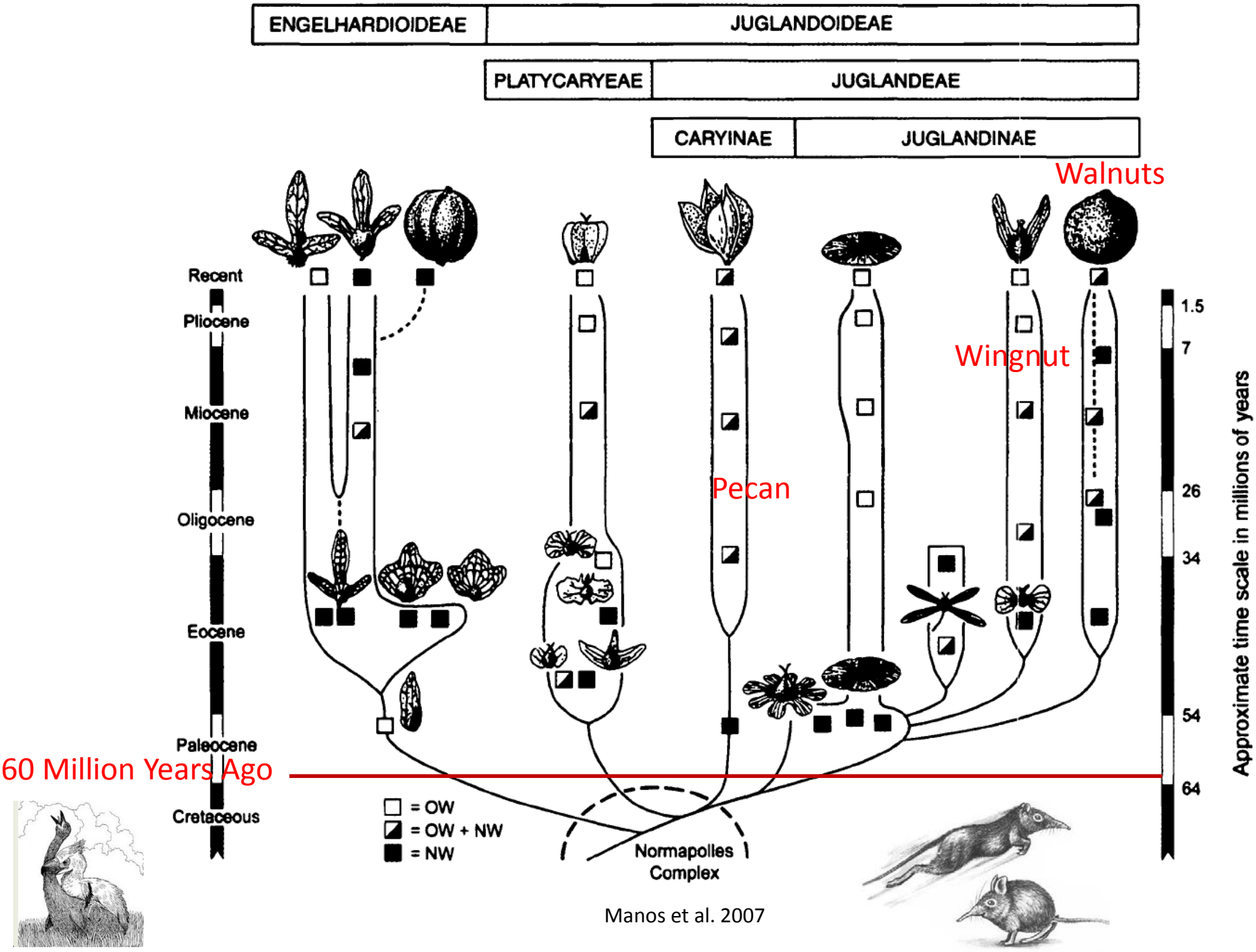
Walnut Origins, Breeding, and Choosing Varieties

UC Davis Walnut Improvement Program

Chuck Leslie
Patrick J. Brown

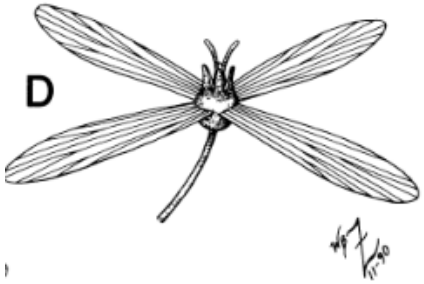
- ✓ Walnut evolution
- ✓ Species and geography
- ✓ Breeding varieties
  - Program history
  - Objectives/traits of interest
  - Breeding process
- ✓ Choosing varieties
- ✓ Rootstock development

