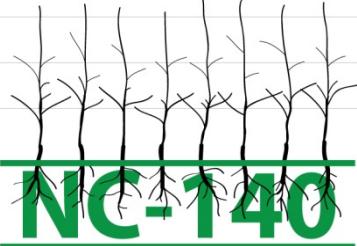




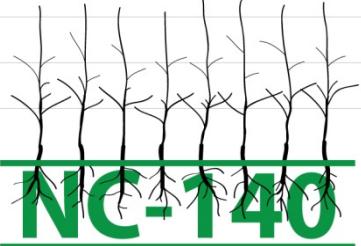
NC-140 Regional Rootstock Research Project: Past, Present, Future

Wesley R. Autio
Winfred P. Cowgill, Jr.



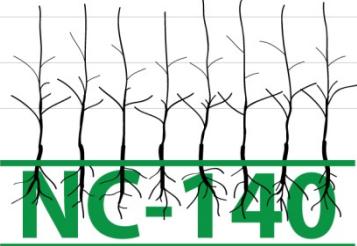
Pre-NC-140 History

- Morrill Act of 1862 – Land Grant
- Hatch Act of 1887 – Experiment Stations
 - Amended in 1955 – formula funding
- Research & Marketing Act of 1946
 - 25% of Hatch Funds for regional research
 - Regional Experiment Station Associations
 - South (SAAED) - 1946
 - Northeast (NERA) - 1947
 - North-Central (NCRA) - 1947
 - West (WAAESD) - 1948



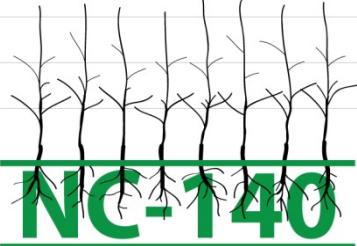
Pre-NC-140 History

- Dwarf Fruit Tree Association – 1958, Hartford, MI
 - Jerry Mandigo, H.B. Tukey, Bob Carlson, and Wally Heuser
- NC-78 – Rootstocks for Horticultural Crops
 - Mid 1960's to 1970 – rejected
- NCR-82 Stock/scion Relations in Horticultural Plants
 - AK, IL, IN, IA, KS, MA, MI, MN, MO, NE, ND, OH, SD, WI
 - Developed first NC-140 proposal
 - Developed first cooperative trial, planted in 1976
- IDFTA Rootstock Research Committee -- 1976



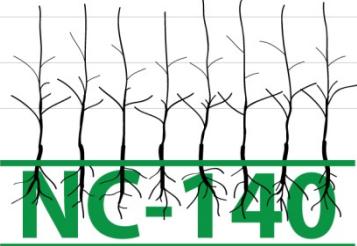
NC-140 Beginnings

- First approved project, 1977-1982
- “Scion/Rootstock and Interstem Effects on Apple Tree Growth and Fruiting”
- Objectives:
 1. Evaluate production efficiency over a wide range of climactic conditions.
 2. Investigate propagation and compatibility.
 3. Ascertain cause of decline on new and existing rootstocks and enhance survival.



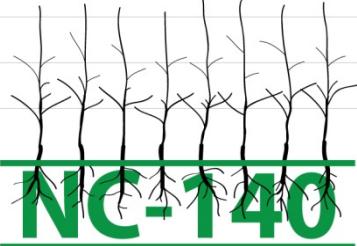
NC-140 First Participants

Don Dinkel	University of Alaska	S. Steinegger	University of Nebraska
Roy Rom	University of Arkansas	Jim Cummins	Cornell University
Roy Simons	University of Illinois	Neal Holland	North Dakota State University
Dick Hayden	Purdue University	Dave Feree	Ohio State University
Paul Domoto	Iowa State University	Mel Westwood	Oregon State University
Neil Miles	Kansas State University	Ron Peterson	South Dakota State University
Ray Lockard	University of Kentucky	Joe Costante	University of Vermont
Bill Lord	University of Massachusetts	Frank Gilbert	University of Wisconsin
Bob Carlson	Michigan State University	Aleck Hutchinson	Vineland, Ontario
Harold Pellet	University of Minnesota	Gilles Rousselle	St. Jean, Quebec
Aubrey Hibbard	University of Missouri		



Over 36 years

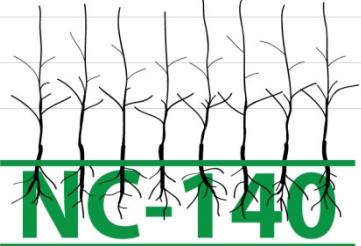
- Eight 5-year projects proposed and approved
- Began with apples, expanded to other tree fruit
 - Peaches in 1984
 - Sweet and tart cherry in 1987
 - Pear in 1988
 - Plum in 1990
 - Apricot in 2014
- Outreach increased in importance
- Scope of objectives has expanded



NC-140 Plantings -- Apple

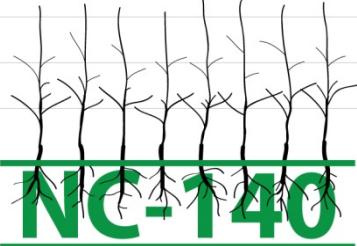
- **Trials: 14 finished, 5 underway, 3 planned**

