growth and their preparation for lifting will be very similar to what is (or should be) done for seedlings. If it becomes operationally possible to encapsulate cloned embryoids, then