

Forest genetic and tree improvement research in the US: past, present and future

REVIEW ARTICLE

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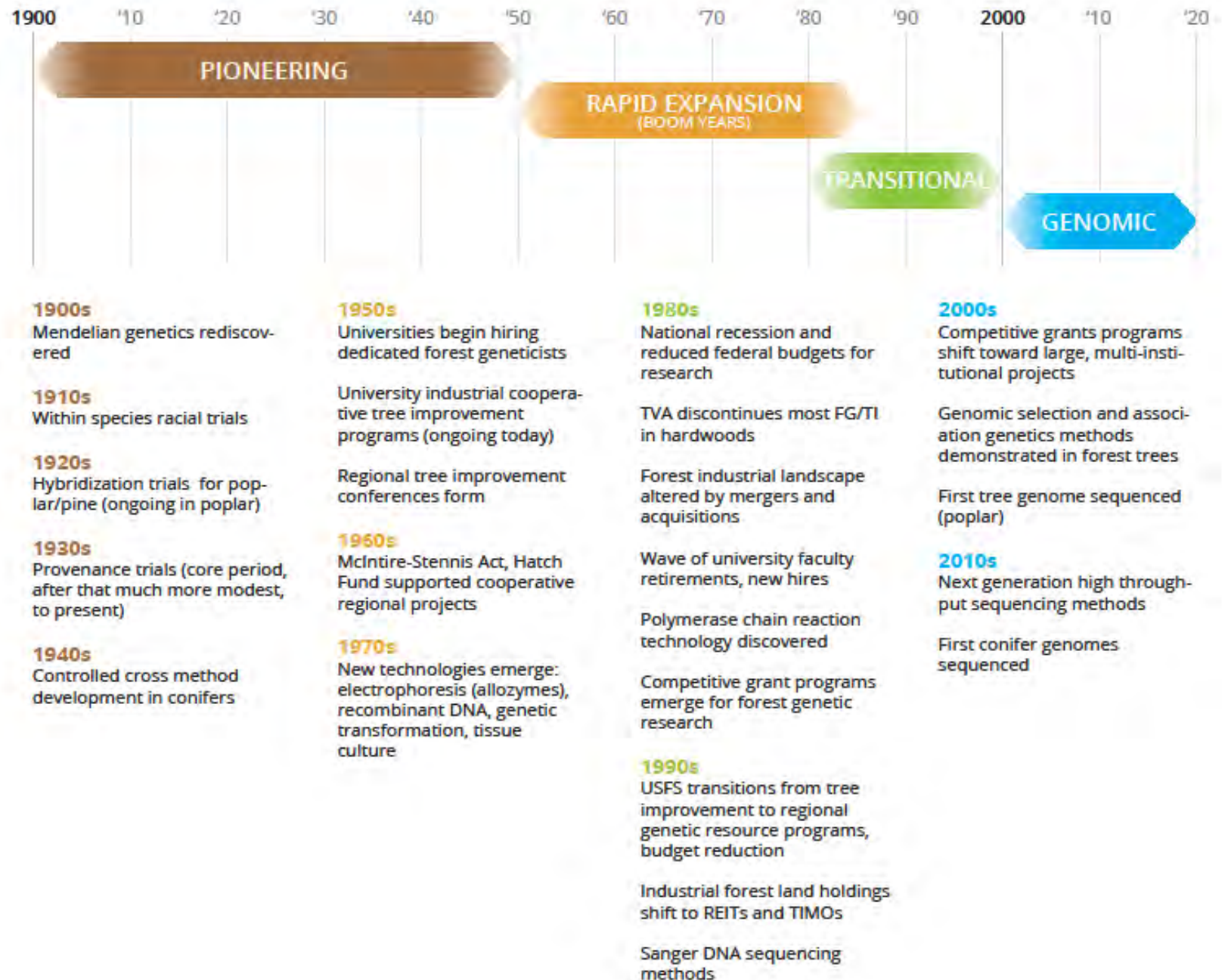
The Evolution of Forest Genetics and Tree Improvement Research in the United States