- 1976 Interstem – Delicious, Empire – 9 sites
- 1980 Delicious Rootstock – 18 sites
- 1981 Delicious Rootstock – 6 sites
- 1984 Delicious Rootstock – 27 sites
- 1990 Cultivar Rootstock – Golden D., Jonagold, Empire, Rome – 12 sites
- 1990 Gala Rootstock – 8 sites
- 1990 Systems – Empire, Jonagold, Delicious, Fuji – 9 sites
- 1992 Liberty Rootstock – 13 sites
- 1993 Liberty Rootstock – 14 sites
- 1994 Gala Dwarf Rootstock – 25 sites
- 1994 Gala Semidwarf Rootstock – 23 sites
- 1999 McIntosh Dwarf Rootstock – 10 sites
- 1999 Fuji Dwarf Rootstock – 8 sites
- 1999 McIntosh Semidwarf Rootstock – 10 sites
- 1999 Fuji Semidwarf Rootstock – 6 sites
- 2002 Gala Rootstock – 11 sites
- 2003 Golden Delicious Rootstock – 14 sites
- 2003 Golden Delicious Rootstock Physiology – 20 sites
- 2006 Gala Replant Rootstock – 11 sites
- 2010 Honeycrisp Rootstock – 15 sites
- 2010 Fuji Rootstock – 7 sites
- 2014 Honeycrisp Rootstock
- 2014 Fuji Rootstock
- 2014 Organic Modi Rootstock



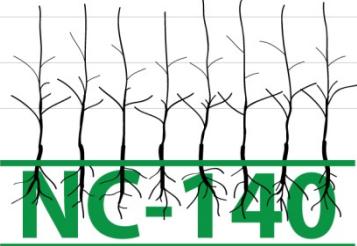
100 Apple Rootstocks

East Malling	Russia Czech Republic	Michigan Germany	Japan Poland	Geneva	Geneva	Geneva Vineland Various
M.4	B.9 Europe	MAC.1	JM.1	CG.2034	CG.6002	G.11
M.7 EMLA	B.9 NA	MAC.24	JM.2	CG.3001	CG.6008	G.16
M.9	B.10	MAC.39	JM.4	CG.3007	CG.6103	G.30
M.9 Burgmer 756	B.490	Mark	JM.5	CG.3029	CG.6210	G.41
M.9 EMLA	B.491		JM.7	CG.3902	CG.6239	G.65
M.9 Fleuren 56	B.496	PiAu 9-90	JM.8	CG.4003	CG.6253	G.202
M.9 NAKBT337	B.7-3-150	PiAu 36-2	JM.10	CG.4004	CG.6521	G.935
M.9Nic29	B.62-396	PiAu 51-4		CG.4013	CG.7707	
M.9 Pajam 1	B.64-194	PiAu 51-11	P.1	CG.4214	CG.7760	V.1
M.9 Pajam 2	B.67-5-32	PiAu 56-83	P.2	CG.4222	CG.8096	V.2
M.9/MM.111	B.70-6-8	Supp.1	P.14	CG.4247	CG.8189	V.3
M.9/O.11	B.70-20-20	Supp.2	P.16	CG.4814	CG.8228	
M.9/Ant. Seed.	B.71-7-22	Supp.3	P.18	CG.5087	CG.9934	C6
M.26 EMLA		Supp.4	P.22	CG.5179		OAR.1
M.26 NAKB	J-TE-G			CG.5222		O.3
M.27 EMLA	J-TE-H			CG.5935		A.313



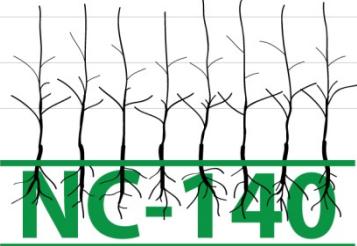
NC-140 Plantings -- Peach

- **Trials: 8 finished, 2 underway**
 - 1984 Redhaven Rootstock – 16 sites
 - 1994 Redhaven Rootstock – 22 sites
 - 2001 Redtop Rootstock – 4 sites
 - 2001 Redhaven Rootstock – 6 sites
 - 2001 Cresthaven Rootstock – 8 sites
 - 2002 Redhaven Rootstock – 10 sites
 - 2002 Cresthaven Rootstock – 9 sites
 - 2002 Cresthaven Physiology Rootstock – 7 sites
 - 2009 Redhaven Rootstock – 16 sites
 - 2009 Physiology Rootstock – 13 sites