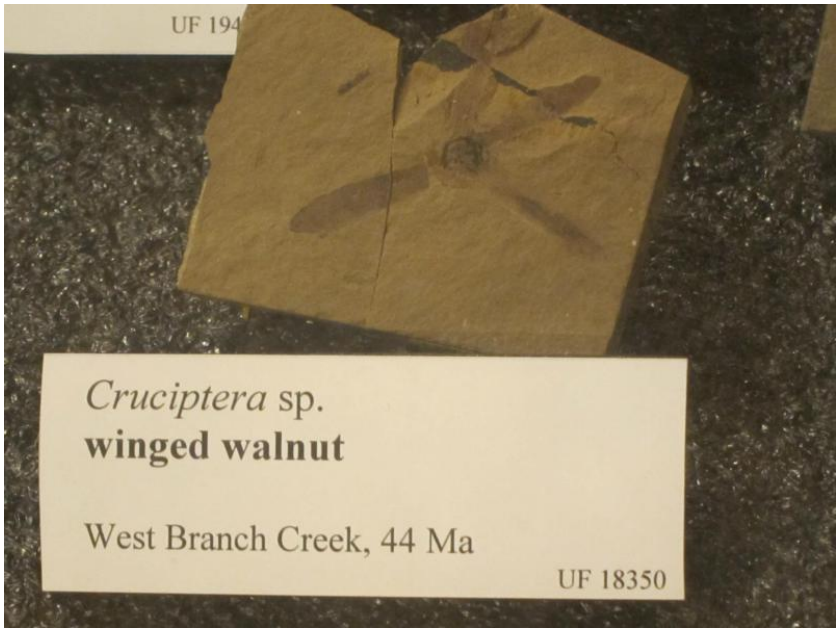


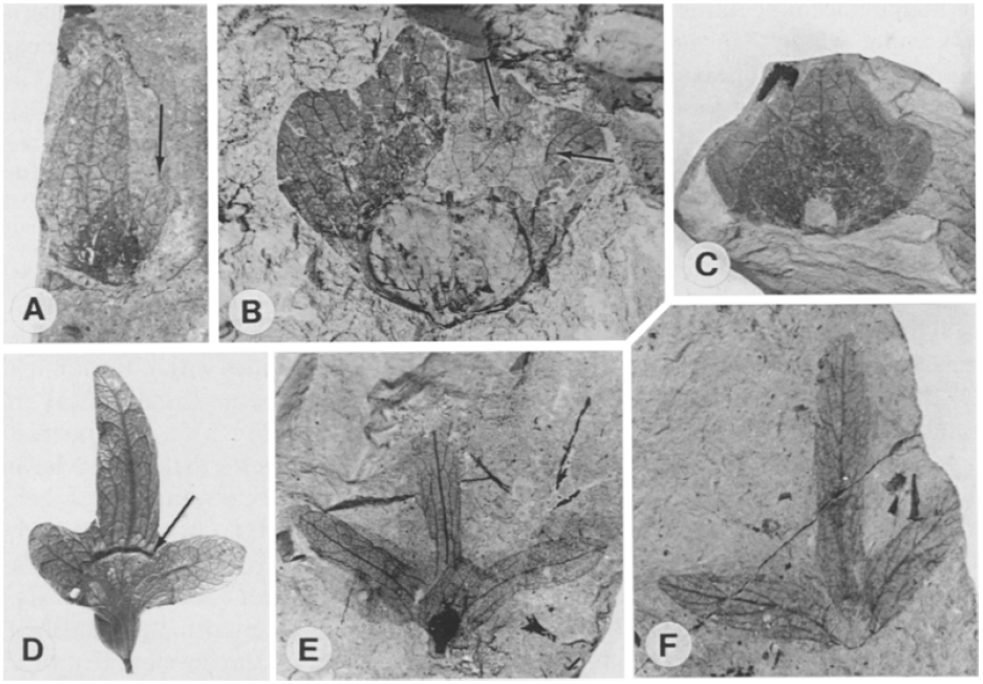
Manos et al. 2007

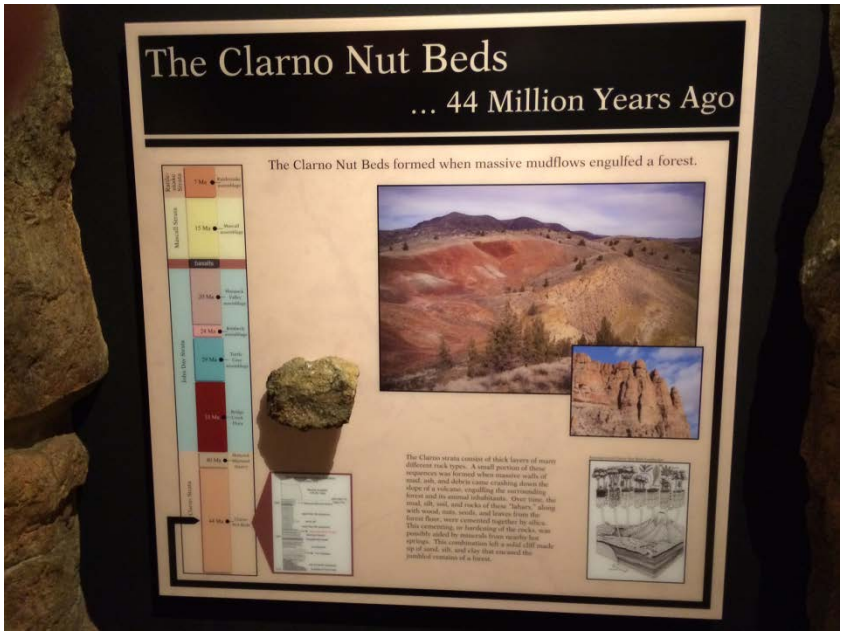
Early Walnuts of North America

Juglans clarnensis



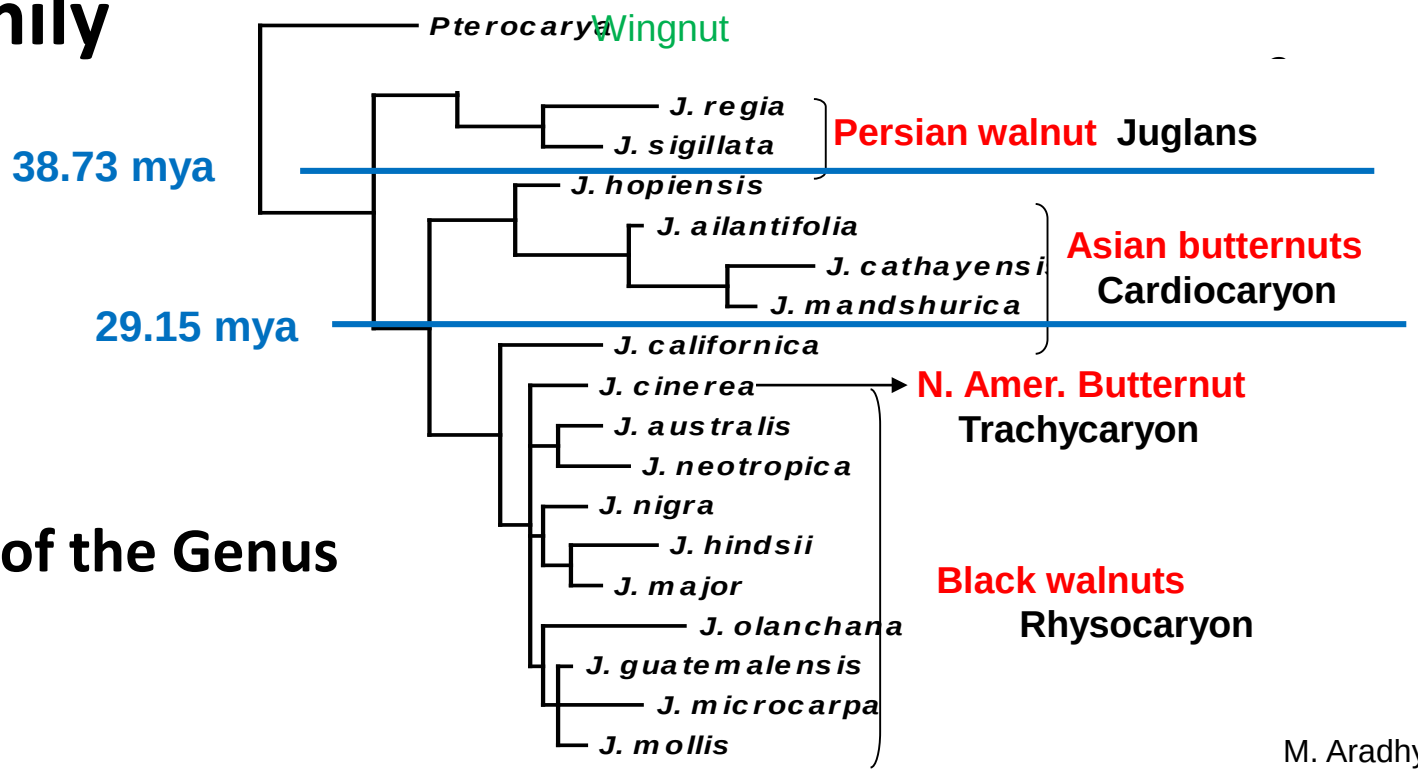






John Day, Oregon

Walnut Family

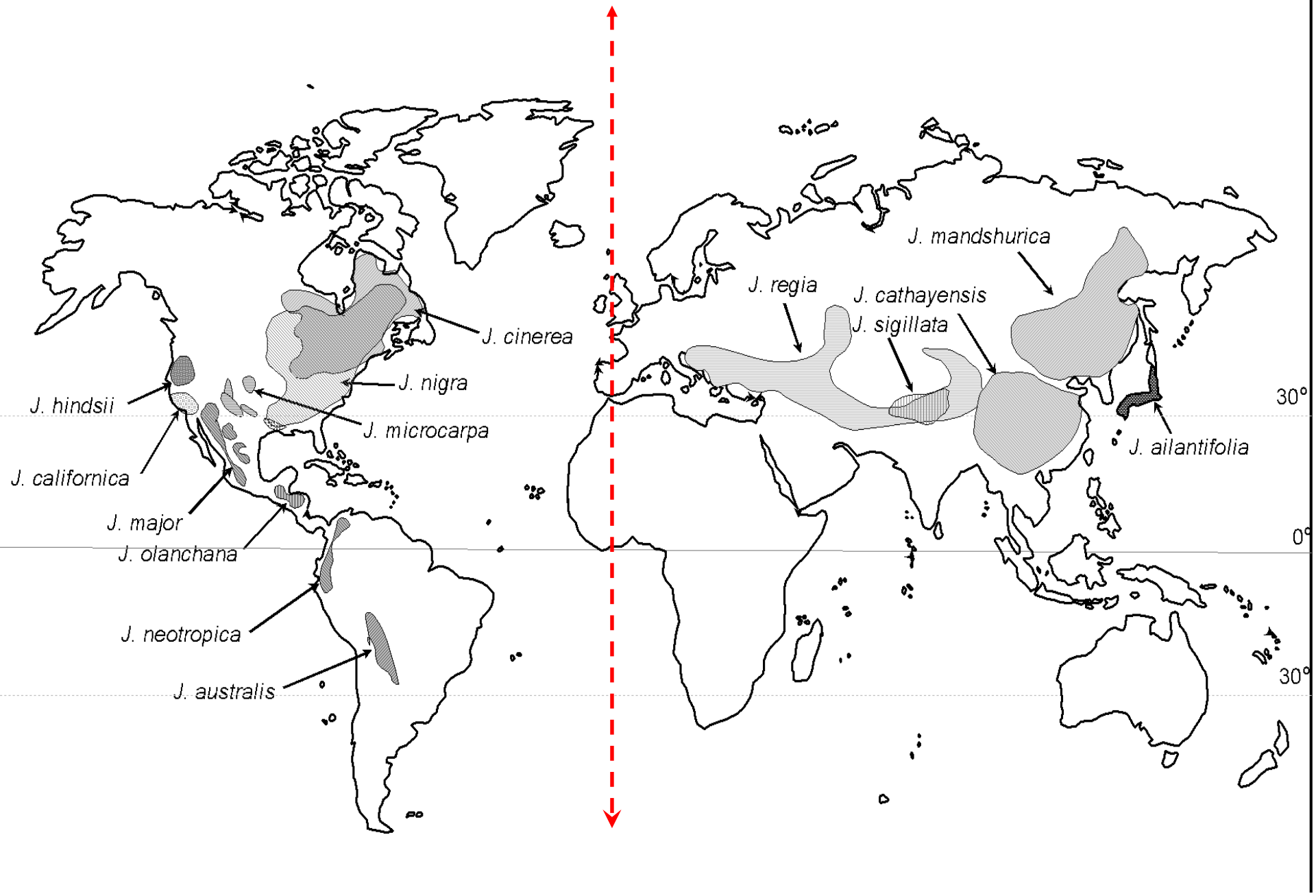


Four Sections of the Genus

M. Aradhya

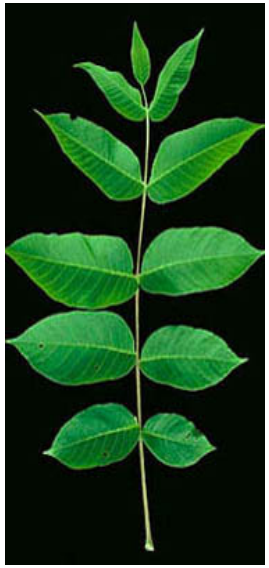
USDA - NCGR - Davis

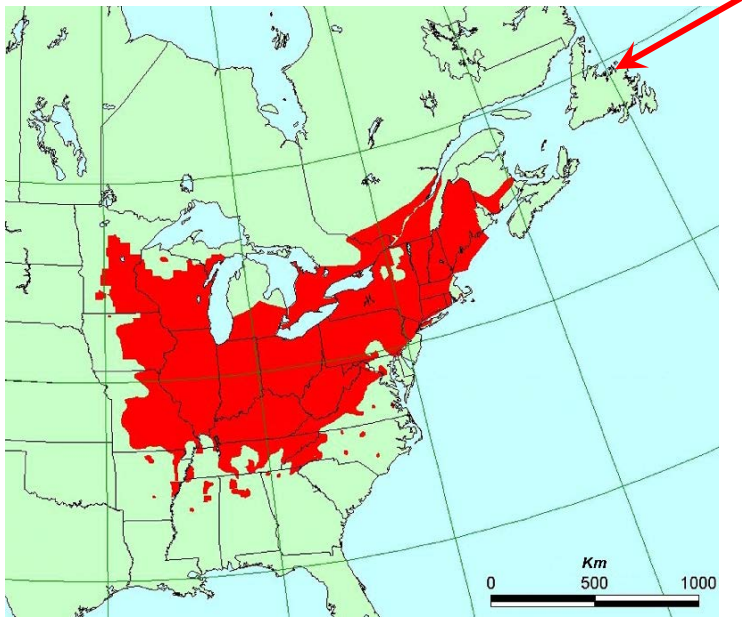
USDA - NCGR - Davis


