# Climate Change Influences on Forest Genetics and Fire Regimes

**Climate Change Integration Team**
**Webinar Series**
**September 5, 2013**

R5 Climate Change Integration Team

**Please *Mute Your Phone***

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# Webinar Agenda

- *Forest Genetics*: Provenance Tests of Sugar Pine and Valley Oaks in Region 5
- Questions
- *Fire Regimes*: Climatic variations on fire regimes in montane ecosystems of the Pacific Coast
- Questions

**Please *Mute Your Phone***

***- use *6 to mute /un-mute your phone***

# Presenters

- **Jessica Wright**, USFS Pacific Southwest Research Station Conservation Geneticist
  jessicawwright@fs.fed.us

- **Carl Skinner**, USFS Pacific Southwest Research Station Research Geographer
  cskinner@fs.fed.us

# Using provenance tests to understand forest responses to climate change

Jessica W. Wright
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USDA Forest Service
jessicawwright@fs.fed.us

**USDA Forest Service, Research & Development**

***Pacific Southwest Research Station***

# Overview

- Provenance tests
  - Importance in understanding tree responses to climate change
- Full life-cycle of a provenance test
  - Establishment of a new test
  - Measurement and analysis of PSW-IFG Heritage tests

# Provenance tests

- Long-term common garden study in forest trees
- Sampling a number of different provenances (or sources) of trees
- Can be range-wide, or a more restricted study area
- Examine tree performance in a common garden setting

# Provenance tests

- Data is collected on growth and survival on regular intervals
- Can determine which sources of trees perform best in a given environment (or environments)
  - Information that is needed to determine seed zones and seed transfer rules
  - Can explore tree responses to climate change
    - All the trees were grown in a new climate- so, can look at how a change in climate impacts tree growth
- Are a long-term resource for a species

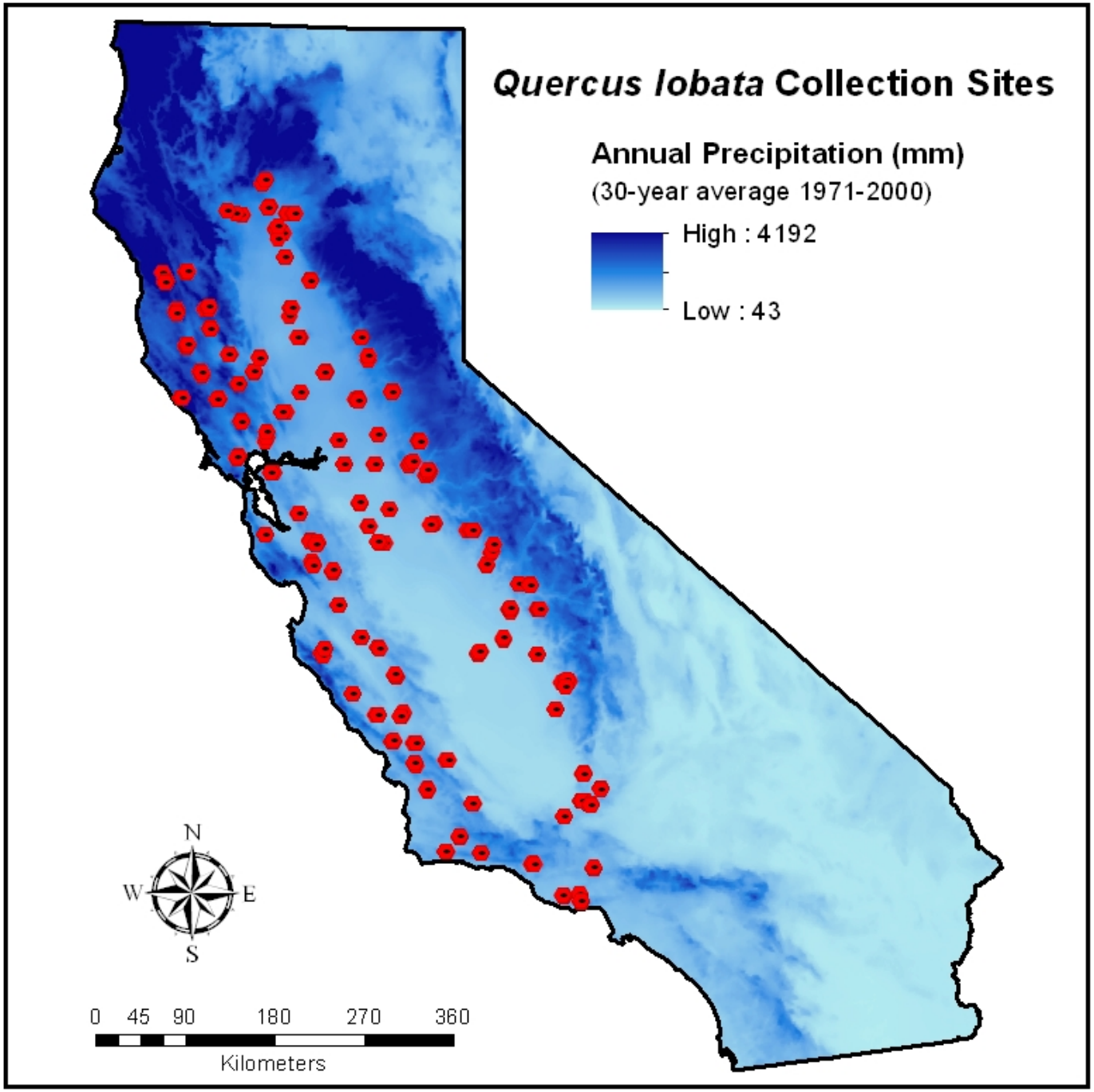
Collaborators-
Victoria Sork (UCLA)
Paul Gugger (UCLA)
Christina Liang (PSW)

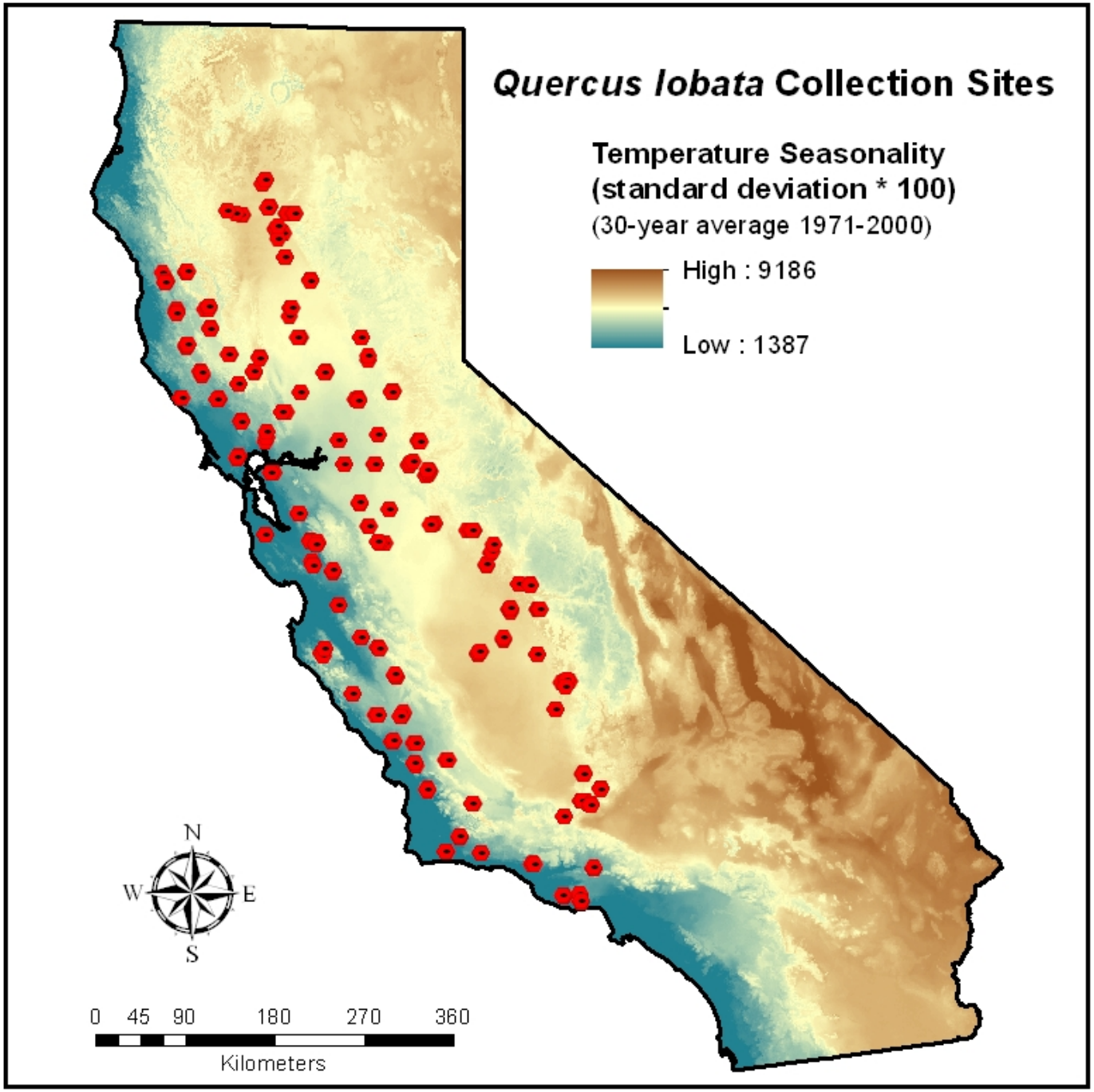
# Valley Oak Provenance test

- Valley oaks are already highly impacted by human activity
  - Housing and agriculture
- Anticipated to be highly impacted by climate change
- No provenance test resources are available for any California Oak species