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Overview

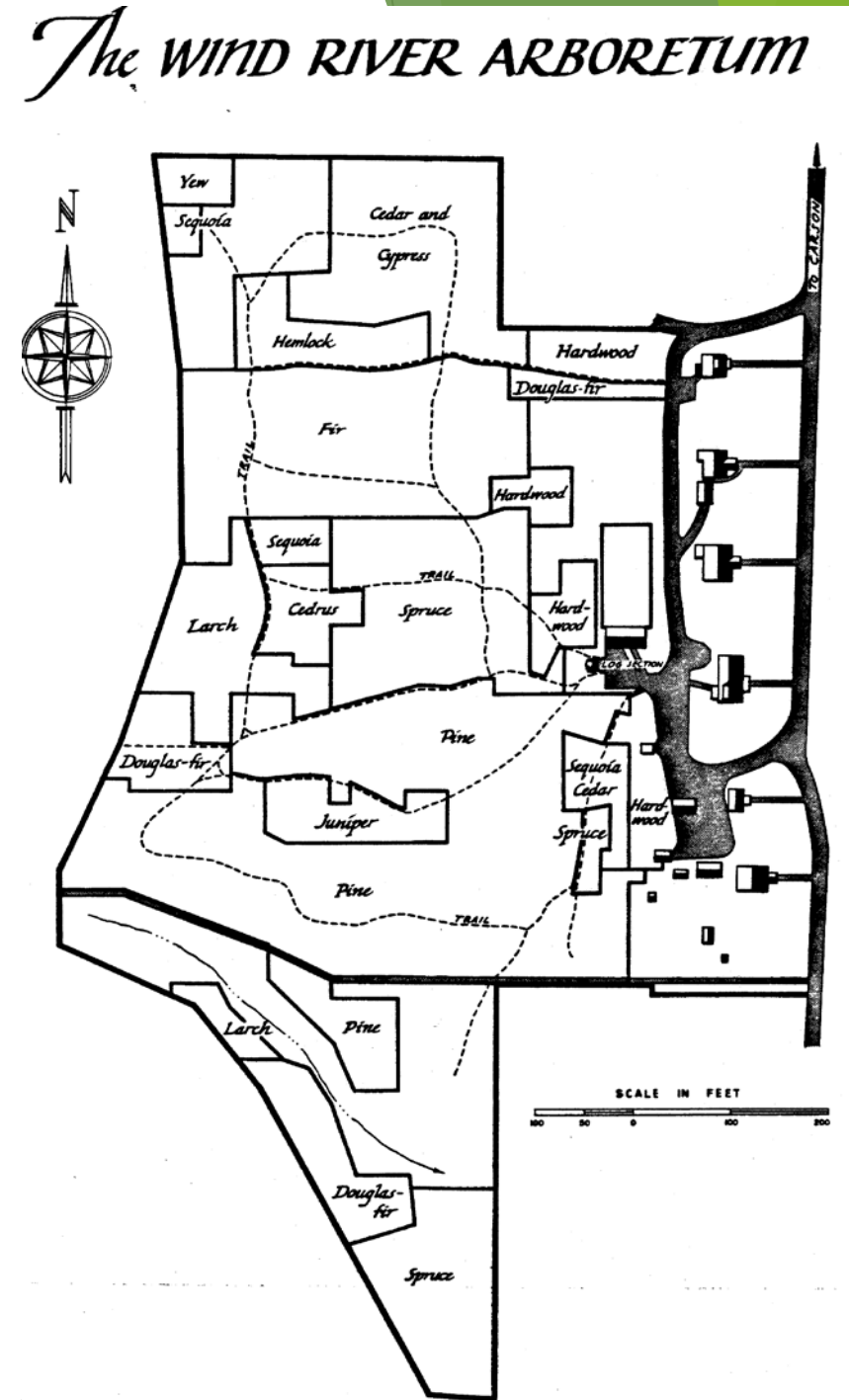
- ▶ Forest genetics (FG) research began in the US over 100 years ago
- ▶ FG slowly emerged as a distinct and important discipline w/i forestry; an important element in forest management
- ▶ Coupled with tree improvement (TI), FG enjoyed rapid expansion for over three decades (1950's – 1980's)
- ▶ Subsequent 30 years saw dramatic contraction and transformation of both FG and TI
- ▶ What led to the decline
- ▶ Why FG/TI may be more important than ever
- ▶ How do we reboot

Major eras in the evolution of forest genetic and tree improvement research in the United States, including seminal decadal activities, discoveries and new technologies.



The Pioneering Era of Forest Genetics in the US

- Early 20th century marked by rapid advances in the science of genetics and plant/animal breeding. Early foresters eager to follow.
- USFS establishes first experiment station in Arizona (1908); the Wind River Arboretum and experiment station along the Columbia River, in Washington State, in 1912.
- Species, hybrid and provenance trials predominated early forest genetics research activities for several decades, directed in large part by the USFS. (SN)



The Rapid Expansion Era - A High Tide of Interest and Activity (1950 - 1985)

- ▶ “Almost everyone wants to climb onto the bandwagon” **

Growth in all sectors of the forestry community was rapid and well funded.