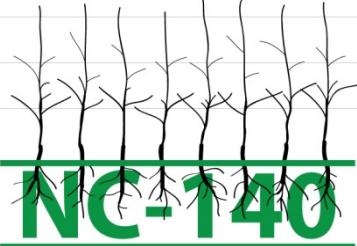
>50 Peach Rootstocks

1984 Trial	1994 Trial	2001 Trials	2002 Trials	2009 Trials
Halford	TN 281-1	BH-4	Adesto 101	Viking
Siberian C	Nemaguard	SLAP	MRS 2/5	Atlas
Citation	Stark's Redleaf	SC-17	Penta	BH-5
GF 677	GF 305	Cadaman	Krymsk 1	Mirobac
GF 655-2	Higama	Julior	Krymsk 2	KV010-123
Damas 1869	Montclar	Jaspi	Pumiselect	KV010-127
Lovell	Rubira	Pumiselect	Cadaman	Krymsk 1
Bailey	Ishtara	Hiawatha	Lovell	Krymsk 86
	Myran	Controller 5		Empyrean 2
	S.2729	Controller 9		Empyrean 3
	Chui Lum Tao	K146-44		Imperial Cal.
	Tzim Pee Tao	Krymsk 1		HBOK 10
	H7338013	Lovell		HBOK 32
	H7338019	Bailey		<i>Prunus americana</i>
	BY520-8			Fortuna
	Guardian			Controller 5
	Lovell			Guardian
	Bailey			Lovell



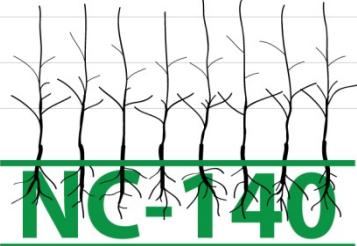
NC-140 Plantings -- Cherry

- **Trials: 6 finished, 1 underway, 2 planned**
 - 1987 Bing Rootstock – 6 sites
 - 1987 Hedelfingen Rootstock – 3 sites
 - 1987 Montmorency Rootstock – 9 sites
 - 1998 Bing Rootstock – 6 western sites
 - 1998 Hedelfingen Rootstock – 5 eastern sites
 - 1998 Montmorency Rootstock – 5 sites
 - 2010 Benton, Skeena, Regina, Bing Systems Rootstock – 11 sites
 - 2015 Sweet Cherry Rootstock – 6-12 sites
 - 2015 Tart Cherry Rootstock – 3 sites



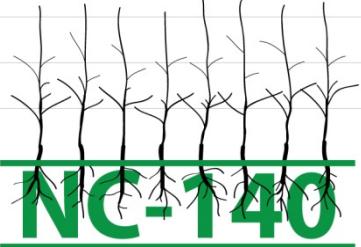
>40 Cherry Rootstocks

1987 Trials	1998 Trials	2010 Trials	2015 Trials
GI.148/1	Tabel Edabriz	Gisela 3	Gisela 5
GI.154/7	Gisela 4	Gisela 5	Gisela 12
GI.172/7	Gisela 5	Gisela 6	Krymsk 5
GI.173/9	Gisela 6		Krymsk 6
GI.195/1	Gisela 7		MSU Cass
GI.195/2	GI.195/20		MSU Clare
GI.196/4	GI.209/1		MSU Clinton
GI.196/13	GI.318/17		MSU Kent
GM.9	Weiroot 10		PiKu 1
GM.61/1	Weiroot 13		PiKu 4
GM.79	Weiroot 53		MxM.14
MxM.2	Weiroot 72		Mahaleb
MxM.39	Weiroot 154		
MxM.46	Weiroot 158		
MxM.60	Mazzard		
Colt	Mahaleb		
Mazzard			
Mahaleb			



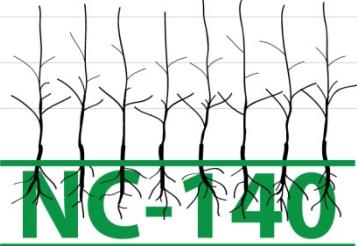
NC-140 Plantings -- Pear

- **Trials: 4 finished, 1 underway, 2 planned**
 - 1988 Rootstock – multiple varieties – 17 sites
 - 2002 Rootstock – d'Anjou, Bartlett, Bosc – 4 sites
 - 2004 Rootstock – Concorde, Taylor's Gold – 2 sites
 - 2005 Rootstock – d'Anjou, Bartlett, Bosc – 5 sites
 - 2012 Rootstock – d'Anjou, Bartlett – 3 sites
 - 2013 Rootstock System – d'Anjou, Bartlett, Bosc – 4 sites
 - 2015 Rootstocks – 10 sites



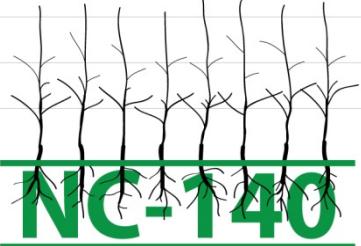
>25 Pear Rootstocks

1988 Trials	2002 Trial	2004 Trial	2005 Trial	2012 Trial	2013 Trial
OHxF.40	708-36	OHxF.87	708-36	A1	Pyro 2-33
OHxF.217	Fox 11	OHxF.97	BM 2000	A4	OHxF.69
OHxF.333	Fox 15	Pyrodwarf	Fox 11	A7	OHxF.87
OHxF.339	OHxF.40		Horner-4		
OHxF.513	OHxF.87		Pyrodwarf		
EM Quince C	Pyrodwarf		Pyro 2-33		
<i>Pyrus calleryana</i>	Pyro 2-33		28-119		
<i>Pyrus betulaefolia</i>	Winter Nellis		BU-2		
Bartlett sdlg			BU-3		
			Winter Nellis		