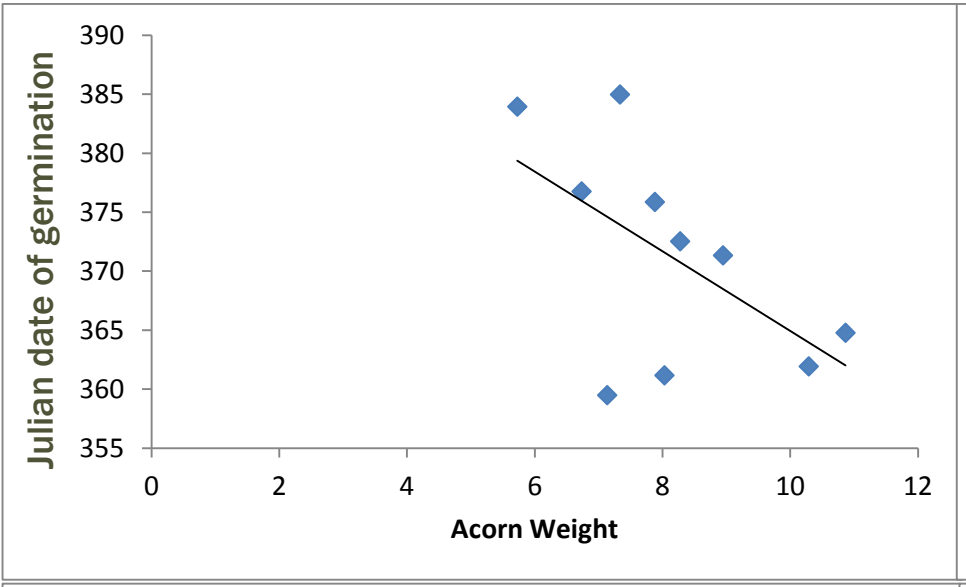
# Questions

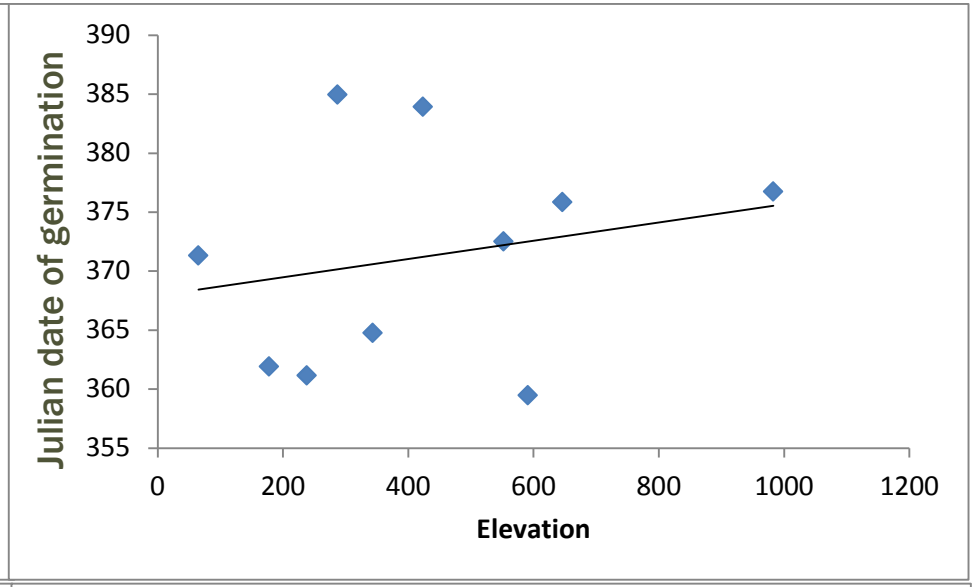
- How do different sources of trees respond to novel climates?
  - Is there genetic variation for survival and growth?
  - Is there genetic variation for traits associated with fitness
    - Drought tolerance
    - Phenology
    - GXE
- Can we identify candidate genes associated with these traits?
  - Association genetics approaches

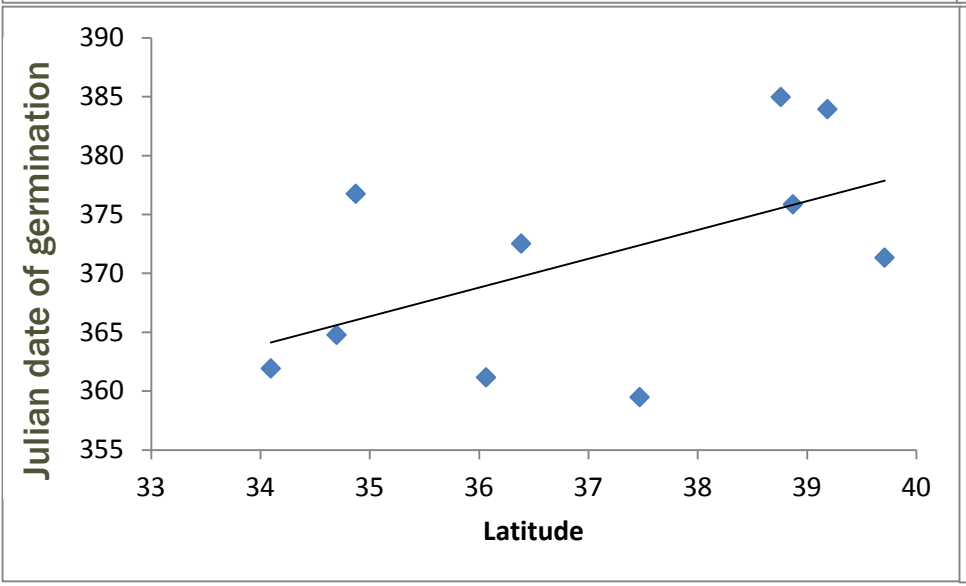

*Quercus lobata* Collection Sites
Annual Precipitation (mm)
(30-year average 1971-2000)
High : 4192
Low : 43
N
W
E
S
0 45 90 180 270 360
Kilometers

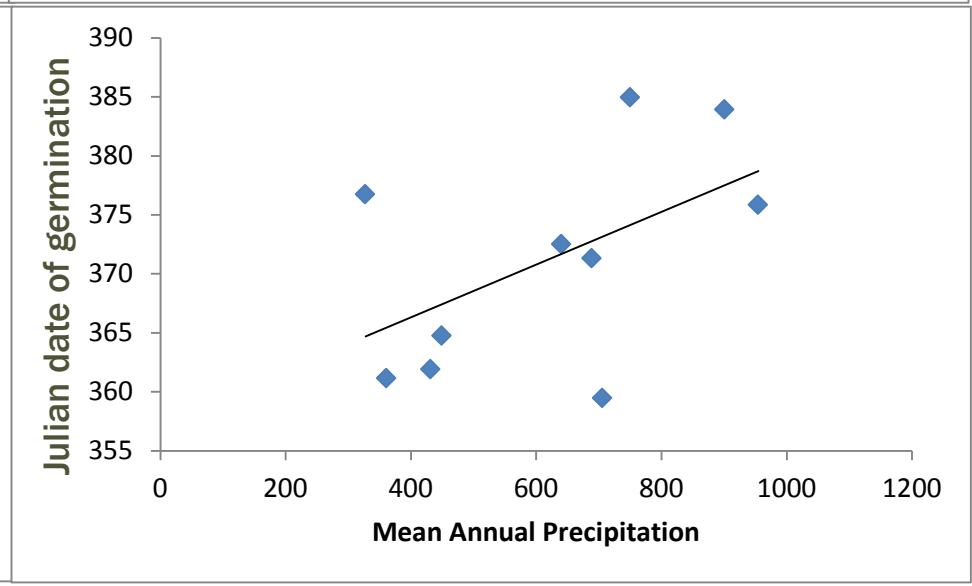

*Quercus lobata* Collection Sites
Temperature Seasonality
(standard deviation * 100)
(30-year average 1971-2000)
High : 9186
Low : 1387
N
W
E
S
0 45 90 180 270 360
Kilometers

# Preliminary analyses of pilot data show timing of germination is associated with acorn weight, climate and geographic variables.



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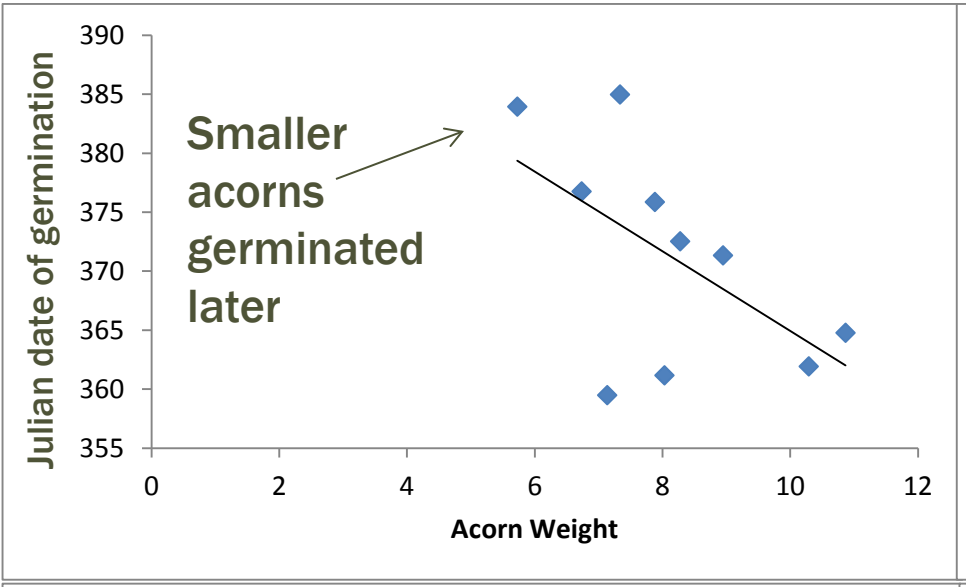