By the early 1980's, FG research activities at:

- 65 private companies

- 22 state agencies

- All USFS regions and experiment stations

- Virtually all Research 1 University forestry schools

- Major and minor University / Industrial Coops



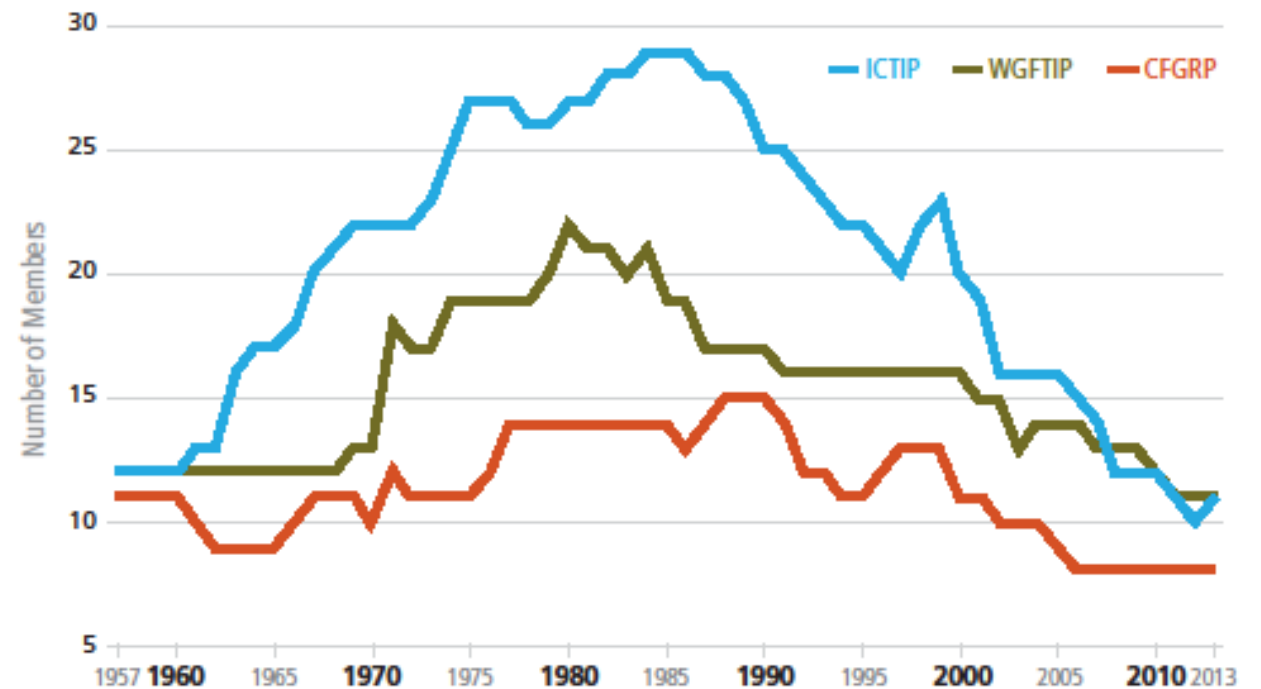
** Righter, F.I., C. Heimburger, C.M. Kaufman, S.N. Wyckoff, P.O. Rudolf, E.J. Schreiner, A.E. Squillace, R.I. Bingham, and J.W. Duffield. 1954. Briefs of forest tree improvement work in North America by region or organization. *J. For.* 52: 681-693.

Universities

- ▶ First course in forest genetics taught at Yale (1954).
By 1980, few forestry research programs without a geneticist on staff.
 - ▶ Graduate training became a central focus; competition for support would become stiff. Students finding jobs.
 - ▶ Facilitated by McIntire-Stennis and Hatch funding
 - ▶ Early efforts focused on provenance source trials, TI for non-industrial species and ultimately, population genetics.

University / State / Industry Tree Improvement Cooperatives

- ▶ 1951: Texas Forest Service Tree Improvement Cooperative (Zobel). 1969 WGFTIP.
- ▶ 1953: CFGRP at the University of Florida
- ▶ 1955: PNWTIC (now at Oregon State Un)
- ▶ 1956: ICTIP at NCSU
- ▶ 1968: Inland Empire TIC
- ▶ Smaller programs at U Tennessee, Michigan State U, U. Minnesota, PSU.
- ▶ Enduring and consequential FG/TI applied and basic research endeavors



Corporate Programs

- ▶ Integrated forest products companies developed internal FG/TI programs or hired trained geneticists to interact with cooperatives.
 - ▶ Competition was stiff; some staffs were very large.



