Tree Breeding and Genetics in New Zealand

C. J. A. Shelbourne • Mike Carson

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Preface

As of the year 2018, tree breeding in New Zealand was 67 years old. *Tree Breeding and Genetics in New Zealand* is an account of its development since the late Ib Thulin, the future chief, arrived from Denmark in 1951. Our main motivation for writing this book was the realisation that I (CJAS) was the only tree breeder still surviving who had experienced much of the programme's development (and had contributed much to its thinking and planning). The thinking, the science behind it and the technology have evolved tremendously in that period. This account also demonstrates the international role the New Zealand programme possessed; overseas tree breeders actually came to see how we did it.

'Tree breeding', at the practical level, consists of the selection of superior parent trees to improve their offspring's characteristics that are defined by the breeder. The requirements of selecting 'good' parents, mating them and harvesting their offspring or clonal propagules are common to most domesticated species of plants and animals. The sciences on which this 'tree breeding' is based include genetics, especially quantitative genetics, and statistics. Latterly, genomics has become increasingly important in tree improvement. Plant geography has always been an important basis for planning, especially because all of the species we were improving were exotics, not native to New Zealand.

This book is useful in outlining the early work on provenance differentiation of the many conifers that were tested. A few of these rivalled the species under breeding and selection, but most did not. The tree species that eventually became subjects of breeding programmes were *Pinus radiata, Pseudotsuga menziesii, Pinus contorta, Eucalyptus regnans, E. nitens and E. fastigata*. We will attempt to trace the development of improvement programmes in several exotic tree species through a compendium of abstracts, summaries and summaries of summaries of reports, mostly published. It will also include comments and other contributions by us and the authors.

We see the book being a useful basis for teaching graduate students in forest genetics about the history of tree breeding and tree improvement in NZ. A full-scale provenance testing and plus tree selection programme was initiated in Douglas fir, but it was later realised that the northern coastal populations of the USA were

'wrong' and the breeding programme was put on hold for over 20 years, when the southern coastal USA provenances in the 1959 trials were used to restart the programme. There are many lessons to be learnt from these breeding programmes. Most important is the genetic constitution of the base population, which must include the best-grown and adapted provenances. Another critical choice is what traits to select for, sometimes not done on the basis of genetic parameters. A formal breeding objective is also needed to link trait heritabilities, trait intercorrelations and economic value.

Rotorua, New Zealand — C. J. A. Shelbourne
Ngongotaha, Bay of Plenty, New Zealand — Mike Carson

Acknowledgements

Tree breeder Ib Thulin retired in 1983 after a long career dedicated to genetic tree improvement in New Zealand. I joined his team in 1966 and retired in 2006, a work period of 55 years and 66 years till the present. I was aged 32 when I started to work with him at the New Zealand Forest Research Institute (FRI) and left the institute, renamed Scion, when I was 72.

This long period of time means there is opportunity for memory error, but this account will attempt to trace the development of the improvement programme in several exotic species through a compendium of abstracts, summaries and summaries of summaries of reports and publications. It will also include comments and other contributions by me and the authors. Reviews of some aspects of the programme are made in the following chapters.

The NZ Forest Research Institute was more of a research 'village' in the last half of the twentieth century. Everyone knew each other. Ib's office was at the back of what had once been stables (in the 1900s), and my office was up some steps overlooking the old building.

Various staff members all gathered inside or outside the Training Centre cafeteria at the morning and afternoon 'smokos' (tea and coffee breaks). Most lab-oriented groups were in Nissen huts (small portable army huts) to the west of the 'stable' offices. In the 1950s and 1960s, there were no more than half a dozen staff with PhDs in the whole of the FRI.

Important Colleagues

I don't have all the names of the various technicians who were responsible for establishing the early trials, but colleagues of the time include the following.

1950s and 1960s

Eric Appleton, later a South Island nurseryman, and Jap van Dorsser, who was initially involved in radiata pine plus tree selection, were later in charge of the FRI nursery. Trevor Faulds became a vital member of the group, raising seedlings of various species provenances and grafting (for the new seed orchards).

The late Egon Larsen, a friend of Ib from Denmark, was a key person in the early programme. He was particularly good at exploring the local distribution of species, especially in the Pacific Northwest, USA, and organising stand selection and seed collection of desired species. He was no longer with Tree Improvement when I joined, but his name was attached to one of the most important trials, the 1959 Douglas-fir provenance trial.

The late John Miller, a UK-trained forester working in Southland, joined the group in the mid-1950s as a scientist, based in the South Island at Rangiora, where he was later assisted for many years by Robin Parr. Geoff Sweet joined the group in the late 1950s, was producing numerous reports by 1962 and left to do a PhD in tree physiology at Aberystwyth, Wales, in 1964.

I was hired in 1965 while still a student at North Carolina State and started to work with Ib Thulin in late 1966. Mike Wilcox started about the same time as me with a new degree from Oxford, later completing a PhD at NC State in 1973.

1970s and 1980s

Mike Carson joined the group in 1976 and completed a PhD at North Carolina State, returning to New Zealand in 1982 with wife, Sue, also with a PhD in forest genetics, who specialised initially in disease resistance selection. The important members of the team included Gerry Vincent, who was originally a forest ranger responsible for trial inspection and maintenance and who later became a specialist in trial establishment and seed orchards, and, later, Tony Firth, who had been a research forester working in tree improvement in Zambia and became the main organiser of the practical side of the breeding programme. Rick Hand was there when I started but later ‘migrated’ to the Forestry and Timber Bureau in Australia.