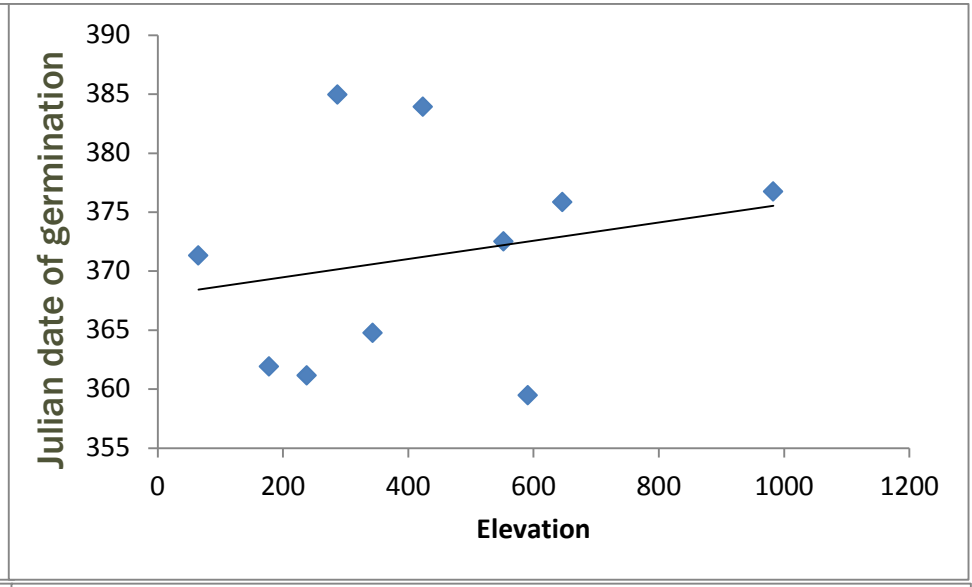


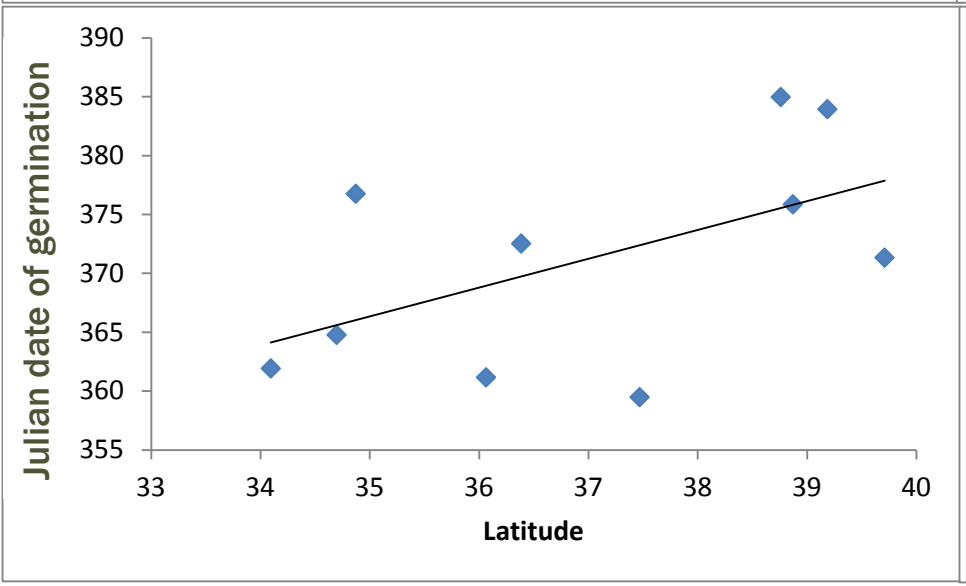


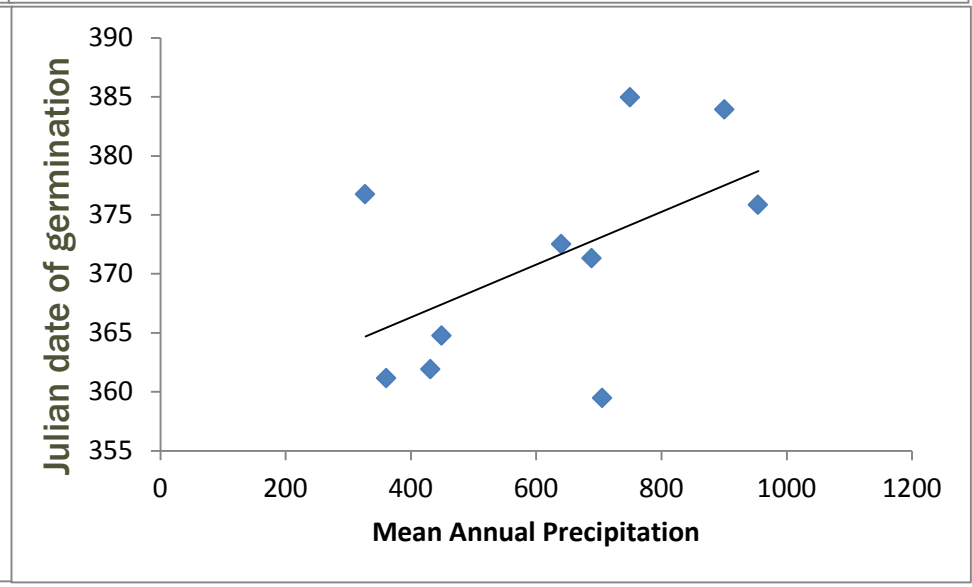

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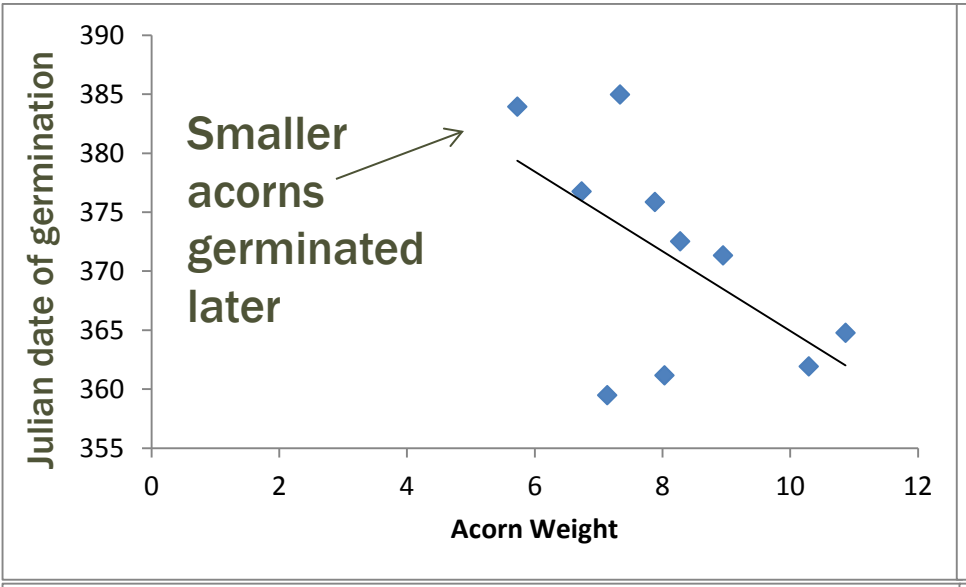


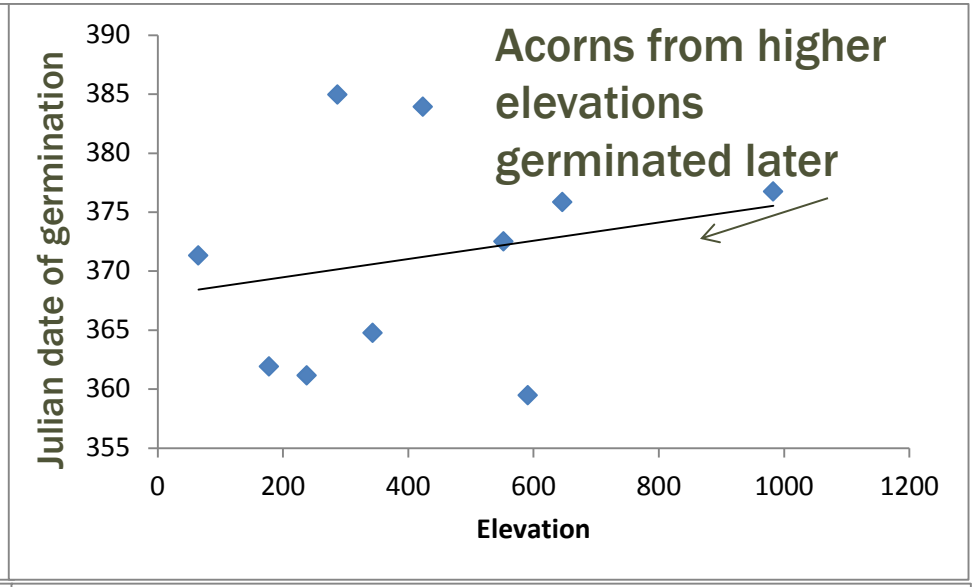


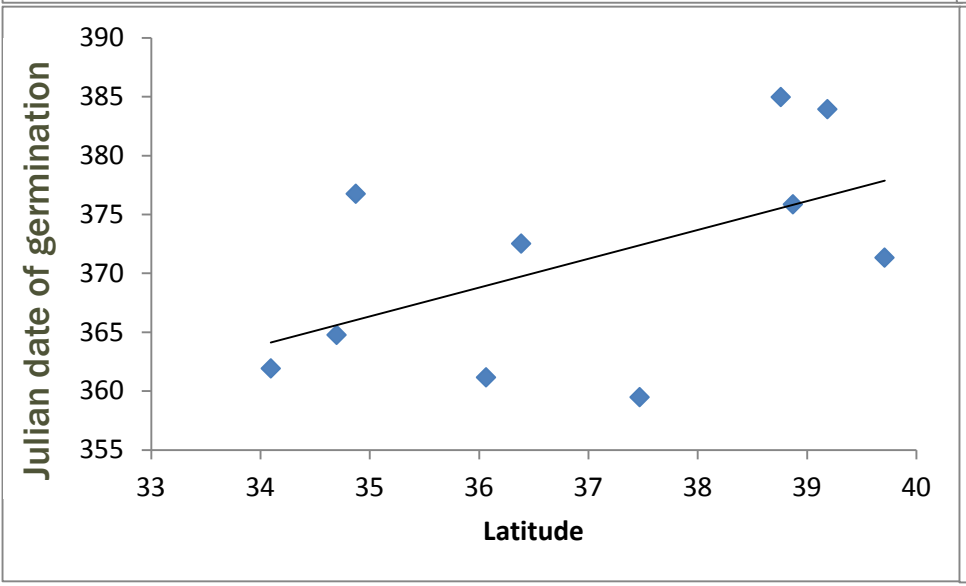


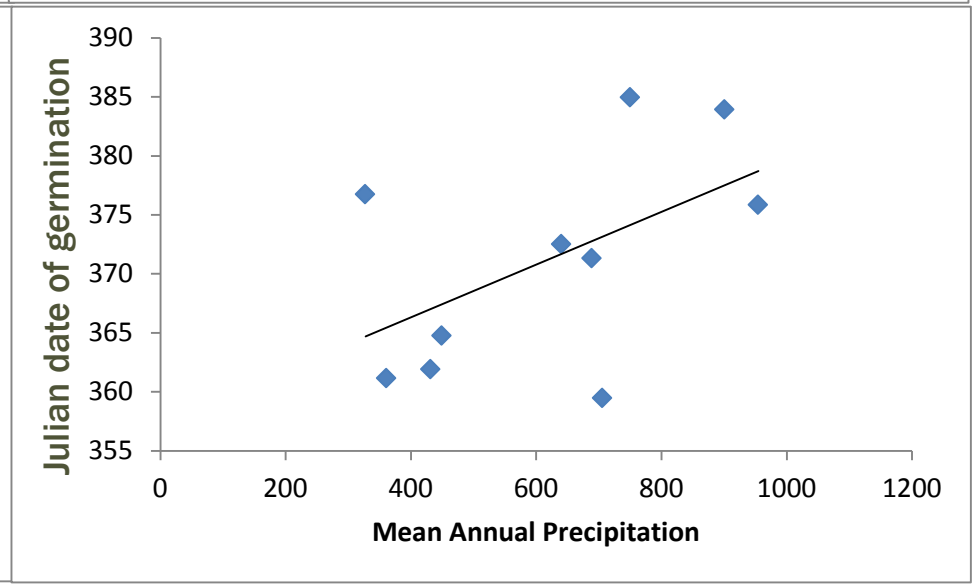

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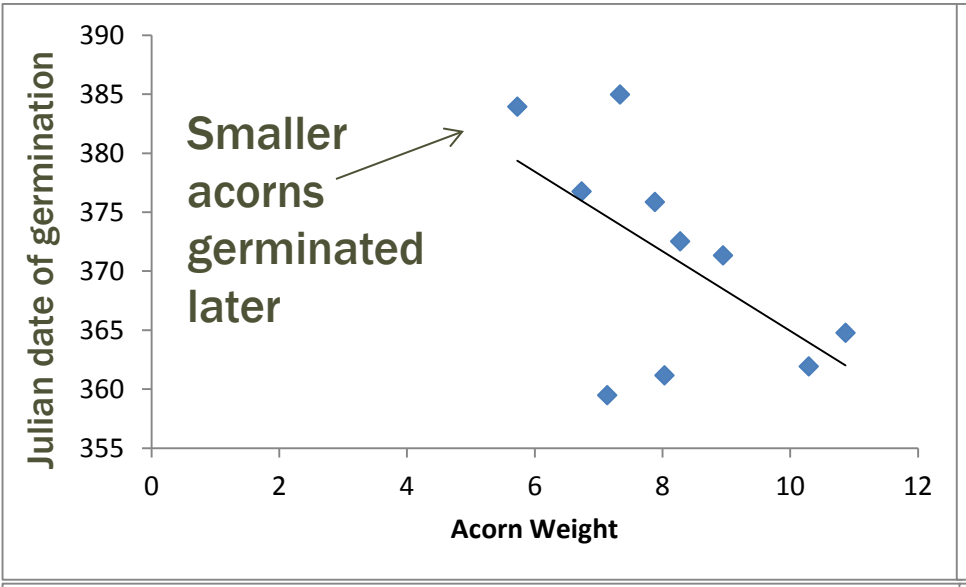