Non-Industrial Programs

- ▶ USFS greatly expanded efforts in FG/TI research, both basic and applied. (SN)
- ▶ TVA : extensive hardwood and softwood TI programs for productivity and mast.
- ▶ State programs

Collectively, over 120 forest tree species were being studied.

Ancillary Activities

- ▶ Regional Tree Improvement Conferences
- ▶ Regional Cooperative Programs (Hatch)
 - ▶ NE 27 (SN)
 - ▶ NC 99 / 51

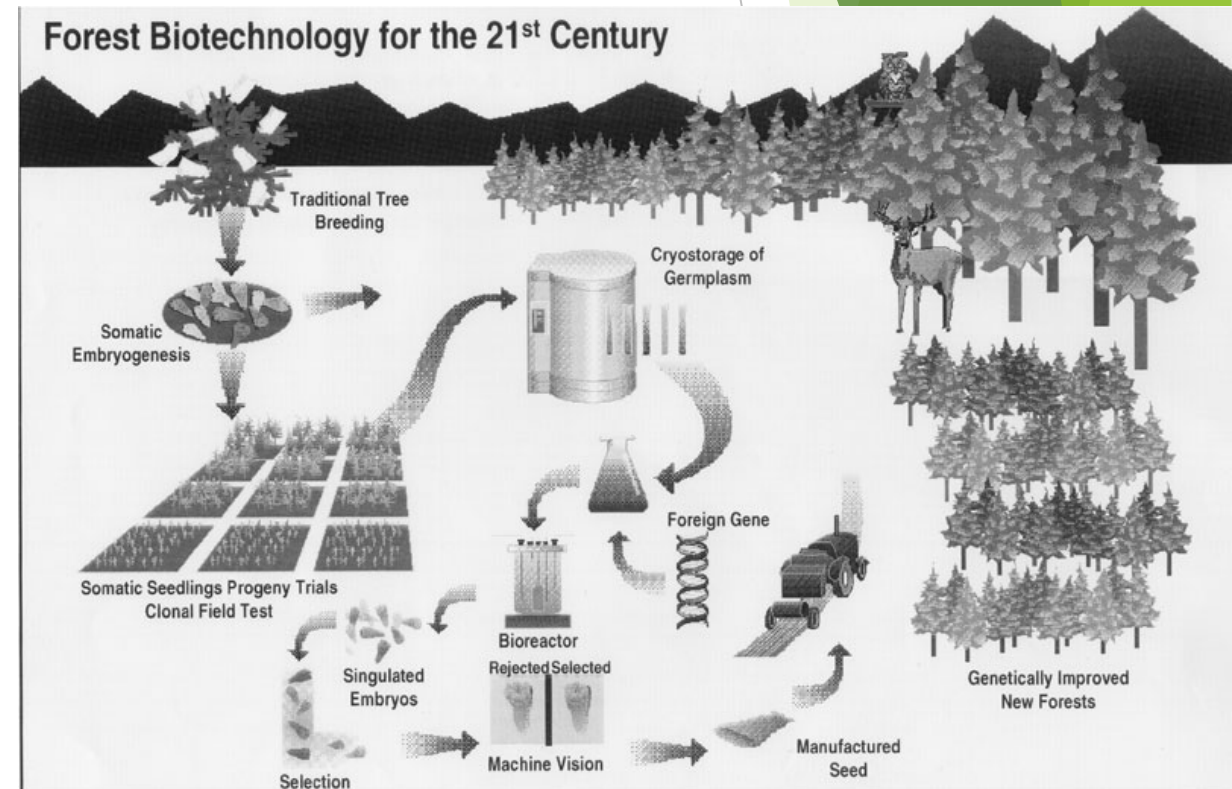
Conference Affiliation	Years of Operation
Southern Forest Tree Improvement Conference	1951 – Present
Northeastern Forest Tree Improvement Conference	1953 – 1980's
Lake States Forest Tree Improvement Conference	1953 - 1980's
Central States Forest Tree Improvement Conference	1959 – 1980's
Western Forest Genetics Association	1955 - Present

New Technologies Change the Face of FG/TI Research

Biotechnologies (SN)

- ▶ Electrophoresis
- ▶ Tissue culture
- ▶ Genetic Engineering
 - ▶ Emergence of an array of new research tools and approaches, collectively called biotechnology, brought infusion of funding, novel research goals, and new crop of graduate students.