J. cinerea
J. nigra
J. hindsii
J. microcarpa
J. californica
J. major
J. olanchana
J. neotropica
J. australis
J. regia
J. mandshurica
J. cathayensis
J. sigillata
J. ailantifolia
30°
0°
30°

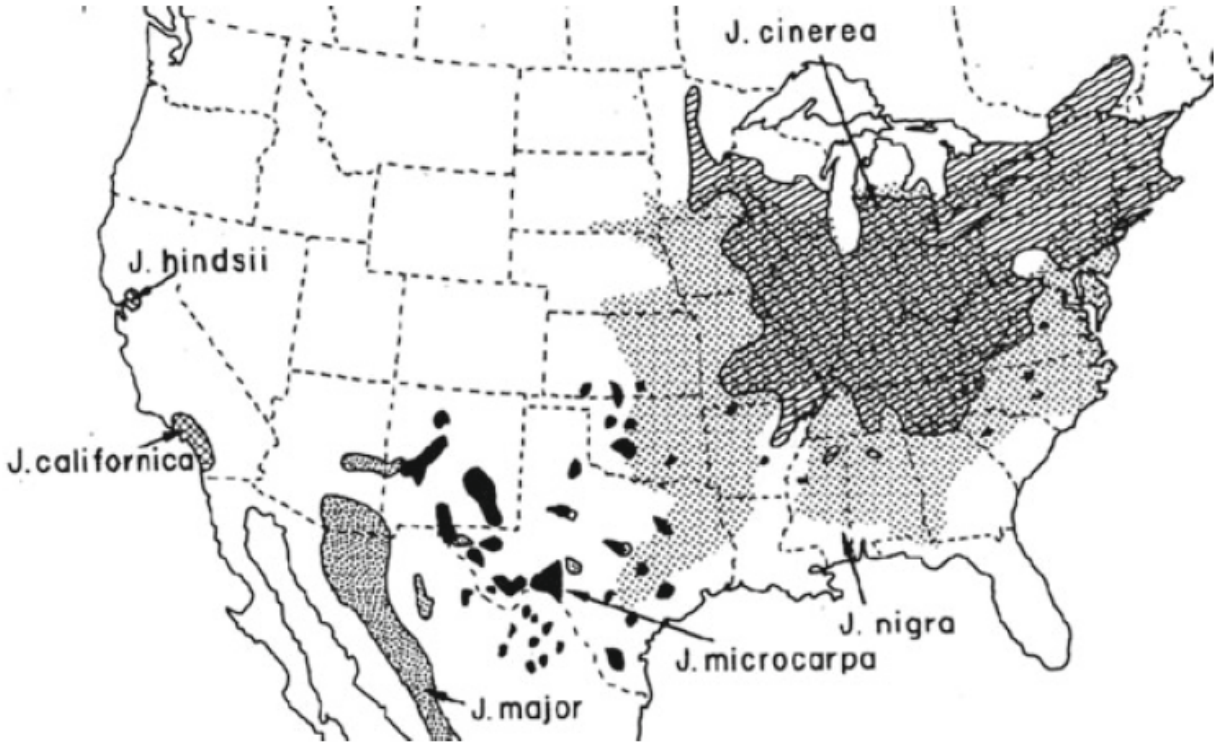
Butternut (*J. cinerea*)

Butternut Canker

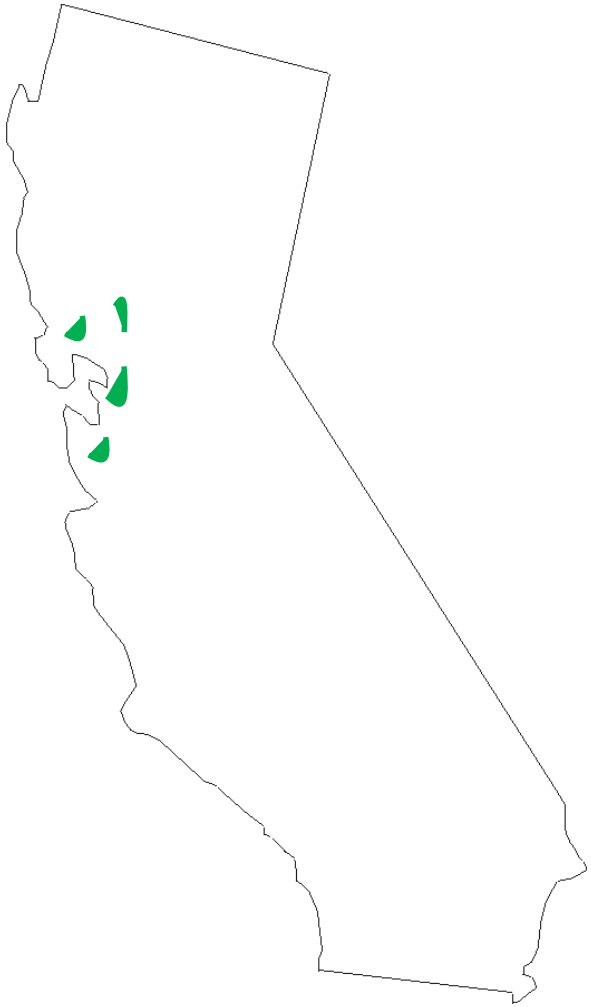


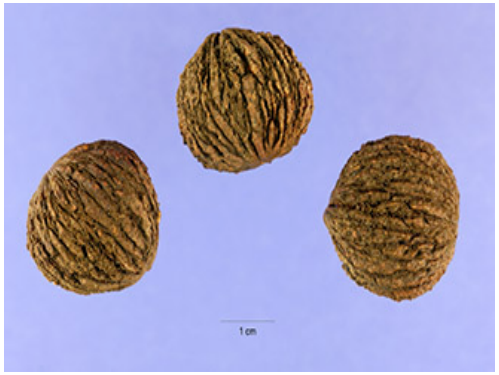


North American Black Walnuts



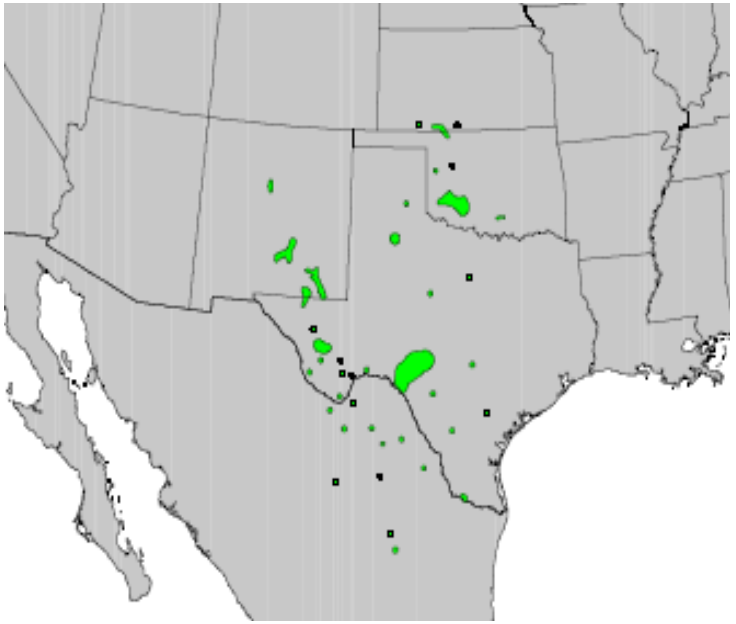
Northern California Black (*Juglans. hindsii*)