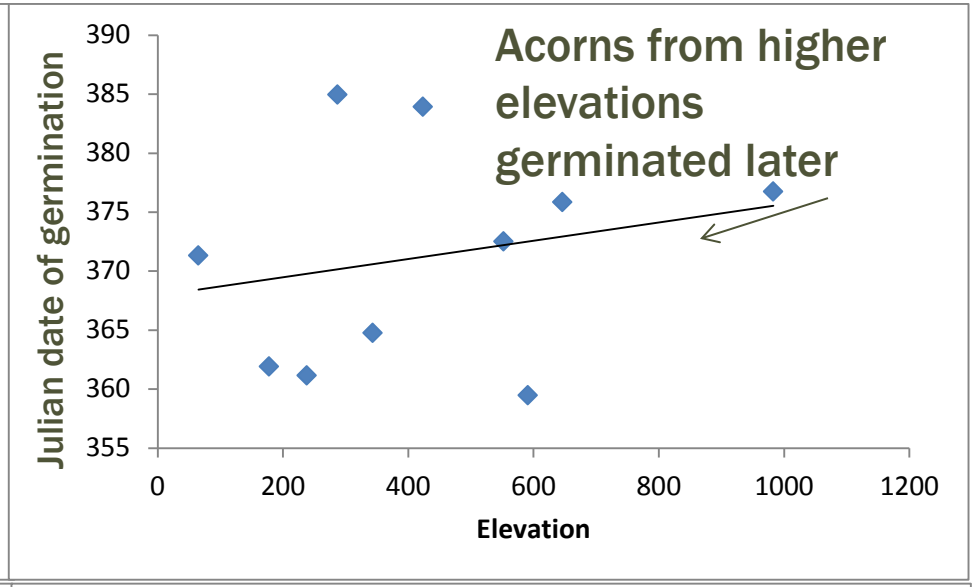


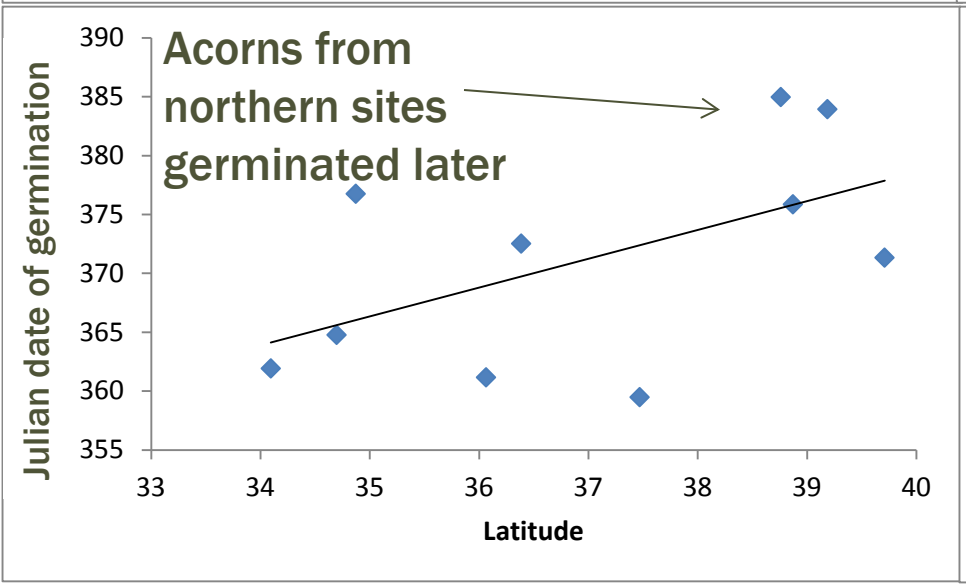


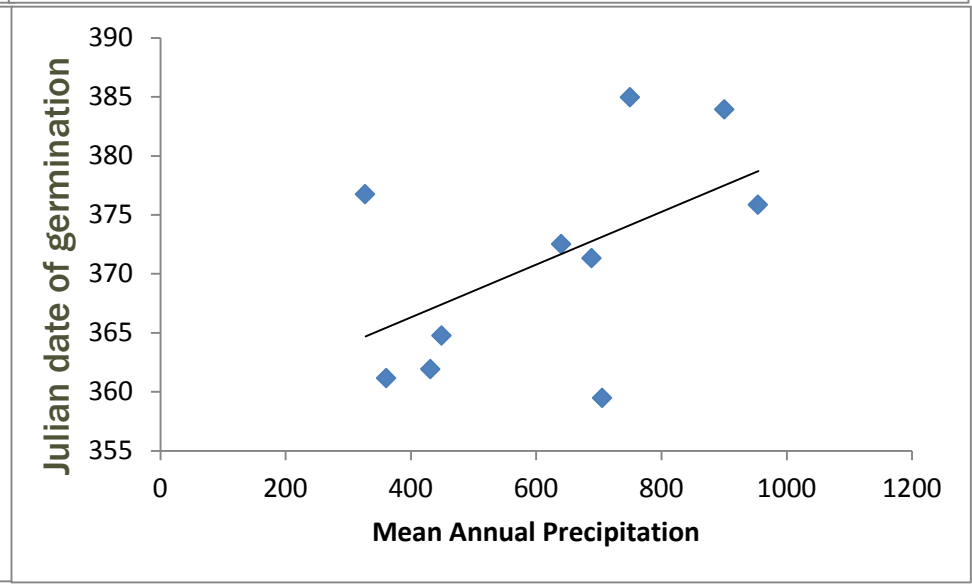

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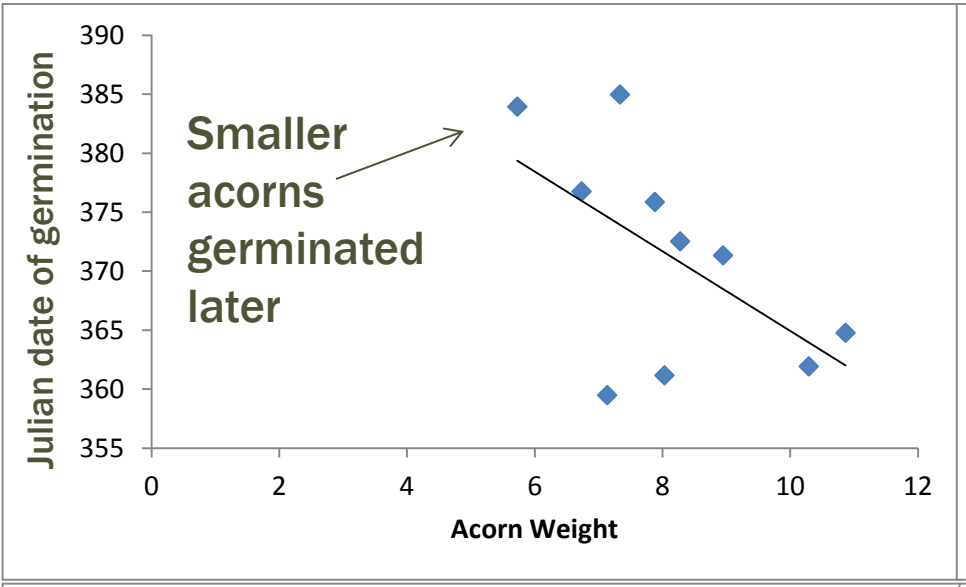
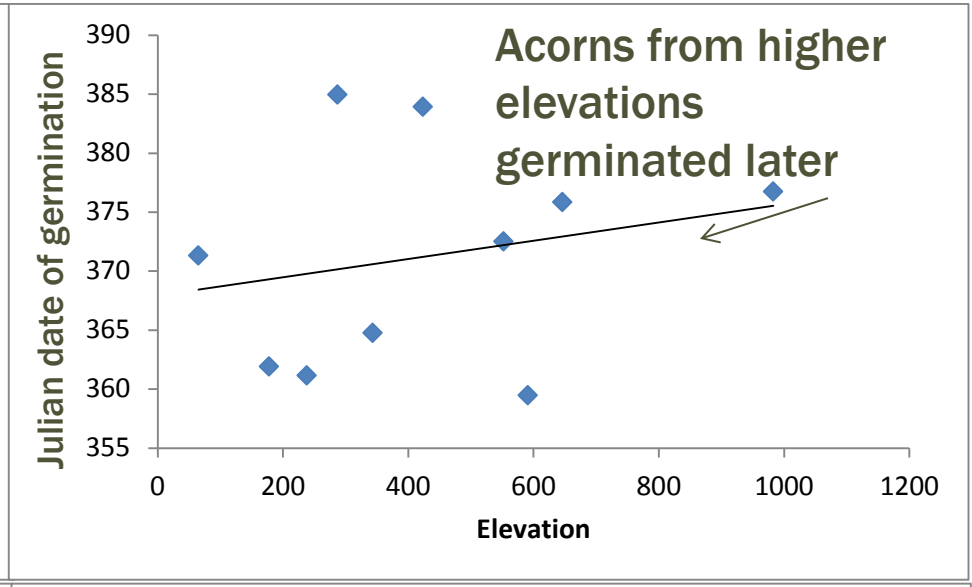
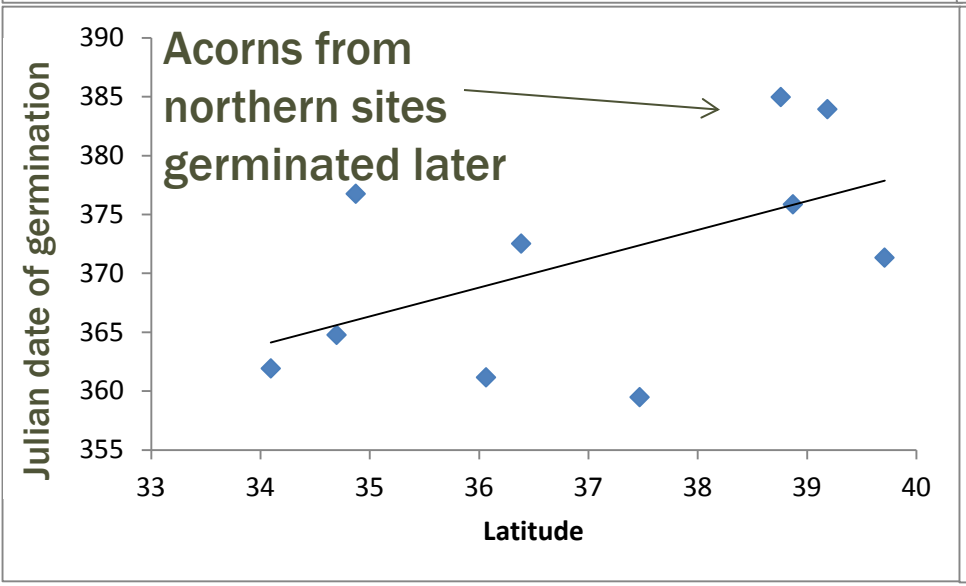
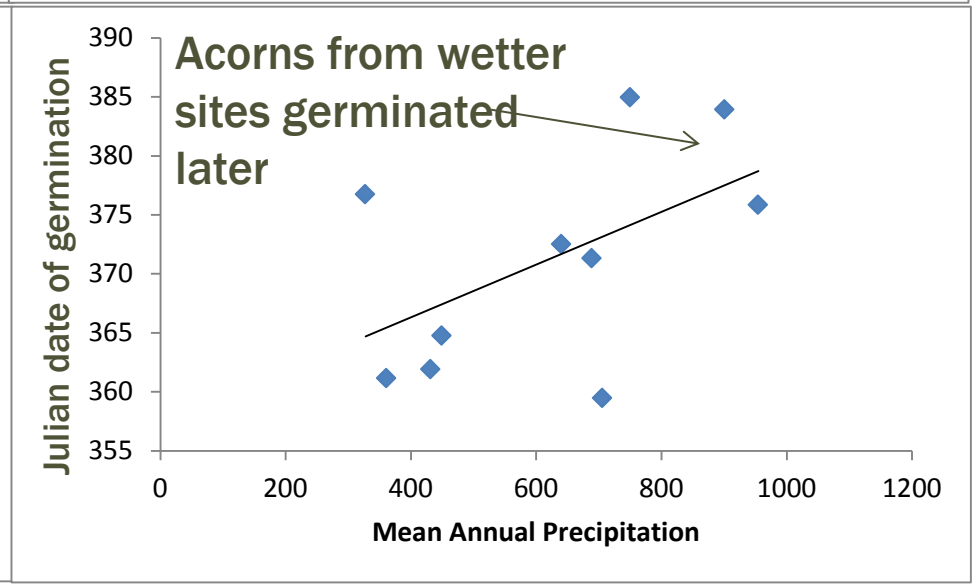