Lure of Clonal Forestry

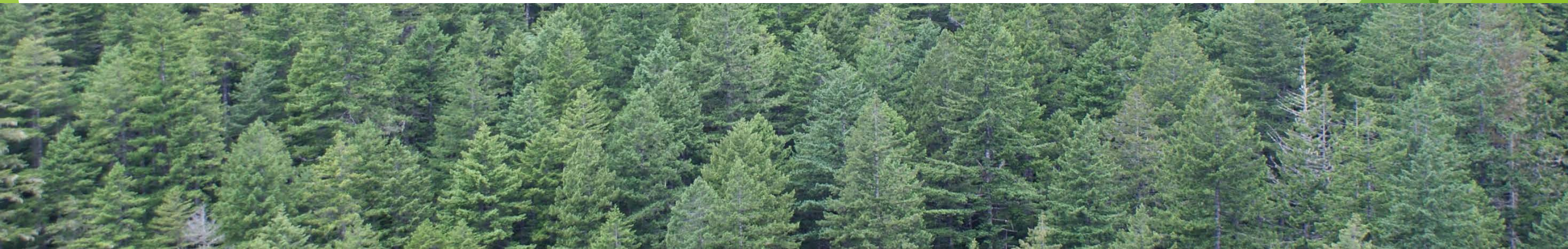


The Transitional Era: FG/TI Research Begins Rapid Decline

Even as interest and engagement in FG/TI was flourishing in the early 1980s, social and economic forces were emerging that would soon cause a reversal of fortune in FG/TI research, a trend downward that has continued for 30 years. Notably,

- Retirements
- Timber companies reduced or eliminated FG/TI programs
- USFS closed or severely cut back on FG/TI projects; embraced ecosystem management
- TI conferences discontinued or became sporadic; Regional cooperative projects were abandoned
- Small university/industrial coops disappeared, large coop memberships declined

How could there have been such a rapid decline in support of FG/TI research?



Contributing Factors to Decline:

Budgetary Constraints (SN)

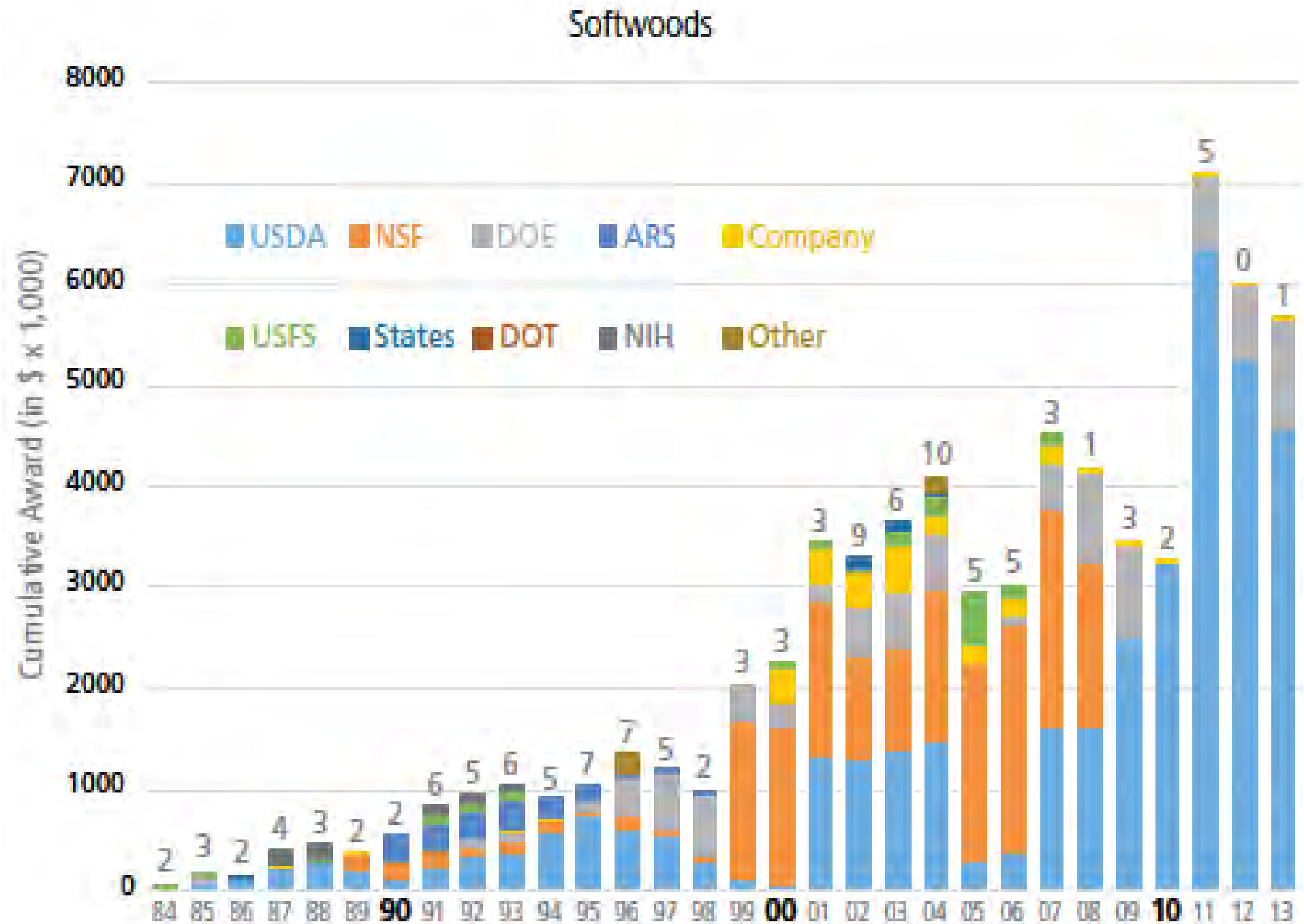
Early 1980's saw the nation experience a severe depression.