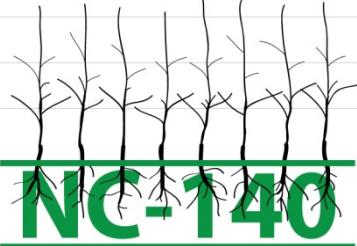
NC-140 Accomplishments

- Rootstock evaluation much faster
 - Many sites and many climactic/management conditions
- Defined rootstock characteristics, for example:
 - Mark identified as a potential dwarf rootstocks for some regions, but performed poorly in hot arid regions or without irrigation
 - B.9 identified as a possible replacement for M.9
 - Clonal differences in M.9 characterized
 - G.30 identified as an efficient semidwarf rootstock, but with a brittle union
 - Rootstock effects are consistent among varieties
- Developed procedures for managing multi-site trials, handling the data, and disseminating the results



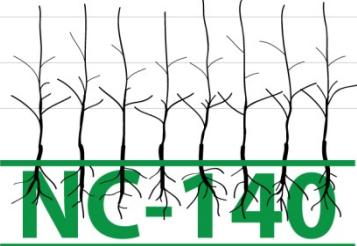
NC-140 Accomplishments

- Extensive outreach through talks, extension articles, trade journal articles, websites, and eXtension
- Enhanced networking of North America's pomologists
- Guided all rootstock recommendations in North America and affected them worldwide
- NC-140 cooperators have introduced molecular approaches to breeding programs, greatly enhancing breeding efficiency



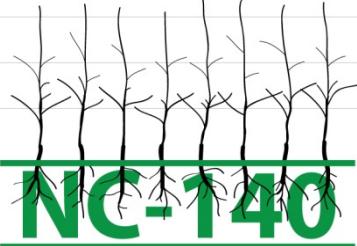
NC-140 Impacts

- Effects of NC-140 recommendations over the last 10 years:
 - Guided planting of 300,000 acres,
 - Resulted in earlier returns, higher yields, greater size, and better packout = financial benefit of \$300,000,000,
 - Reduced tree size reduced pesticide by 40% with financial and environmental benefits of \$100,000,000
 - Adoption of disease-resistant rootstocks reduced tree losses by 10%.
 - State/Federal investments in NC-140 estimated to have been about \$10,000,000, with resulting grower benefits in excess of \$400,000,000



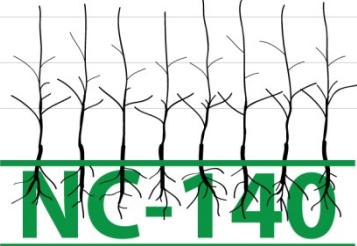
NC-140 Now

- Current project, 2012-2017
- “Improving Economic and Environmental Sustainability in Tree-fruit Production through Changes in Rootstock Use”
- Objectives:
 1. Study the influence of rootstocks on tree fruit grown under varying environments using sustainable systems
 2. Develop improved rootstocks using modern genomic tools
 3. Increase adoption by:
 - (a) improving propagation techniques
 - (b) acquiring new rootstocks from worldwide sources
 4. Better understand biotic and abiotic stresses.
 5. Develop and distribute information utilizing eXtension