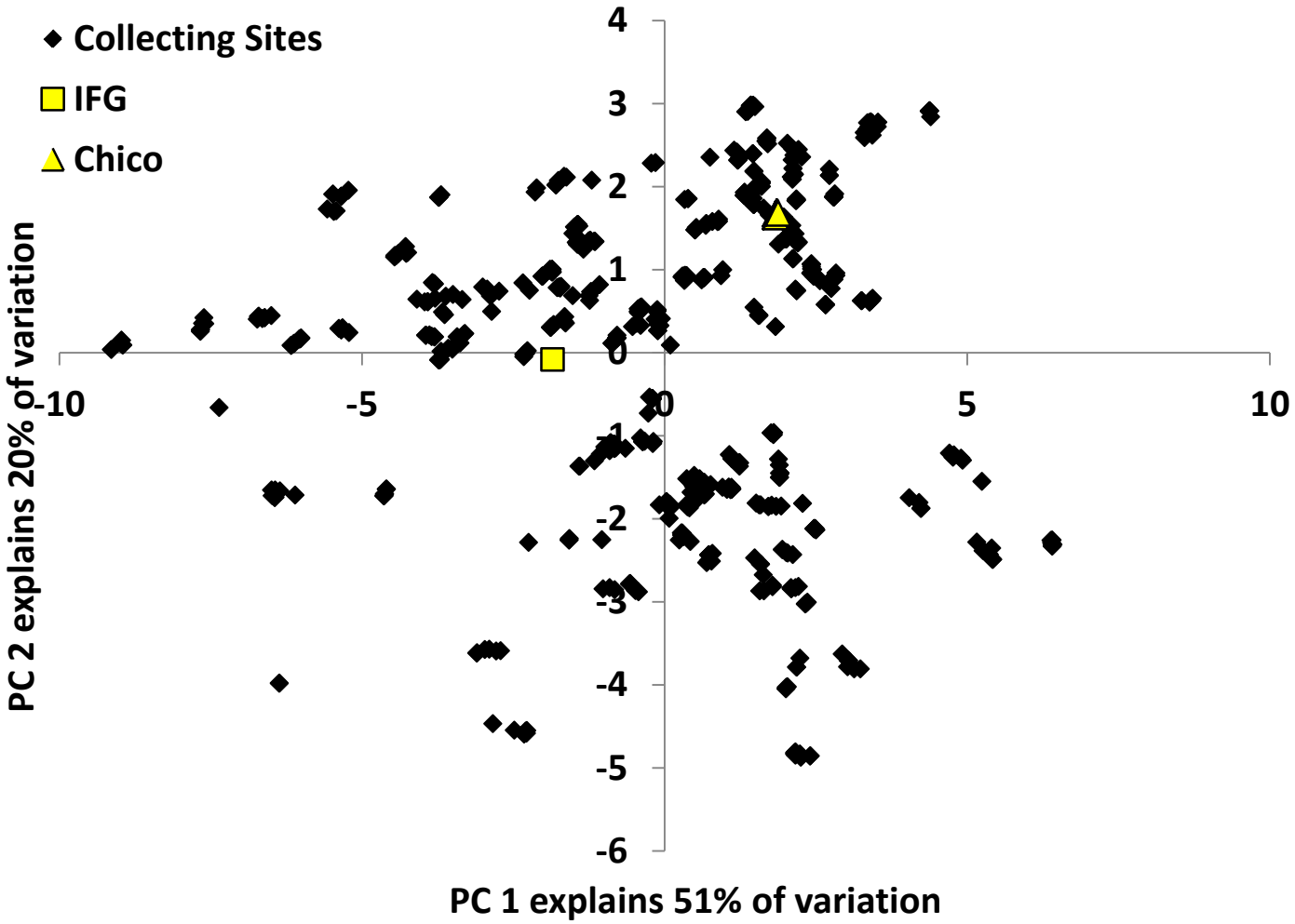



# Future planting site at the USDA-FS PSW Institute of Forest Genetics, Placerville

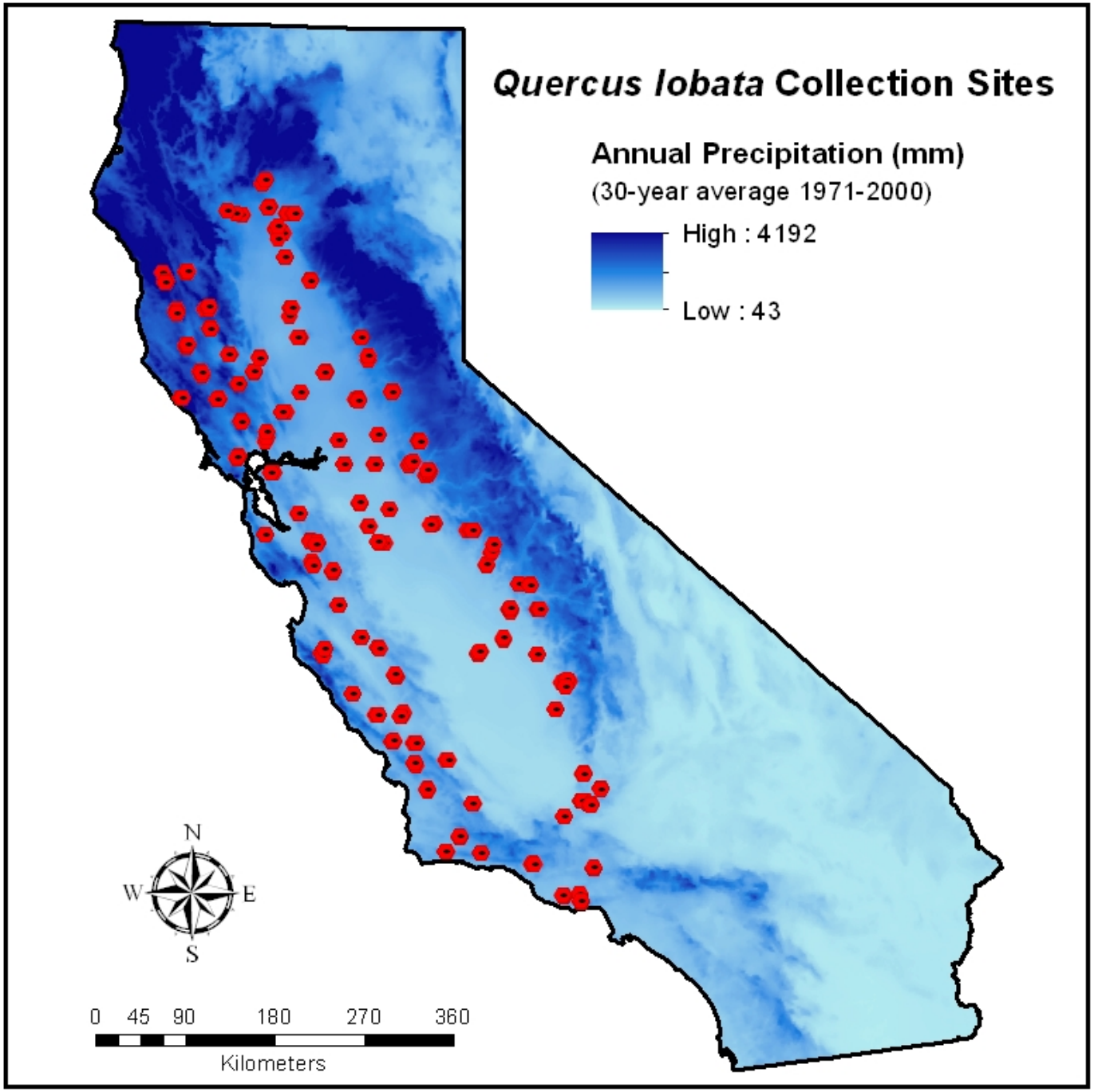
Future planting site at the USDA-FS Genetic Resource and Conservation Center, Chico

# The two planting sites represent two different valley oak climate environments.



# Landscape Genomics

- Associate genotype (at a large number of loci) with climate
- Using Genotyping-by-Sequencing
- Current project in 2 species-
  - Valley Oaks in California
    - 12,000 SNPs
  - Koa in Hawaii
    - 7500 SNPs