USFS budgets significantly reduced; TI programs renamed (RGRP); staff reductions (~25 in 2015)

University programs faced fiscal challenges (MacStennis and Hatch); reduced genetics faculty; transition to reliance on federal grants.

State programs reduced

Cumulative total
dollars awarded
by granting
agencies for
forest genetic
research



Contributing Factors to Decline: Irrational Exuberance

The Period of Rapid Expansion was fueled by the belief that forestry's biggest challenge was to improve productivity, and that science, including genetics could meet the challenge. FG/TI programs proliferated for dozens of species. (SN)

“Unreasonable optimism, divorced from practical reality, about the power of science and the efficacy of scientists is not unusual, but it had a particularly strong effect on FG/TI.” Kim Steiner in JOF article.

Photo: Scott Schlarbaum; Watauga Red Oak Seed Orchard, an example of a very successful, long-term minor species TI program

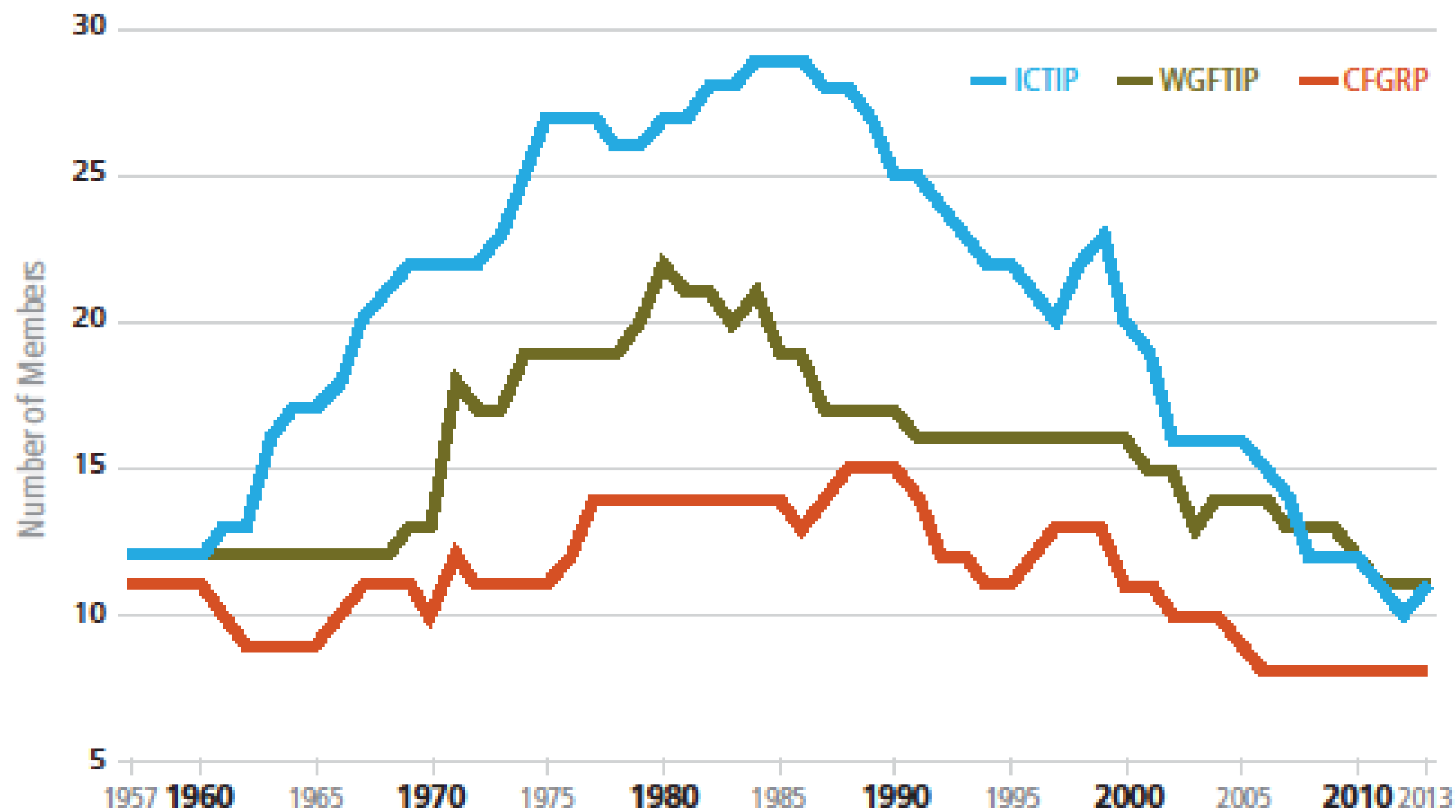


Contributing Factors to Decline: **Industry Mergers, Acquisitions and Conversions**

In the late 1980's and early 90's, corporate mergers reduced the number of integrated forest product companies

In the 1990's and 2000's, large-scale divestitures of forest lands to REITs and TIMOs.

As a result, companies largely discontinued FG/TI programs and TI Cooperatives saw a reduction in their memberships



Contributing Factors to Decline:

Elevated Priority for Ecosystem Management

- ▶ USFS philosophical and strategic approaches to research changed.
 - ▶ Dramatic decline in old growth timber harvests
 - ▶ Move from long term to short term research
 - ▶ Emphasis on Ecosystem Management
 - ▶ Conservation and restoration