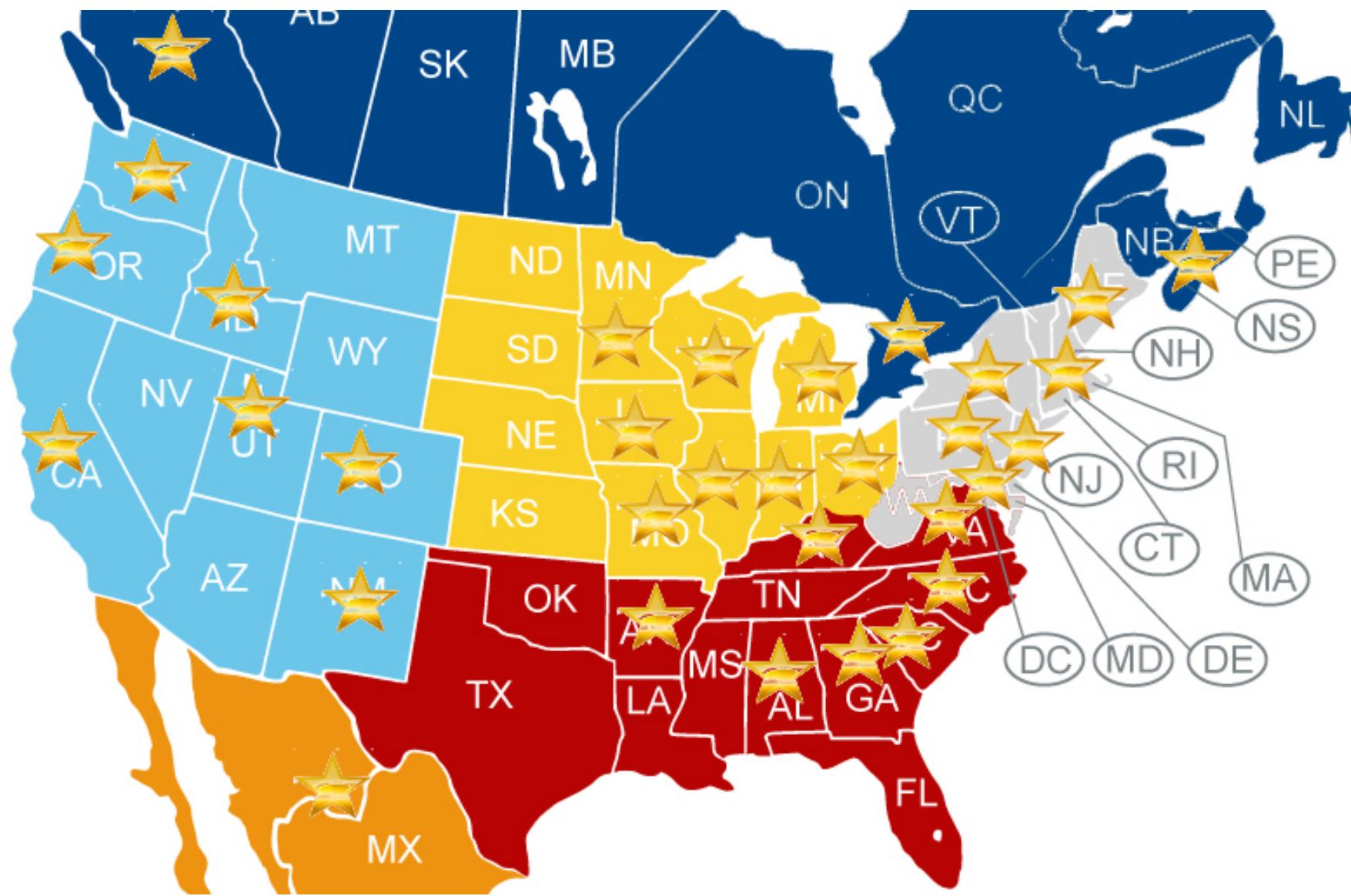


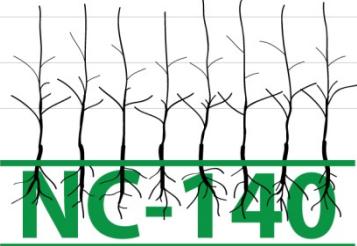
NC-140 Current Participants

Coneva, Elina	Auburn University	Lang, Greg	Michigan State University	Crassweller, Rob	Penn State University
Rom, Curt	University of Arkansas	Perry, Ron	Michigan State University	Marini, Rich	Penn State University
Elkins, Rachel	CA Cooperative Extension	Hoover, Emily	University of Minnesota	Schupp, Jim	Penn State University
DeJong, Ted	University of California Davis	Warmund, Michele	University of Missouri	Reighard, Greg	Clemson University
Atucha, Amaya	Colorado State University	Cowgill, Win	Rutgers University	Beckman, Tom	USDA-ARS -- Georgia
Fallahi, Essie	University of Idaho	Yao, Shengrui	NM State University	Fazio, Gennaro	USDA-ARS -- New York
Kushad, Mosbah	University of Illinois	Hoying, Steve	Cornell University	Black, Brent	Utah State University
Hirst, Peter	Purdue University	Robinson, Terence	Cornell University	Peck, Greg	Virginia Tech
Domoto, Paul	Iowa State University	Parker, Mike	NC State University	Dhingra, Amit	WA State University
Archbold, Doug	University of Kentucky	Miller, Diane	Ohio State University	Evans, Kate	WA State University
Moran, Renae	University of Maine	Einhorn, Todd	Oregon State University	Stasiak, Matt	University of Wisconsin
Walsh, Chris	University of Maryland	Hampson, Cheryl	British Columbia, Canada		
Autio, Wes	University of Massachusetts	Ana Luisa Chavez-Jimmenez	Cuauhtimoc, Mexico		
Clements, Jon	University of Massachusetts	Cline, John	University of Guelph		



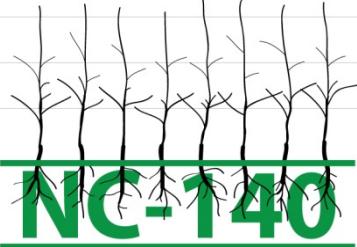
NC-140 Participation





NC-140 Future

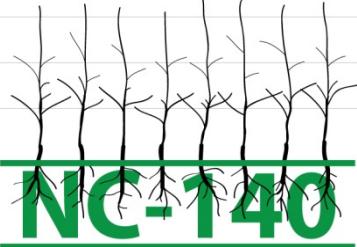
- Access new rootstocks from all sources and evaluate them for North America
- Develop improved rootstocks using modern genomic tools
- Study the physiology and responses to biotic and abiotic stresses
- Study of rootstock propagation
- Improve electronic delivery of rootstock recommendations



NC-140 People



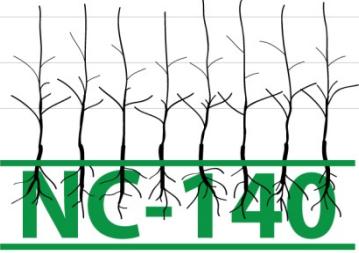
Dick Hayden (IN) chaired the first NC-140 Meeting in Geneva, NY, 1977. Photo, 1984.