Eastern Black Walnut (*J. nigra*)

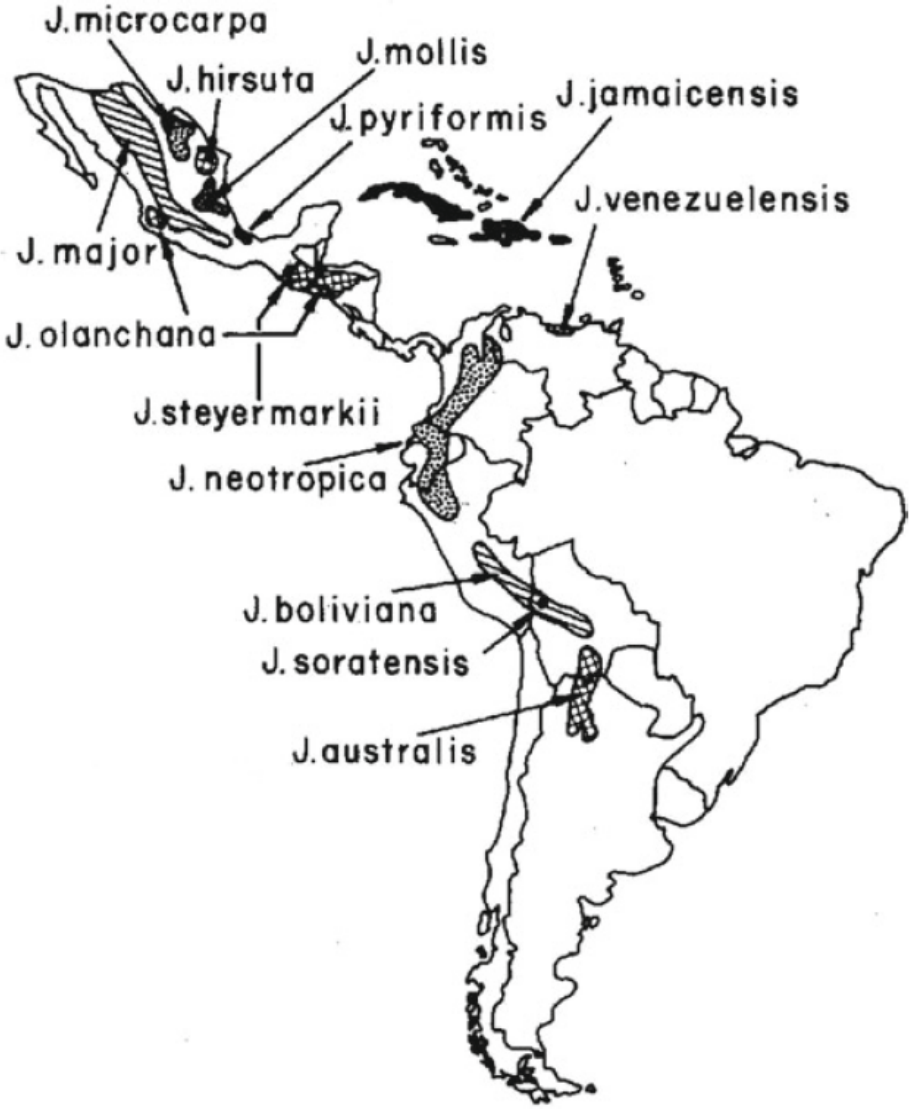
Texas Black Walnut (*J. microcarpa*)



South American Black Walnuts

J. neotropica –grows at high elevations

J. mollis in January – nearly evergreen



Asian butternuts

J. mandshurica

J. ailantifolia

J. cathayensis

Persian or “English” walnut (*J. regia*)

Native Range of Persian Walnut

Collecting Material for Breeding


USDA Walnut
Germplasm Collection
Winters, CA
J. major
J. hindsii
J. ailantifolia
J. californica
J. microcarpa
J. regia

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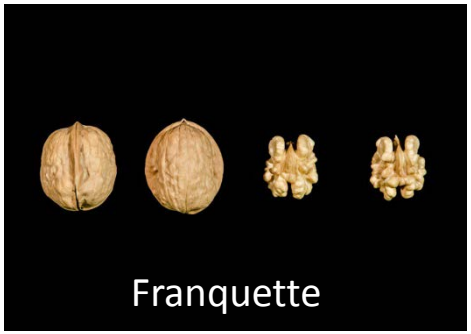
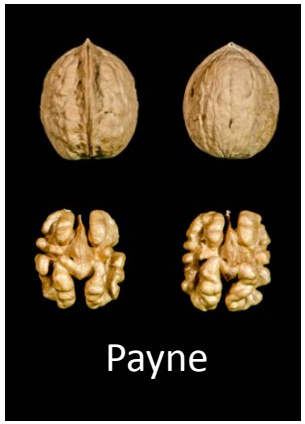
UC Davis Breeding Program
Gene Serr & Harold Forde
1948 - 1979



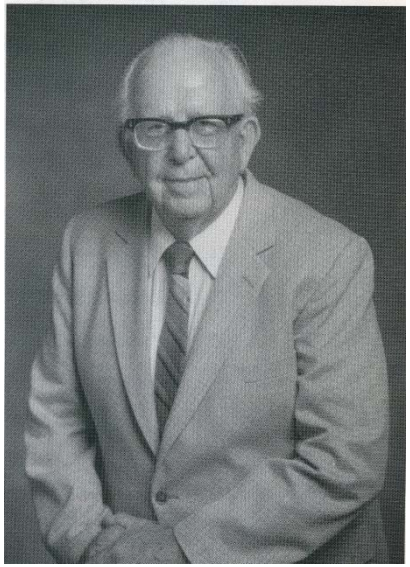
French Introductions



Lateral Bearing

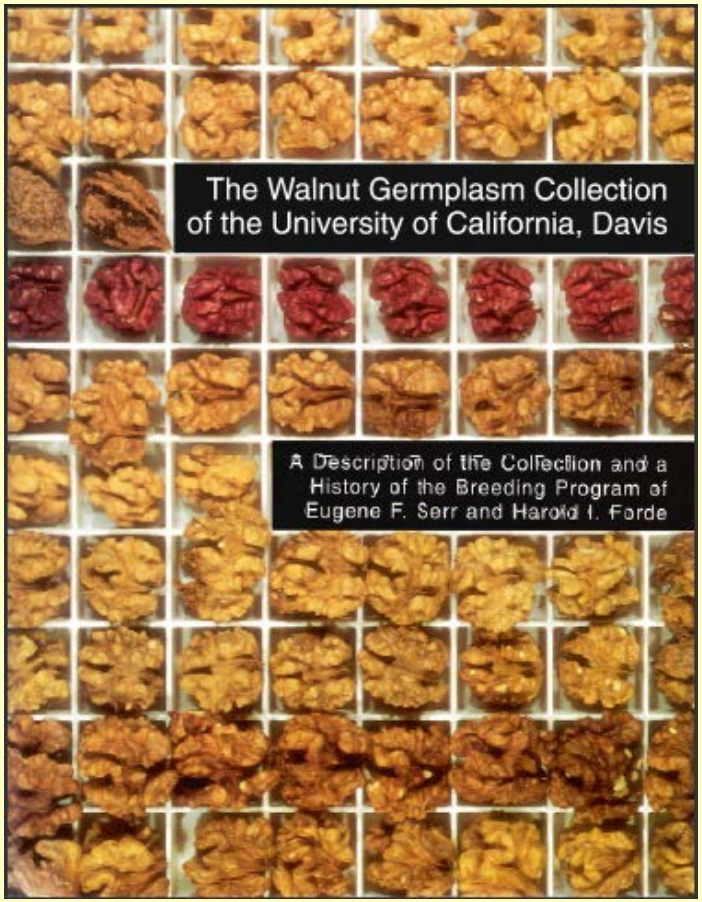
Variety	Date of Cross	Date Released
Midland	1948	1968
Vina	1948	1968
Pioneer	1950	1968
Gustine	1951	1968
Lompoc	1951	1968
Pedro	1952	1968
Amigo	1955	1968
Chico	1955	1968
Tehama	1957	1968
Serr	1958	1968
Chandler	1963	1979
Howard	1963	1979
Sunland	1965	1979