V.J. Erickson: Region 6 zone geneticist

Contributing Factors to Decline: **Advent of Biotechnology**

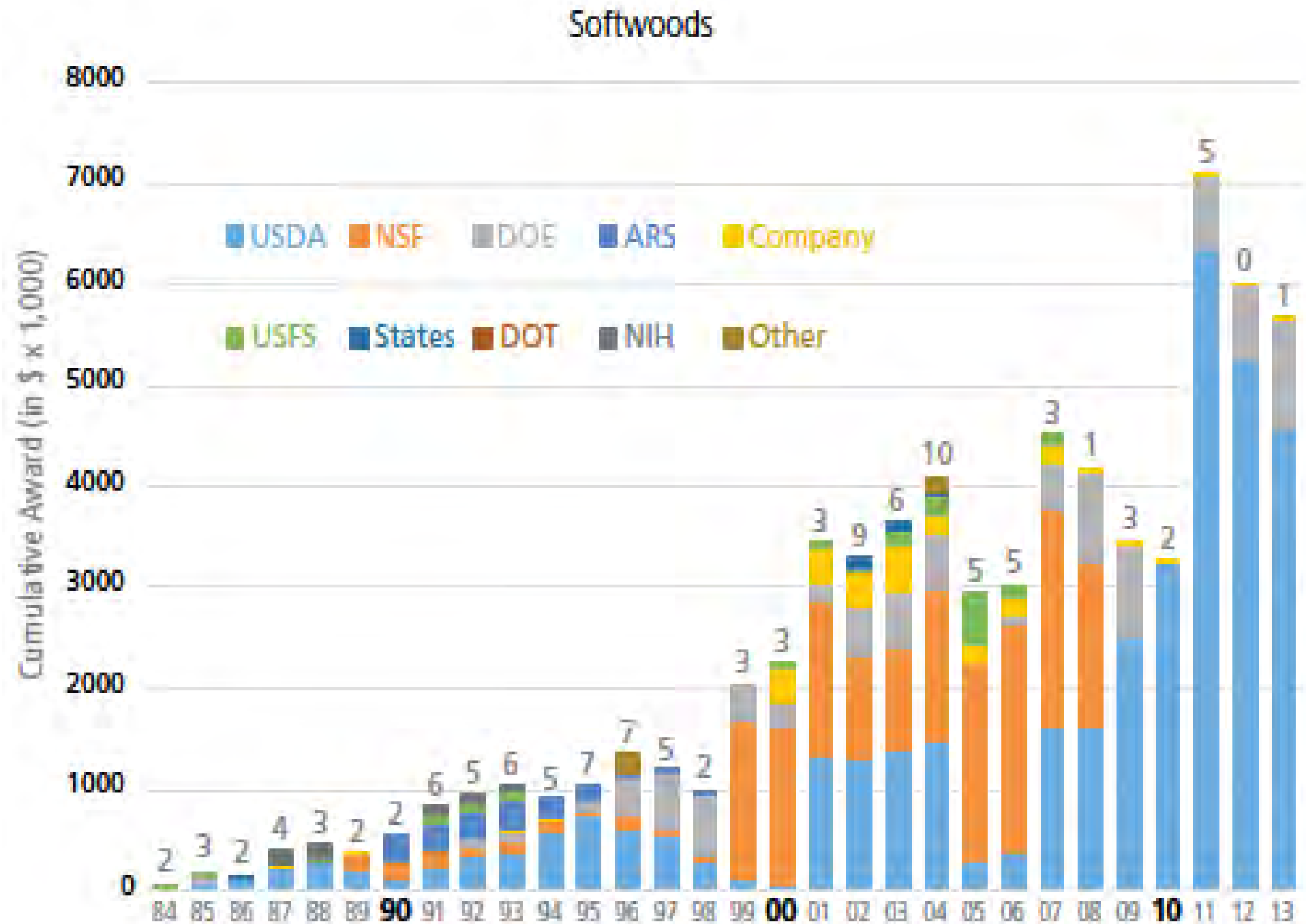
- ▶ Electrophoresis / Allozymes
- ▶ Genetic Engineering
- ▶ Tissue Culture

(SN)

Genomics Era

- ▶ Development of high-throughput sequencing, genotyping and gene expression technologies ushers in a new era.
- ▶ Granting agencies shift from individual investigator awards to large multi-investigator/institutional awards

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Institutional Affiliation of Lead Principle Investigators
Receiving Federal Grants, and The Number of Grants
Received Between 1984 and 2013. (SN)

Taxa	Institution Receiving Funding								
	OSU	NCSU	MTU	USFS	UCD	UF	PSU	VT	UGA
Softwoods	11	41	9	27 ¹	4	10	-	-	3
Hardwoods	34	10	23	2	3	2	6	6	5

Status

- In the US, perhaps fewer than 25 Ph.D scientist in applied TI.
- Approx. 60 faculty members at 25 universities involved in some aspect of forest genetics work.
- USFS has ~12 scientists, 25 staff overall
- Only one university (NCSU) still teaches a full course in forest genetics
- Another wave of retirements is nearing.
- Many genomics researchers have little or no forestry background.
- Relatively few jobs and few candidates to fill them.

Key Issues Before Us

► Plantation Forests