NC-140 People



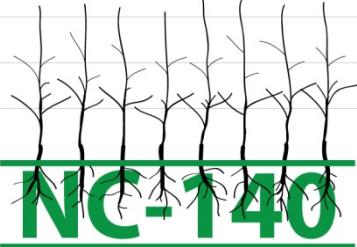
Dave Feree (OH), 1977.



NC-140 People



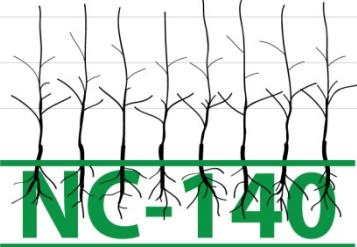
Roy Rom (AR), 1983.



NC-140 People



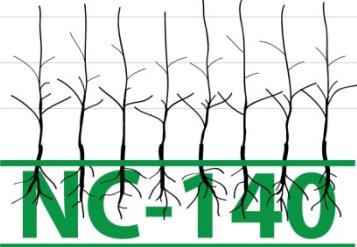
Bill Lord (MA), Jim Cummins (NY), and
Bruce Barritt (WA), 1983.



NC-140 People



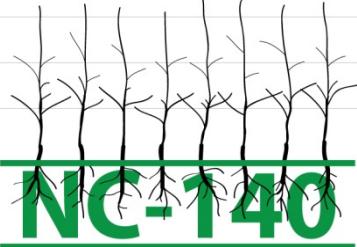
Joe Costante (VT) and Neil Miles (KS), 1975.



NC-140 People



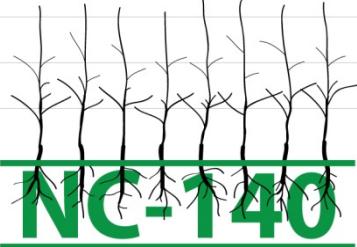
Ron Perry (MI), 1981.



NC-140 People



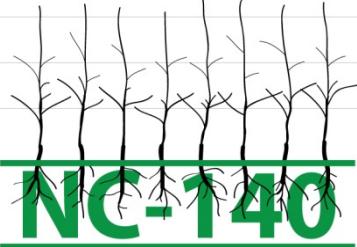
Bruce Barritt (WA), Don Heinicki, and
John Barden (VA), 1988.



NC-140 People



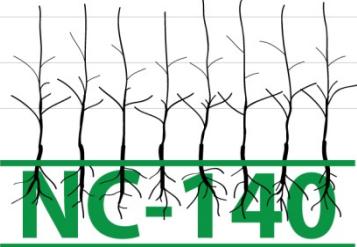
Dick Lane (ON), Gus Tehrani (ON), and
Gerry Brown (KY), 1989.



NC-140 People



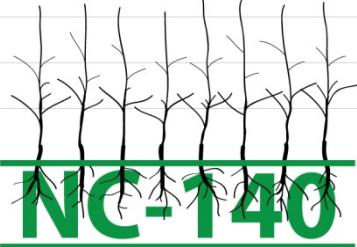
Ray Granger (QUE), Mark Dilley (WA), and Ken Yu (CO), 1988.