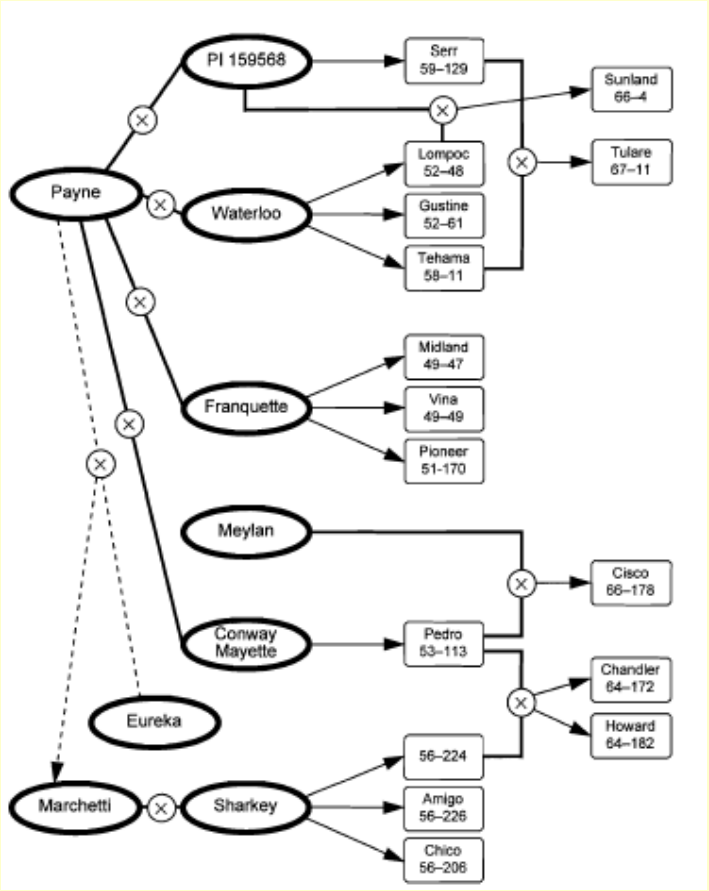
Gene Serr



Harold Forde

Serr/Forde Walnut Breeding Program





Tulecke and McGranahan, 1994

UC Davis Plant Sciences Department - Fruit and Nut Information Center

http://fruitsandnuts.ucdavis.edu/files/259985.pdf

UC Davis Breeding Program
1982-2009
Gale McGranahan

Variety	Released
Cisco	1990
Tulare	1993
R. Livermore	2001
Sexton	2004
Gillet	2004
Forde	2004
Ivanhoe	2010
Solano	2012
Durham	2016

- Blackline resistance breeding
- Chandler pollenizers
- Blight resistance
- Earlier harvest dates
- Rootstock diversity and selection
- Development of clonal rootstocks

Scion Breeding Goals

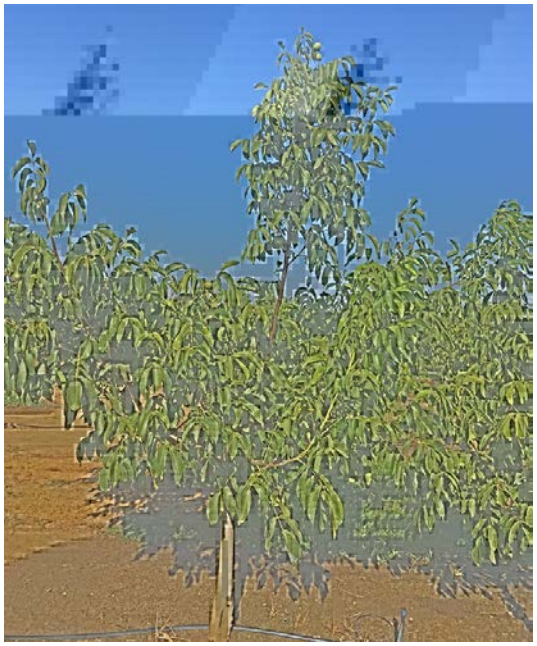
- **Earlier harvest dates**
- **Kernel color**
- **Yield**
- **Reduced input costs**
  - Disease/insect resistance
  - Reduced water use

Breeding Prerequisites

- Germplasm – plant source containing the trait of interest?
- Heritability – trait determined/influenced by genes?
- Genetic Compatibility – can we make fertile crosses?
- Phenotyping methods – can we identify/measure trait of interest

Yield and Precocity

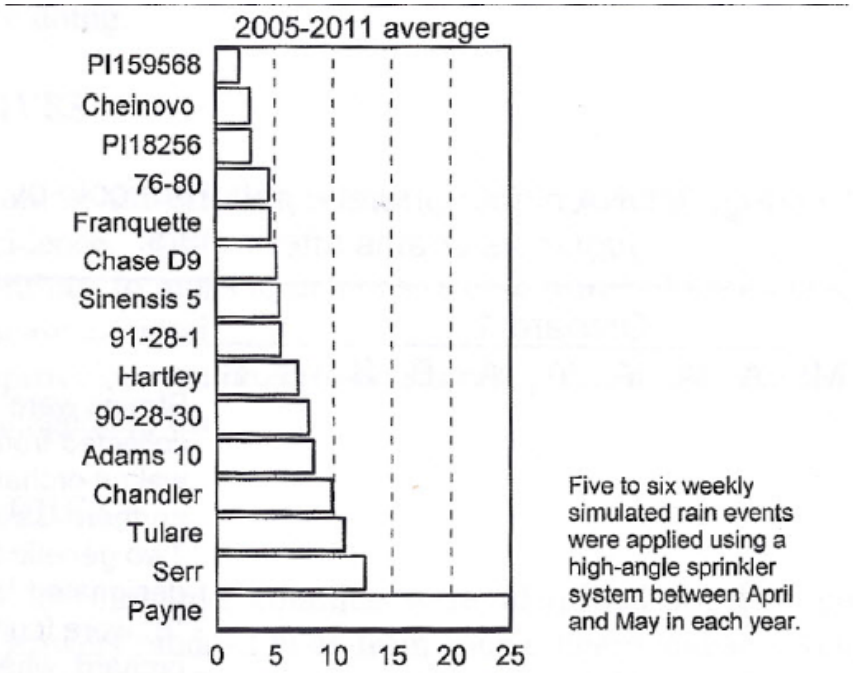
Terminal Bearing



Lateral Bearing

Sources of Blight Resistance

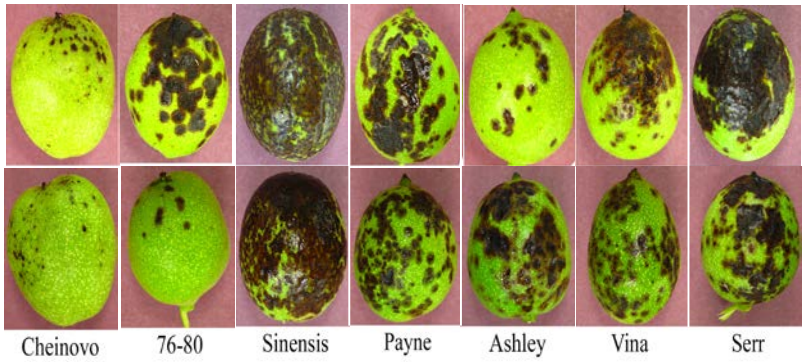
Variation in susceptibility of walnut varieties to blight in an orchard under simulated rain



Five to six weekly simulated rain events were applied using a high-angle sprinkler system between April and May in each year.