- Unique lack of industrial investment for improvement in a major crop
- Significant investment in basic genomics research but lack of translational support

► Natural Forests – Forest Health Issues

- Native and introduced pests and diseases
- Climate change

► Notable lack of long-term institutional support and trained scientists

Forest Health Issues

- ▶ American Chestnut (chestnut blight)
- ▶ Elms (Dutch elm disease)
- ▶ White Pines (blister rust)
- ▶ Butternut (canker)
- ▶ Beech (beech bark disease)
- ▶ Eastern Hemlocks (wooly adelgid)
- ▶ Oaks (SOD)
- ▶ Ashes (emerald ash borer)
- ▶ Pines (pine beetles)
- ▶ Black Walnut (thousand cankers disease)
- ▶ Eastern Hardwoods (gypsy moth)



Whitebark pine mortality, Wind River Range, Wyoming. Photo credit: Bruce Bongarten



Lodgepole pine mortality due to mountain pine beetle: www.weedimages.org

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Management and Policy Suggestions

- ▶ We propose that a balanced and broad-based model should be taken to fund and support future FG/TI research in the United States. (SN)
 1. A balance of long and short term funding (renewed investment in infrastructure to deal with emerging forest health issues)
 2. Formation of a national coordinating board
 3. Investment in education: trained personnel and lay public



Thank You

SAF Meeting in November - 5 speaker panel