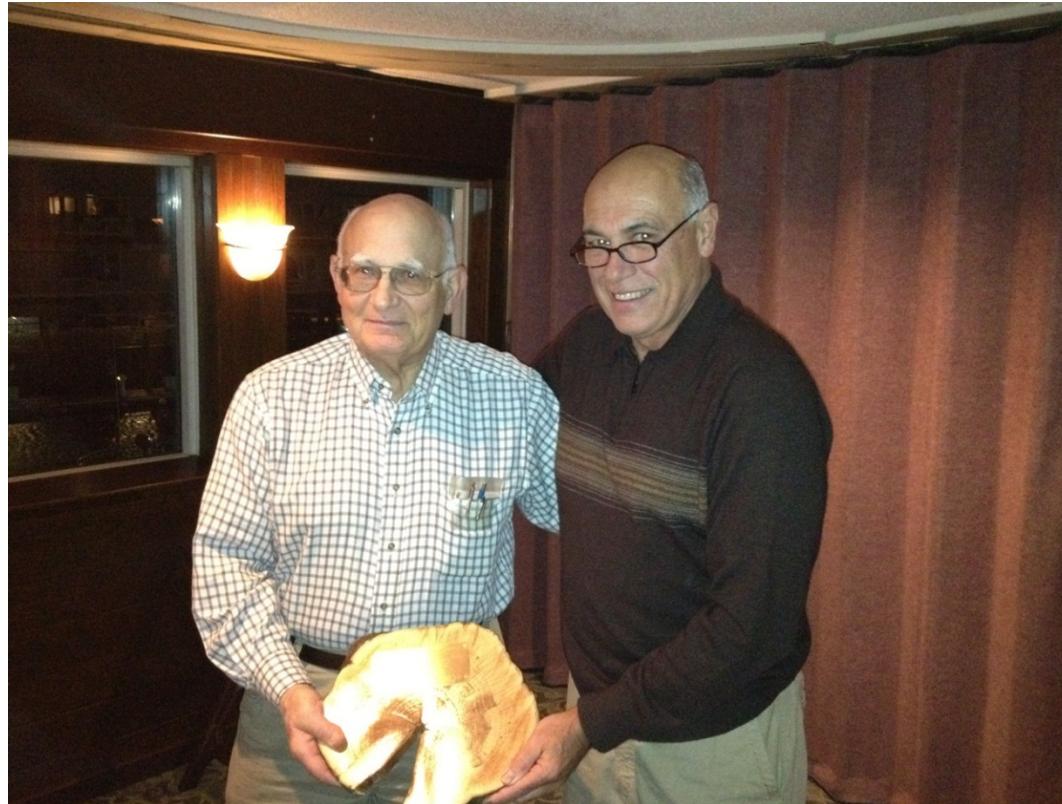
NC-140 People



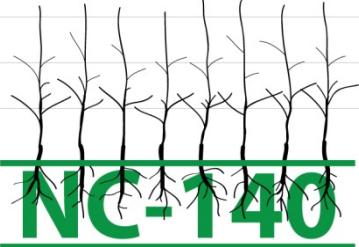
Jim Cummins (NY) and Terence Robinson (NY),
1995.



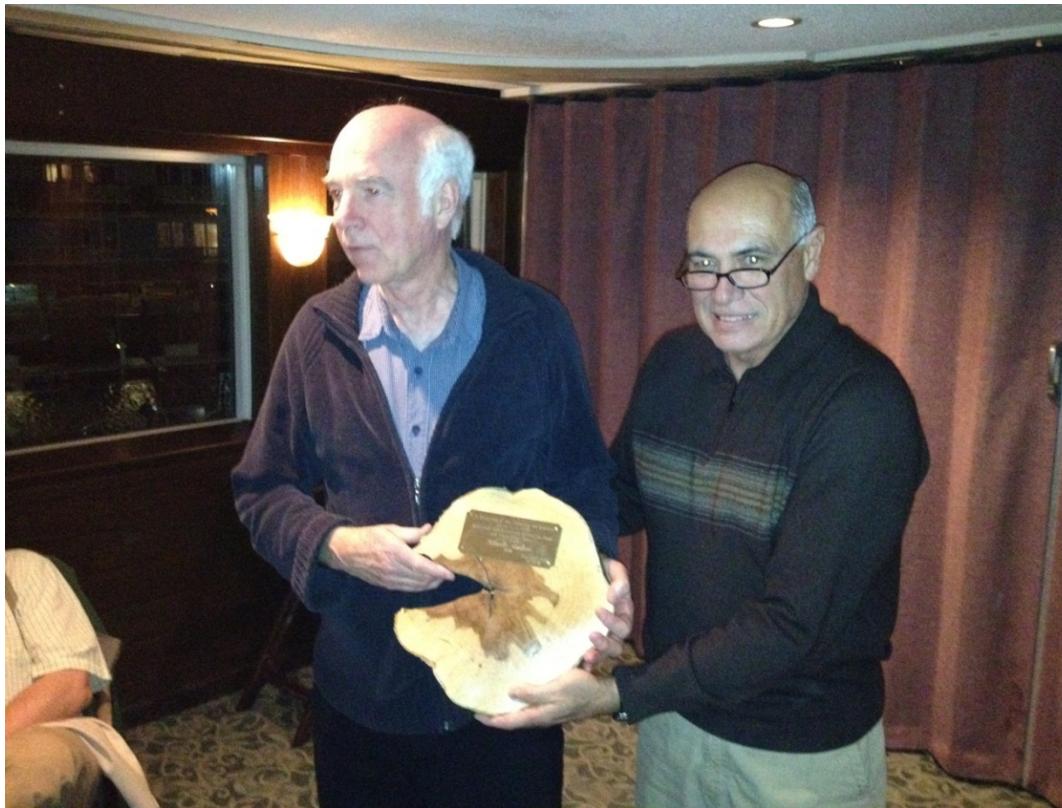
NC-140 People



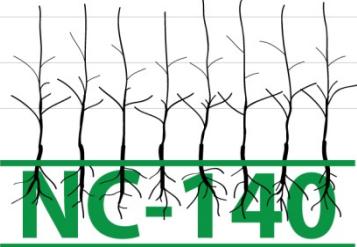
George Greene (PA>ME) and Ron Perry (MI), 2012.