Adaskaveg 2011

Diseased fruit area (%)



Adaskaveg

Husk fly resistance

- ~~Small Nut size~~
- Trichomes/hairy hulls
- Volatile compounds
  - Attractant odors
  - Repellant odors

Sources of resistance are terminal bearing with poor nut quality

Breeding Process

Nuts from crosses are flagged

Seed collected

Germinated in greenhouse

Plants ready for field planting

Planting and Field Evaluation

- **Phenology**
  - Leafing date
  - Flowering dates
  - Harvest date
- **Precocity**
- **Lateral bearing**
- **Yield**
- **Tree form**
- **PFA**
- **Blight resistance**

Nut and Kernel Evaluation

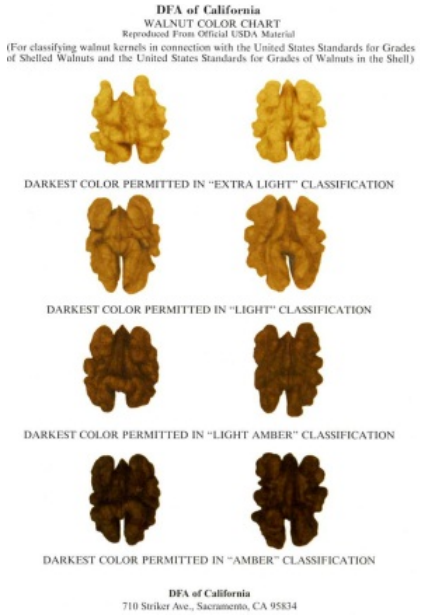
Nut weight

Shell traits

- Seal
- Thickness
- Color
- Texture

Kernel traits

- Color
- Weight
- Kernel percent
- Fill
- Shrivel
- Plumpness
- Ease of halves



Grower Field Trials and Input

- ✓ Walnut evolution
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Considerations in Selecting Varieties

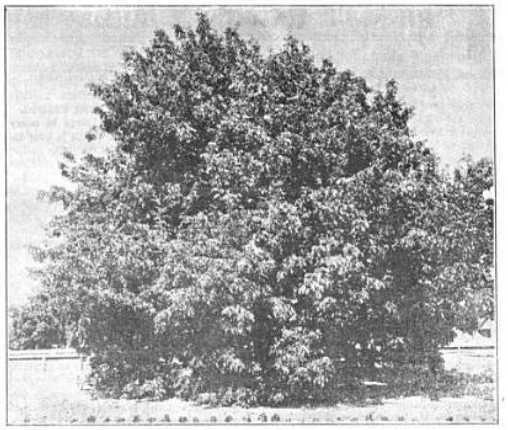
Location and Climate

Spring and fall frost	Leafing and leaf drop dates
Rain pattern	Leafing date, blight resistance
Summer heat	Sunburn, kernel color
Local pests and disease	Blackline, husk fly, CM, NOW susceptibility
Winter cold, fog	Chilling requirement
Wind	Limb breakage
Soil and water	Vigor, stress sensitivity

Marketing

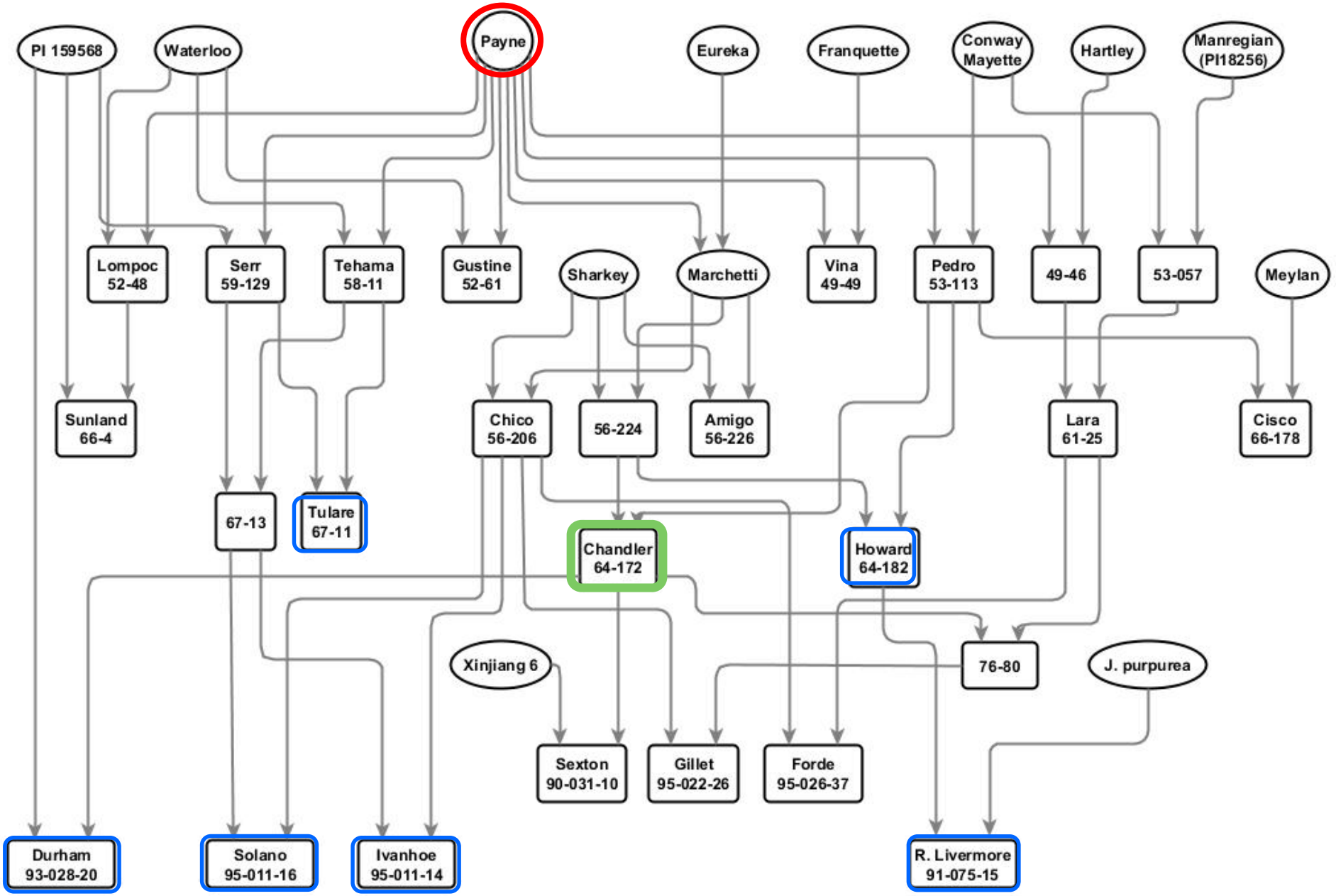
Edible Yield	Precocity, kernel fill, pest resistance
Shelled vs. Inshell	Shell and kernel traits
Price premiums	Harvest dates, kernel color
Organic	Pest and disease resistance

Payne/Ashley


THE FAMOUS PAYNE WALNUT TREE, CALIFORNIA

1898 seedling – George Payne
Lateral bearing – precocious, high yield
Early harvest date
Susceptible to blight, codling moth

Parent/grandparent of all UC varieties


PI 159568
Waterloo
Payne
Eureka
Franquette
Conway
Mayette
Hartley
Manregian
(PI18256)
Lompoc
52-48
Serr
59-129
Tehama
58-11
Gustine
52-61
Sharkey
Marchetti
Vina
49-49
Pedro
53-113
49-46
53-057
Meylan
Sunland
66-4
Chico
56-206
56-224
Amigo
56-226
Lara
61-25
Cisco
66-178
67-13
Tulare
67-11
Chandler
64-172
Howard
64-182
Xinjiang 6
76-80
J. purpurea
Sexton
90-031-10
Gillet
95-022-26
Forde
95-026-37
Durham
93-028-20
Solano
95-011-16
Ivanhoe
95-011-14
R. Livermore
91-075-15

Hartley

1915 discovery by John Hartley - Napa Valley
Classic in-shell variety
Terminal bearing – not precocious
Low kernel yield – 45%
Mid-late season harvest
Susceptible to deep-bark canker, husk fly

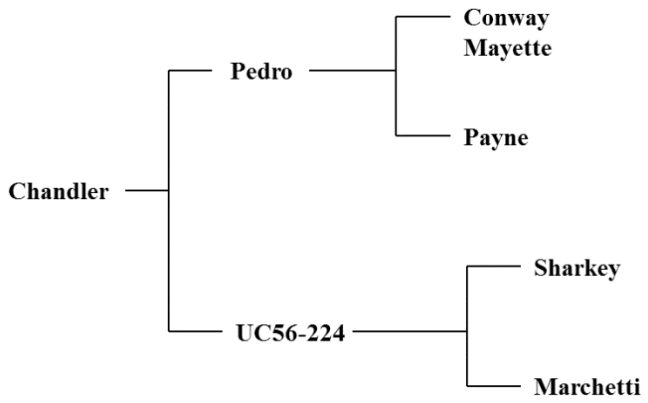
Serr

UC 59-129

Early harvest – early Sept.
Large, well filled nuts
High kernel yield – 57%, 8.3g
Large vigorous tree
Early leafing and flowering
Pistillate flower abscission