*Quercus lobata* Collection Sites
Annual Precipitation (mm)
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High : 4192
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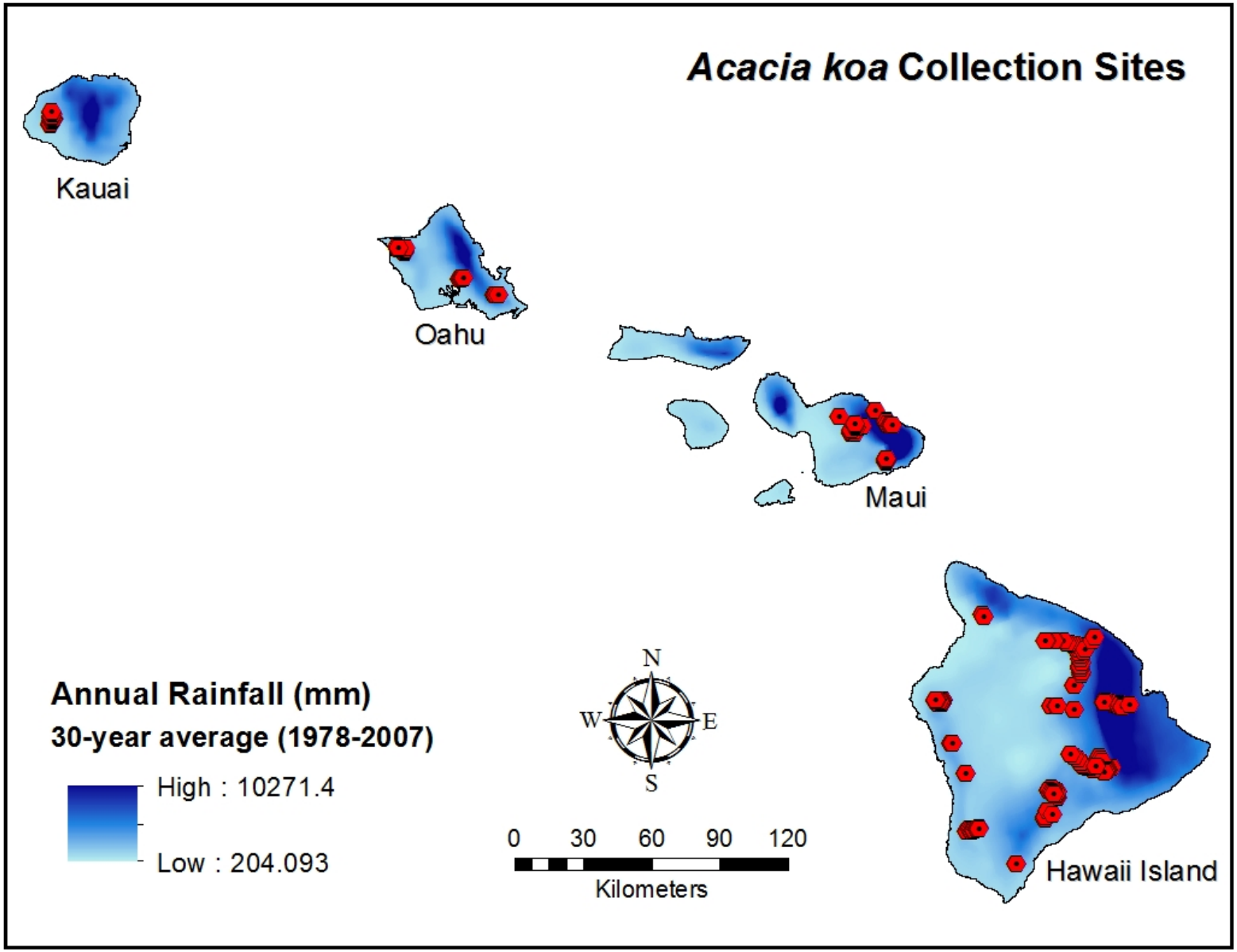
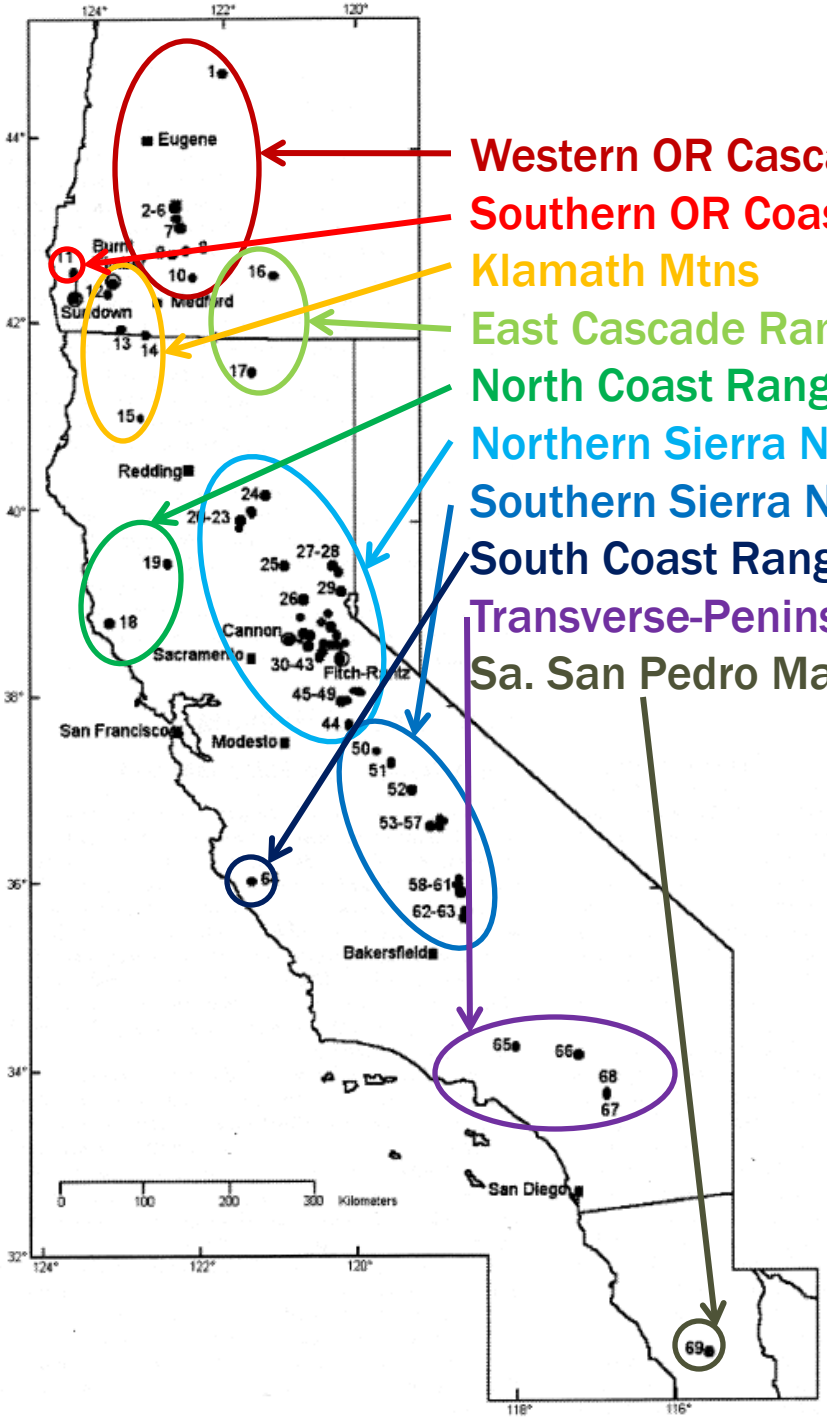
0 45 90 180 270 360
Kilometers


Acacia koa Collection Sites
Kauai
Oahu
Maui
Hawaii Island
Annual Rainfall (mm)
30-year average (1978-2007)
High : 10271.4
Low : 204.093
N
W
E
S
0
30
60
90
120
Kilometers

FITCH RANTZ
PLANTED 1984
INSTITUTE OF FOREST GENETICS
PLACERVILLE CA
PACIFIC SOUTHWEST RESEARCH STATION

Fitch Rantz Block 1

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 109 | 107 | 413 | 410 | 113 | 117 | 9 | 3 | 610 | 617 | 174 | 179 | 189 | 187 | 451 | 458 | 483 | 481 | 20 | 29 | 607 | 600 | 590 | 595 | 511 | 516 | 340 | 343 | 55 | 54 | 47 | 49 | 375 | 372 | 159 | 152 | 389 | 387 | 577 | 576 | 366 | 368 | 121 |
| 100 | 106 | 418 | 414 | 114 | 112 | 2 | 4 | 618 | 612 | 173 | 178 | 184 | 186 | 457 | 455 | 485 | 487 | 23 | 21 | 602 | 605 | 593 | 598 | 515 | 518 | 344 | 341 | 51 | 50 | 48 | 46 | 377 | 373 | 158 | 150 | 384 | 388 | 571 | 570 | 362 | 363 | 122 |
| 103 | 108 | 417 | 419 | 110 | 119 | 8 | 6 | 611 | 619 | 175 | 170 | 188 | 187 | 450 | 456 | 484 | 482 | 22 | 27 | 608 | 604 | 592 | 596 | 513 | 519 | 346 | 342 | 58 | 53 | 40 | 43 | 370 | 371 | 157 | 153 | 381 | 382 | 573 | 579 | 369 | 365 | 120 |
| 101 | 105 | 416 | 415 | 115 | 111 | 0 | 5 | 616 | 614 | 176 | 172 | 181 | 183 | 459 | 452 | 484 | 480 | 281 | 25 | 606 | 603 | 599 | 597 | 517 | 514 | 347 | 348 | 57 | 56 | 41 | 42 | 374 | 376 | 155 | 154 | 383 | 380 | 572 | 574 | 364 | 367 | 123 |
| 102 | 104 | 411 | 412 | 116 | 118 | 7 | 1 | 613 | 615 | 177 | 171 | 185 | 185 | 454 | 450 | 489 | 488 | 24 | 26 | 609 | 601 | 594 | 591 | 512 | 513 | 345 | 349 | 59 | 52 | 40 | 46 | 378 | 379 | 156 | 151 | 386 | 385 | 575 | 578 | 361 | 360 | 125 |
| 215 | 70 | 70 | 334 | 333 | 496 | 492 | 637 | 631 | STUMP | 422 | 426 | 401 | 321 | 325 | 542 | 543 | 37 | 31 | 432 | 432 | 649 | 647 | 526 | 529 | 146 | 507 | 501 | 502 | 10 | 19 | 589 | 581 | 274 | 270 | 231 | 239 | 64 | 68 | 664 | 651 | 124 |
| 217 | 78 | 73 | 339 | 332 | 493 | 490 | 634 | 639 | 638 | 425 | 427 | 400 | 320 | 326 | 540 | 541 | 39 | 32 | 430 | 431 | 648 | 640 | 525 | 527 | 147 | 142 | 503 | 506 | 17 | 15 | 584 | 583 | 272 | 277 | 232 | 238 | 65 | 69 | 660 | 655 | 129 |
| 213 | 75 | 72 | 330 | 337 | 495 | 497 | 636 | 632 | 428 | 420 | 407 | 402 | 328 | 324 | 549 | 548 | 38 | 33 | 434 | 438 | 645 | 643 | 520 | 524 | 149 | 149 | 508 | 504 | 13 | 16 | 587 | 588 | 279 | 273 | 230 | 237 | 63 | 61 | 669 | 653 | 126 |
| 211 | 71 | 76 | 338 | 335 | 491 | 494 | 635 | 633 | 424 | 421 | 405 | 406 | 329 | 327 | 547 | 544 | 35 | 34 | 439 | 433 | 642 | 641 | 523 | 528 | 140 | 148 | STUMP | 505 | 11 | 12 | 582 | 586 | 276 | 271 | 234 | 236 | 66 | 67 | 668 | 667 | 128 |
| 210 | 77 | 79 | 331 | 336 | 498 | 499 | 630 | STUMP | 429 | 423 | 408 | 403 | 322 | 323 | 546 | 545 | 36 | 30 | 436 | 435 | 646 | 644 | 521 | 522 | 145 | 146 | 500 | 509 | 14 | 18 | 580 | 585 | 275 | 278 | 233 | 235 | 60 | 62 | 666 | 662 | 127 |
| 214 | 356 | 354 | 621 | 628 | 223 | 229 | 654 | 650 | 441 | 442 | 559 | 557 | 464 | 468 | 263 | 265 | 563 | 566 | 162 | 167 | 155 | 205 | 200 | 312 | 199 | 195 | 139 | 137 | 477 | 476 | 533 | STUMP | STUMP | 254 | 257 | 252 | 242 | 242 | 83 | 85 | 291 |
| 216 | 359 | 353 | 622 | 626 | 221 | 228 | 650 | 656 | 448 | 440 | 558 | 556 | 466 | 469 | 260 | 264 | 568 | 560 | 163 | 168 | 201 | 200 | 316 | 318 | 197 | 196 | 138 | 133 | 472 | 474 | 537 | STUMP | STUMP | 253 | STUMP | 255 | 244 | 240 | 82 | 84 | 299 |
| 212 | 352 | 351 | 624 | 627 | 220 | 227 | 651 | 652 | 444 | 443 | 553 | 550 | 463 | 465 | 269 | 266 | 567 | 562 | 164 | 166 | 203 | 206 | 319 | 317 | 198 | 193 | 132 | 135 | 475 | 479 | 532 | 539 | STUMP | STUMP | 258 | 256 | 246 | 240 | 81 | 86 | NO TREE |
| 218 | 358 | 350 | 629 | 623 | 224 | 226 | 657 | 657 | 446 | 447 | 551 | 556 | 467 | 462 | 262 | 261 | 564 | 560 | NO TREE | 169 | 205 | 209 | 310 | 315 | 191 | 192 | 136 | 134 | 473 | 475 | 534 | 530 | 538 | STUMP | 259 | 241 | 244 | 89 | 80 | 297 | NO TREE |
| 219 | 357 | 355 | 625 | 620 | 225 | 222 | 658 | 655 | 445 | 442 | 554 | 552 | 460 | 461 | 267 | 268 | 565 | 561 | 161 | 160 | 206 | 202 | 313 | 314 | 190 | 194 | 131 | 130 | 478 | 479 | 531 | 536 | 535 | 251 | 250 | 245 | 249 | 88 | 87 | 292 | 298 |