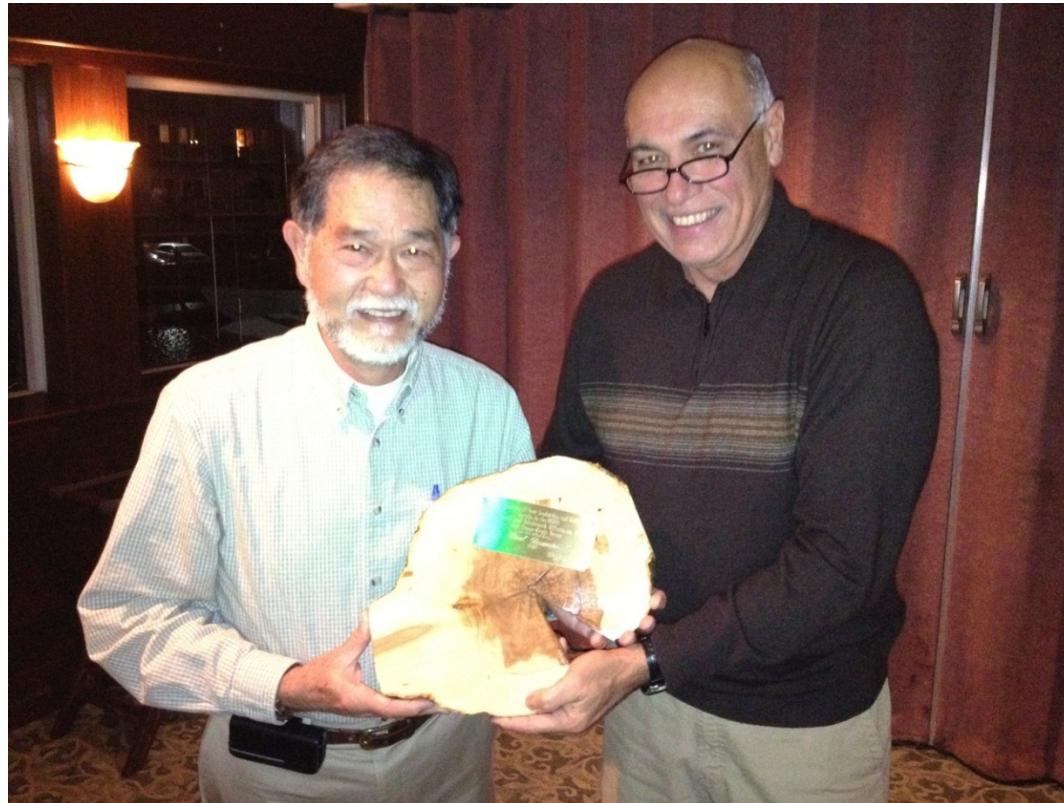
NC-140 People



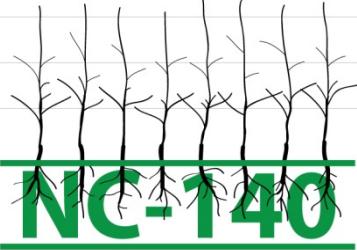
Charlie Embree (NS) and Ron Perry (MI), 2012.



NC-140 People



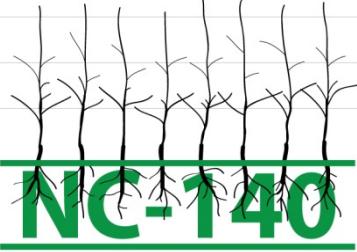
Paul Domoto (IA) and Ron Perry (MI), 2012.



NC-140 People



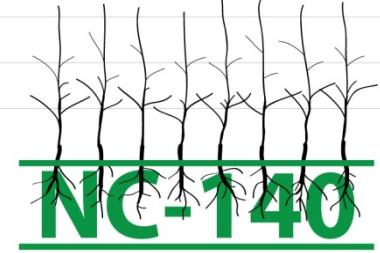
Jon Clements (MA), 2013.



NC-140 People

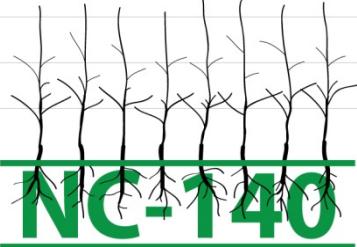


Grand Rapids, Michigan, 2011



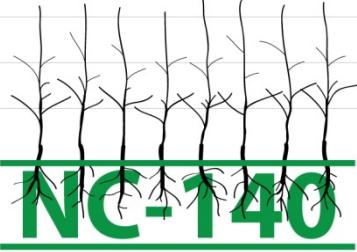
NC-140 People





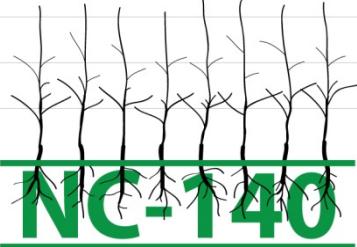
NC-140 People





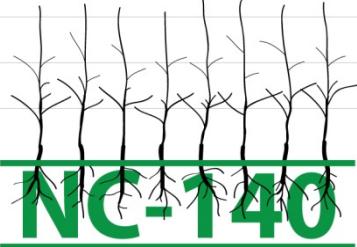
NC-140 People





NC-140 People





NC-140 People