Chandler

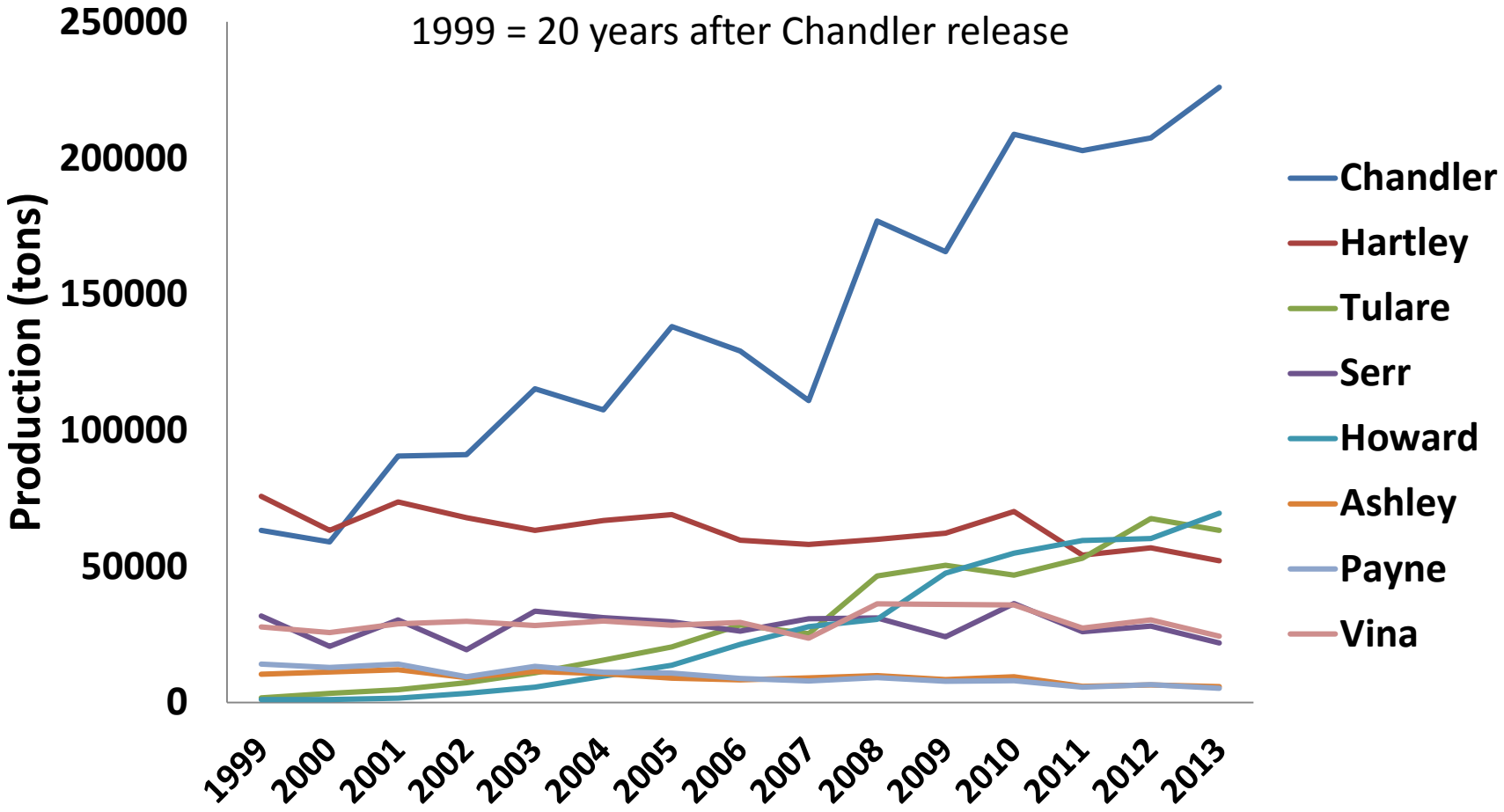
UC 64-172
Released 1979



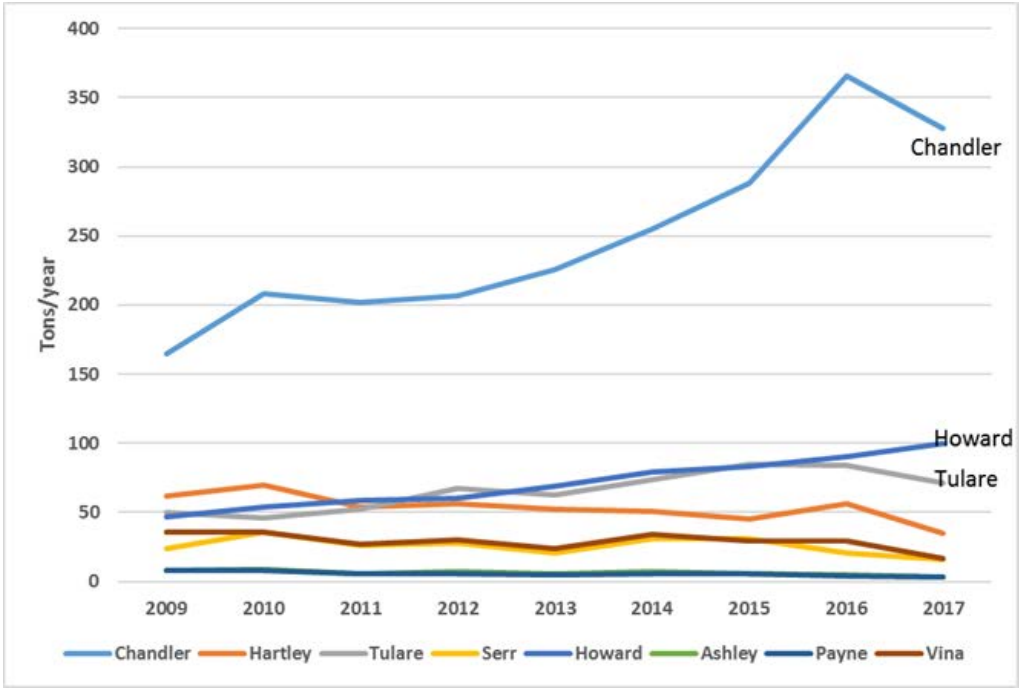
Most commonly grown variety
Excellent color and halves
Relatively few pest problems
Moderately vigorous tree
Late harvest – mid-October
Low fill – 49%
Tip shrivel