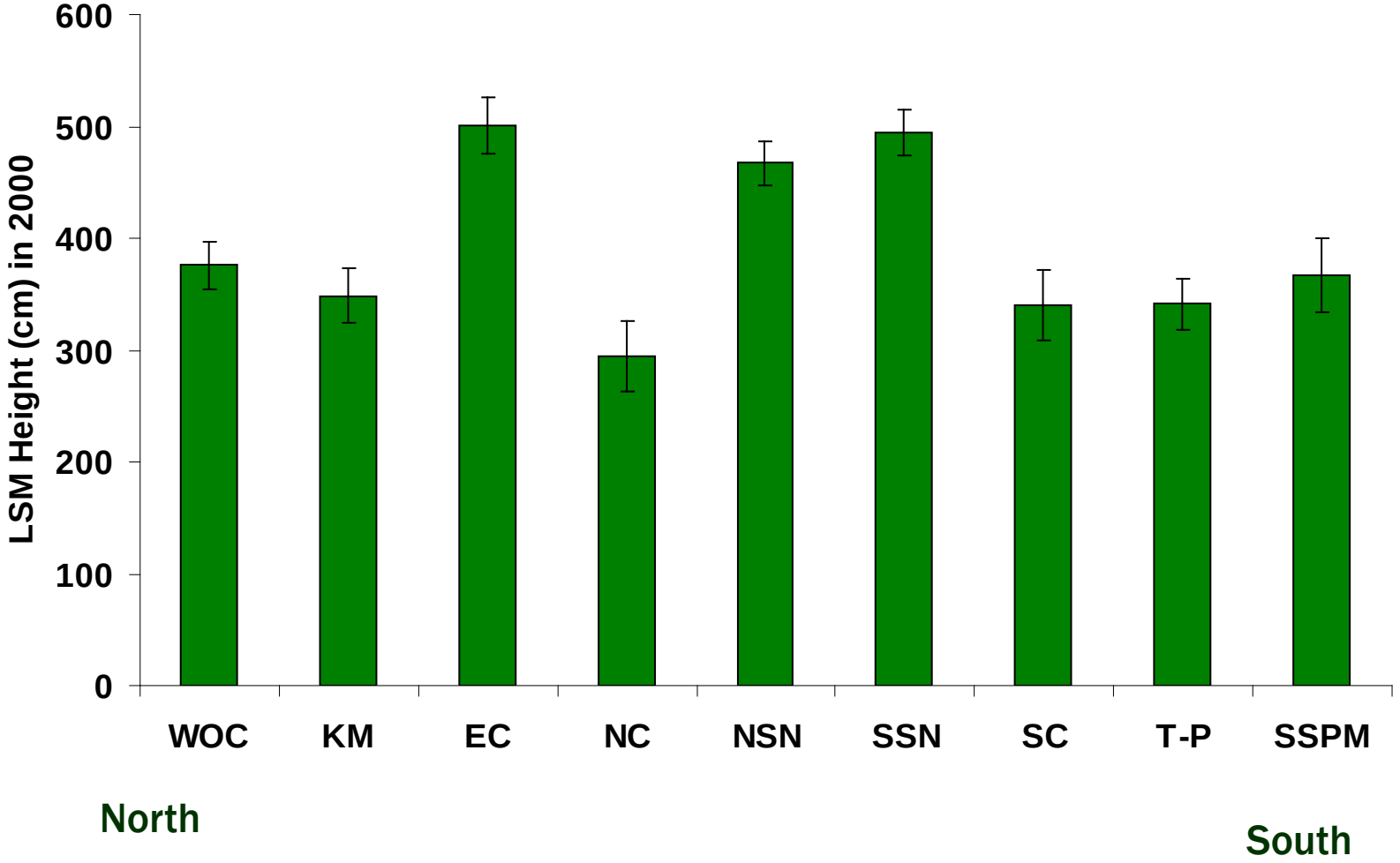

| | MAP | MAT | |
|---|---|---|---|
| Western OR Cascade Range | 1374 | 8.7 | WOC |
| Southern OR Coast Range | 1823 | 10.8 | SOC |
| Klamath Mtns | 1030 | 9.5 | KM |
| East Cascade Ranges | 570 | 5.3 | EC |
| North Coast Range | 1125 | 12.6 | NC |
| Northern Sierra Nevada | 1198 | 19.7 | NSN |
| Southern Sierra Nevada | 869 | 8.8 | SSN |
| South Coast Range | 877 | 11.6 | SC |
| Transverse-Peninsular Ranges | 715 | 10.5 | T-P |
| Sa. San Pedro Martir | 548 | 13 | SSPM |

# Traditional approach…

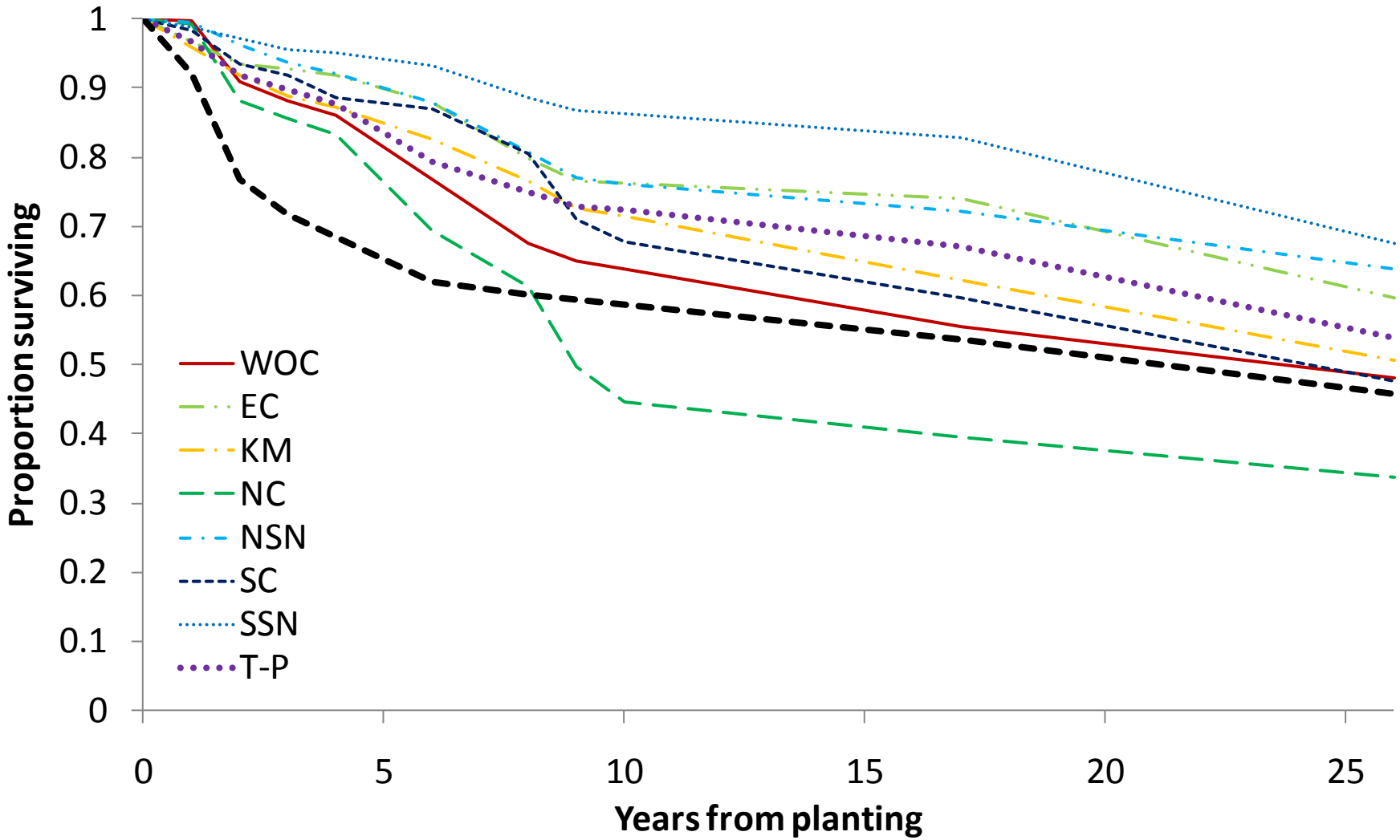
| | Num | Den | | |
|---|---|---|---|---|
| Effect | DF | DF | F Value | Pr > F |
| | | | | |
| Region | 8 | 668 | 41.02 | <.0001 |
| Source(Region) | 55 | 529 | 4.35 | <.0001 |