There were many others in those early years, including Joe Hignett, Joe Thyne, Irene Steel, Mark Bollmann, Dave Briscoe, Theo Russell, Charlie Low and Jan Riley and later Tony Shorland, John Lee, Neil Woods, Mark Miller, Ruth McConnochie, Toby Stovold, Silvia Concheyro, Dean Witehira and Jodie Wharekura. John Ambrose, a Canadian forester, was involved for the first few years, and Hamish Levack, an NZ forester, was to have an important subsequent career in NZ forestry. Cathy Tosh, a Canadian, later did an advanced degree and eventually was in charge of the black spruce breeding programme in Fredericton, New Brunswick (my UNB alma mater).

1990s Onwards

Later, key researchers (several on sabbaticals and postdocs) included Bob Kellison, Randy Johnston, John King, Christine Dean, Luis Gea, Keith Jayawickrama and Satish Kumar. The late Paul Jefferson joined the group from Canada in the early 1990s, prior to his long stint as breeder for the Radiata Pine Breeding Company, and Luis Apiolaza for a brief period, prior to taking up his current professorial role at the University of Canterbury.

Others named in this document are experts who are well-known within their respective fields.

Images Used in This Book

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Editorial Assistance

With thanks to Sue Emms for the editorial assistance.

Contents

About the Authors

C. J. A. Shelbourne
(Chapters 1–15 are authored by Dr. Shelbourne.)

Before coming to New Zealand in 1958, Dr. Tony Shelbourne spent a year researching the ecology of bogs and swamps in New Brunswick, 3 years on species and provenance testing of eucalypts and tropical pines in Zambia and 3 years at North Carolina State University in the USA, studying for a PhD and working on the inheritance of bole straightness and compression wood of loblolly pine (*P. taeda*).

Academic Qualifications

Cyril Joseph Anthony Shelbourne BA Oxon. 1958, MSc New Brunswick 1959, PhD North Carolina State University, 1966

No current memberships of societies

Three Important Papers

C.J.A. Shelbourne 1969: Tree breeding methods. Technical Paper 55, Forest Research Institute, New Zealand Forest Service, Wellington.

C.J.A. Shelbourne, R.D. Burdon, S.D. Carson, A. Firth and T.G. Vincent 1986: Development plan for radiata pine breeding. Forest Research Institute, Rotorua, New Zealand.

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International Consultancy

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6069-15852 C.J.A. Shelbourne 1995: The future development of tree breeding in Chile

C.J.A. Shelbourne 1994 Tree Breeding in sub-tropical China

C.J.A. Shelbourne 1993 South African sabbatical

Mike Carson
(Chapter 16 is authored by Dr. Carson.)

Currently director of Carson Associates Ltd., Dr. Michael Carson has worked in the forestry research sector for more than 40 years as, variously, principal scientist, science manager, programme manager, managing director and consultant.

Academic Qualifications

BForSc (Hons – 1st Class), 1976, University of Canterbury

PhD (Forestry, Genetics), 1982, North Carolina State University

Apptd. Honorary Lecturer, 1993, School of Forestry, University of Canterbury

Professional Associations

New Zealand Institute of Foresters, Royal Society of New Zealand

Three Indicative Papers

CARSON, S.D., DJOROVIC N., DJORORVIC A., CARSON M. J., and R. BALL 2003 (submitted Genetics) Simulation of QTL detection and MAS for quantitative traits II: Comparison of gain and selection bias for alternate experimental designs including selective genotyping and map density.

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International Consultancy

Provision of tree breeding and biotechnology consultancies to forest companies in the USA, Canada, Chile, Argentina, Brazil, PNG, Australia and New Zealand

- Currently designing and implementing a breeding programme for NZ Manuka (Leptospermum sp.) for Comvita NZ Ltd
- Currently designing and implementing a breeding programme for improvement of *Khaya*

- spp. for plantations in Northern Australia and Brazil
- Recent review for Arauco, Chile, validating progress in achieving genetic gain in pine
- plantations
- Reviews of tree breeding programmes in Argentina, PNG, Canada and the USA

Abbreviations and Acronyms

AS	Advanced selection
BLUP	Best linear unbiased prediction
BRQ	Branch quality
BVs	Breeding values
DBH	Diameter at breast height
CF	Clonal forestry
CNI	Central North Island
CP	Clonal propagation
Cpt	Compartment
CRISPR	Clustered regularly interspaced short palindromic repeat
GE	Genotype environment
GF	Growth and form
GxE	Genotype x environment interaction
GTI	Genetics and tree improvement
GCA	General combining ability
GPa	Gigapascal
HGT	Height
HS	Half-sib
IUFRO	International Union of Forest Research Organisations
MFA	Microfibril angle
MOE	Modulus of elasticity
MPa	Megapascal
NI	North Island
OP	Open pollinated
QG	Quantitative genetic
Rep	Replications
RF	Rep x family
RPBC	Radiata Pine Breeding Company
RSGCA	Recurrent selection for general combining ability
SCA	Specific combining ability
SI	South Island

Sib	Sibling
SPM	Stems per square metre
SSO	Seedling seed orchard
Ssp	Subspecies
STP	Single tree plot
STR	Straightness
TI	Tree improvement

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