Production by Variety

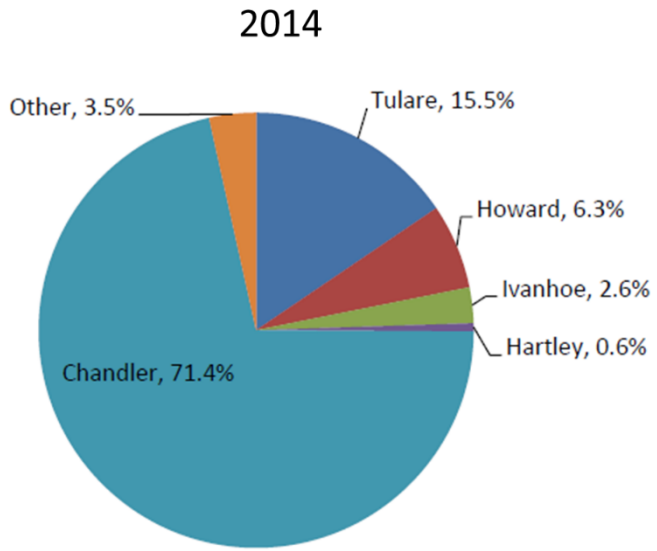
1999 = 20 years after Chandler release



Production by Variety 2009-20117



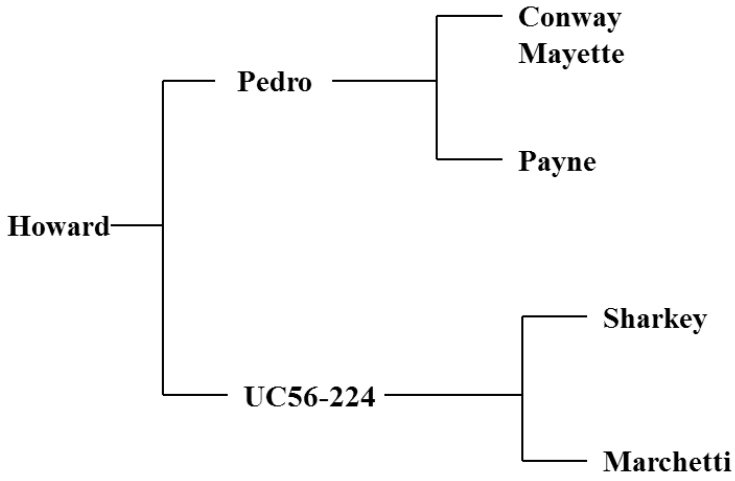
California Walnut Nursery Sales



Source: USDA, National Agricultural Statistics, California Field Office

Howard

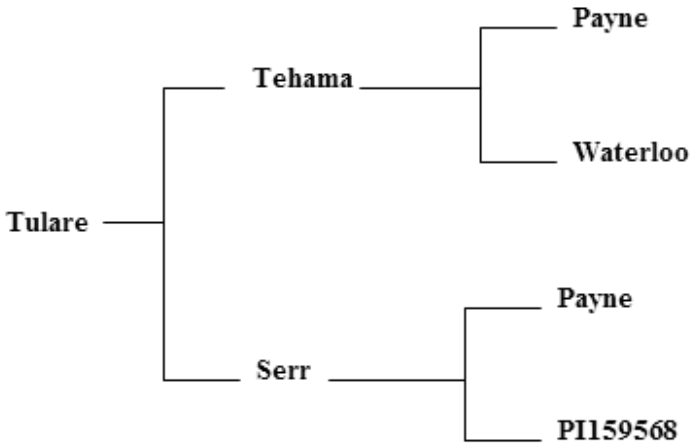
UC 64-182



- Large nuts, good color
- Strong shell
- Suitable for in-shell marketing
- Mid-late season harvest
- Kernels may darken over time
- Not for San Joaquin Valley
- Susceptible to limb breakage
- Susceptible to drop in June

Tulare

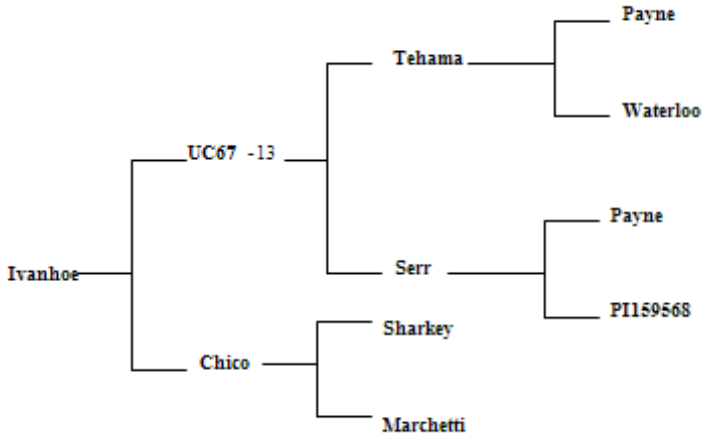
UC 67-11



Vigorous tree
High yields
Mid-season harvest – late Sept.
Upright tree form
Color?
May experience fall cold injury

Ivanhoe

UC 67-13 x Chico
Released 2010



Very early harvest
High yield, precocity
Excellent color
57% kernel, 7.4 g, easy halves
Smaller tree
Blight susceptible
Released for South Valley

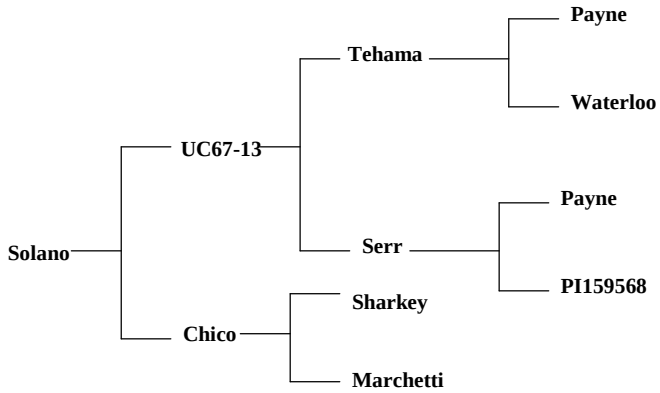
Females
bloom first

Kernel Samples

Solano

UC 95-011-16
Released 2012

Early harvest (Vina time)
Leafing later than Ivanhoe
Precocious strong yield
Good color
Solid uniform shells
54 % kernel, 7.9 g nuts
Vigorous tree



Solano – Nuts and Kernels

Solano

Durham

Chandler x PI159568
Released 2016

- Tulare harvest date or earlier
- Leafs close to Chandler
- 55% kernel
- Kernels - 8.4 g, light color, plump
- Large, oval, smooth nuts – attractive appearance
- Solid shells with good seals
- Nuts fall easily at harvest date
- Mid-season in-shell replacement for Hartley
- Low blight

Durham

Kernels

Chandler

Tulare

Solano

Durham

Comparison of Current Cultivars

Variety	Nut wt	Kernel wt	% kernel	Ex Light	Light	Leaf Date	Harvest date
Ivanhoe	12.9	7.4	57	47	46	3/20	9/12
Serr	14.6	8.3	57	10	65	3/19	9/18
Solano	14.7	7.9	54	36	57	3/25	9/22
Vina	12.8	6.3	49	3	45	3/25	9/22
Durham	15.1	8.4	55	40	52	3/30	9/25
Tulare	14.0	7.6	54	7	75	4/1	9/27
Howard	14.1	7.1	51	17	62	4/4	9/29
Chandler	13.4	6.5	49	51	41	4/5	10/7

Robert Livermore

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USDA Agricultural Research Service
www.ars.usda.gov

CALIFORNIA Walnuts
www.walnuts.org

UCDAVIS
UNIVERSITY OF CALIFORNIA

Rootstock Breeding

USDA-NIFA Specialty Crops (SCRI) Grant

Goal: Development of Disease Resistant Rootstocks

- **Nematodes**
- **Crown Gall**
- **Phytophthora**
- **Oak Root Fungus**
- **Thousand Cankers**

FOREST SERVICE US DEPARTMENT OF AGRICULTURE


USDA Walnut
Germplasm Collection
Winters, CA
J. major
J. hindsii
J. ailantifolia
J. californica
J. microcarpa
J. regia

Rootstock Breeding

Generate hybrids using
‘Serr’ pollen

Clonal Rootstock Initiation

Production of Many Copies of Each Seedling

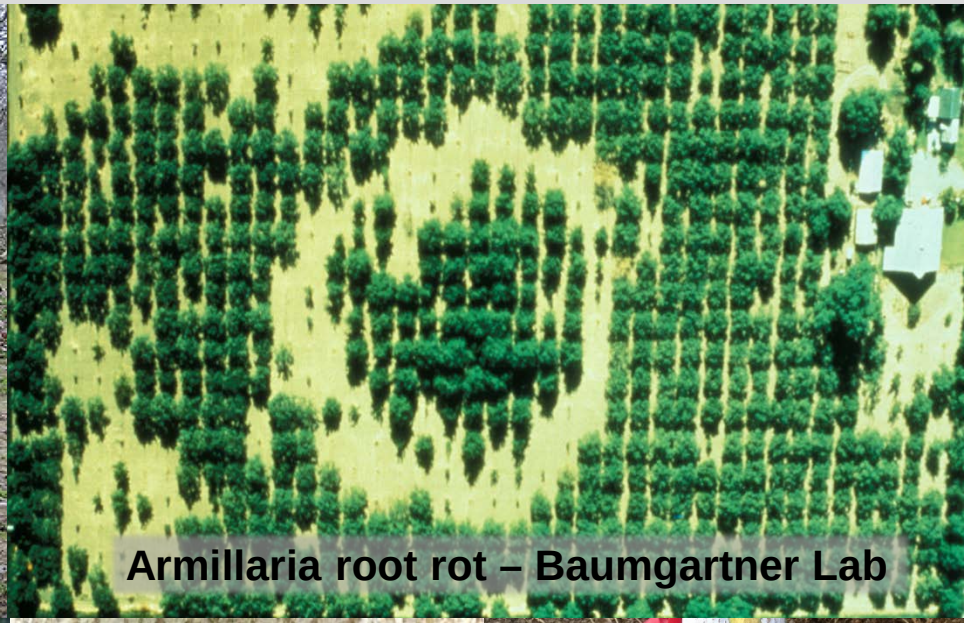





Clonal copies of each seedling are sent to be screened for resistance to each pathogen

Pathogen Resistance Screening


Crown gall disease – Kluepfel Lab


Armillaria root rot – Baumgartner Lab


Nematodes– McKenry/Westphal Lab


Phytophthora– Browne Lab

Field Trials of New Rootstock Selections

Scale up – commercial tissue culture and greenhouse propagation

Replicated Field Testing

Goal: Release New Disease-resistant Rootstocks for the Walnut Industry

- ✓ Walnut evolution
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GEORGIA PACIFIC
5