**Random effects- Family(Source(Region)), Block**

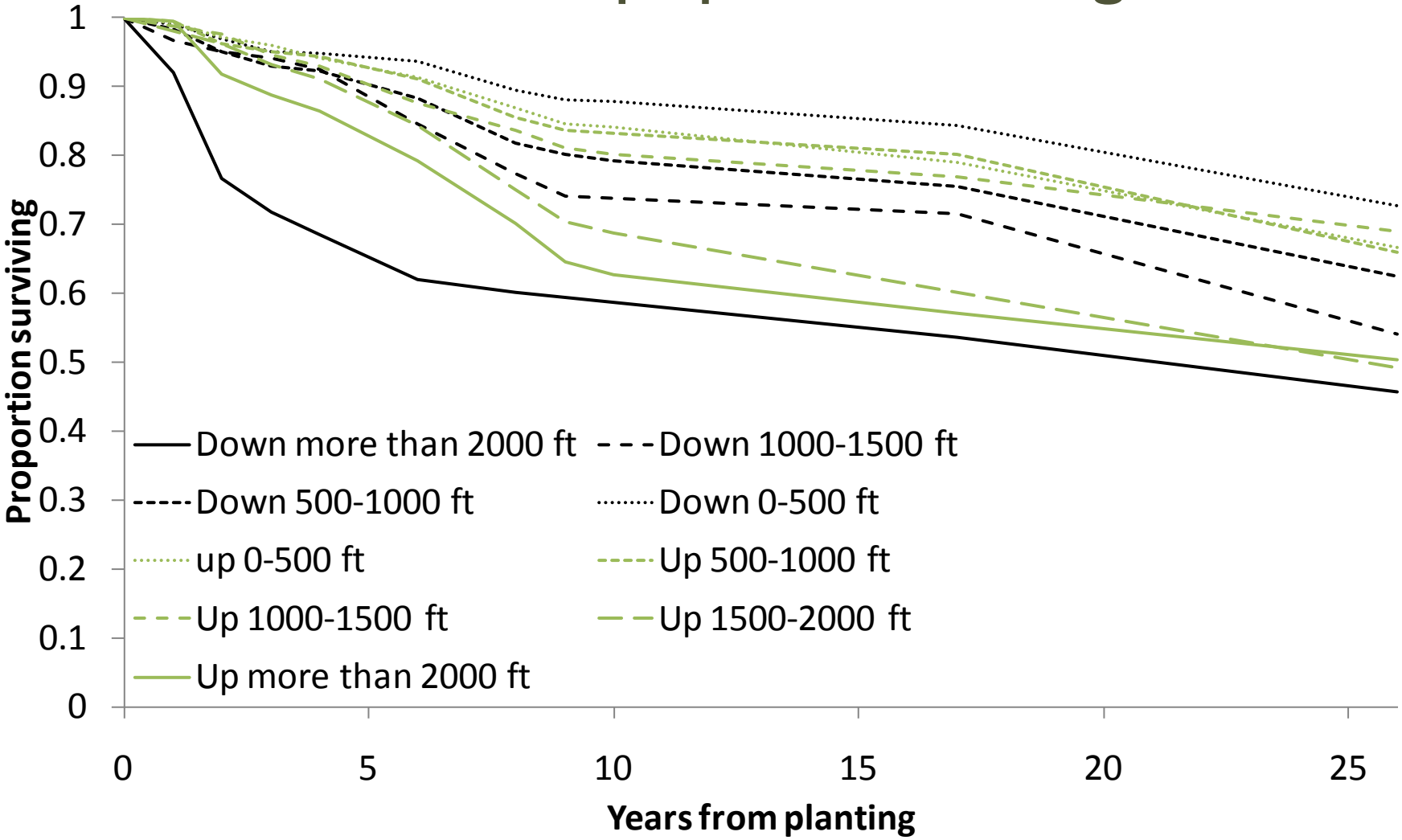
# Preliminary analysis: Regions had different growth at the Fitch Rantz test site.



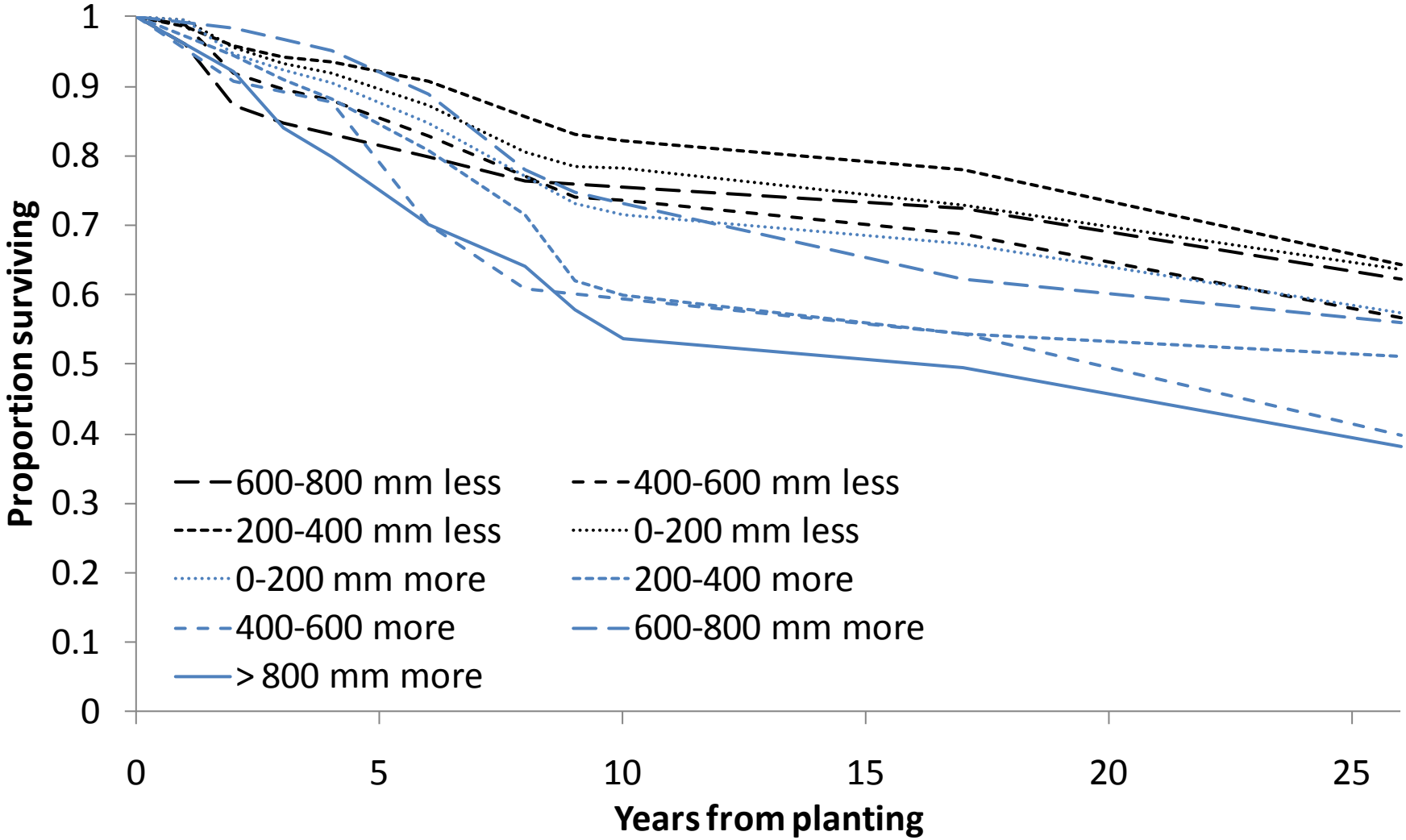
# Preliminary analysis: The regions also had different survival rates.

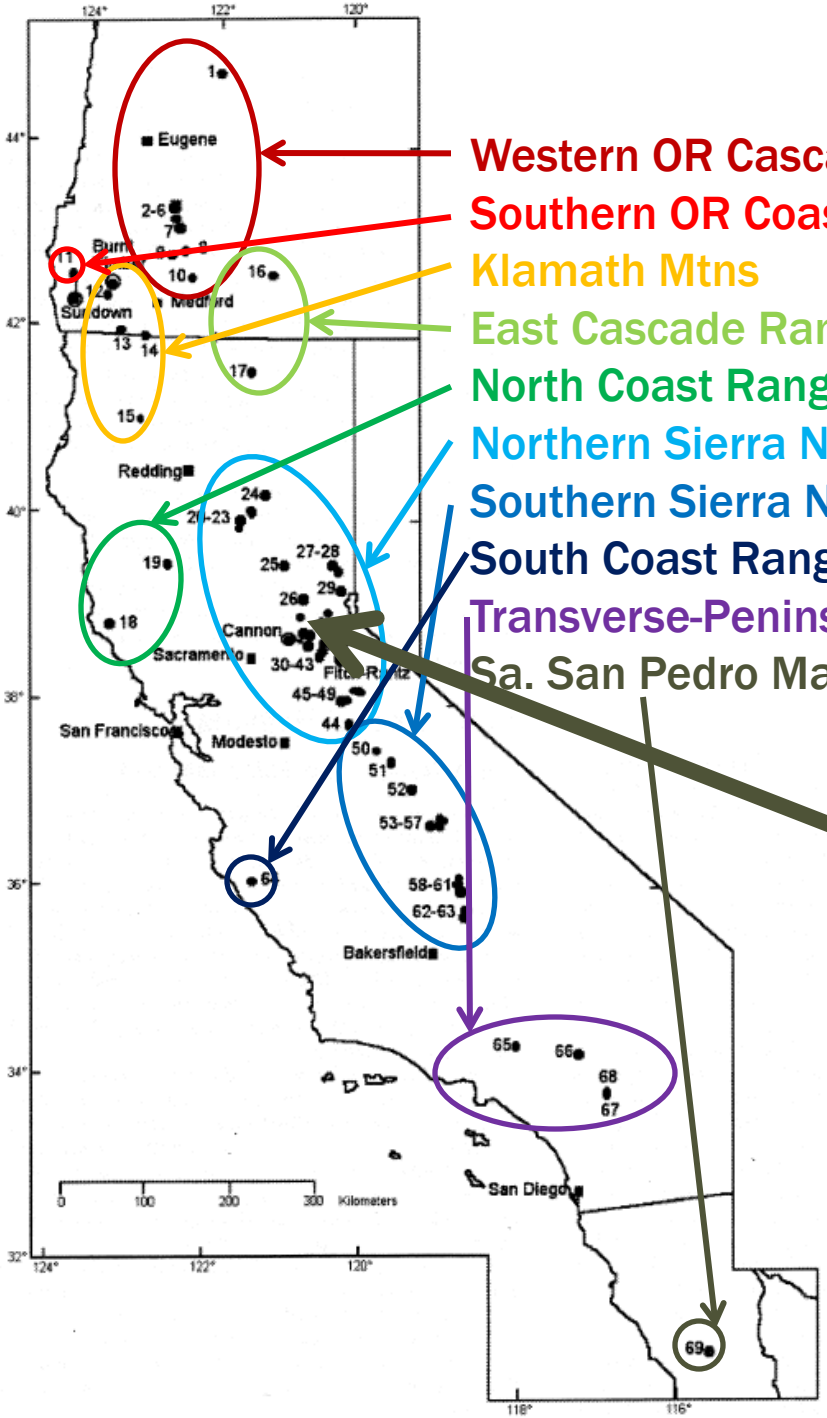


# Preliminary analysis: Changes in elevation were not associated with the proportion surviving.



# Preliminary analysis: trees from wetter sites had higher survival (where F.R. was a drier site for them).



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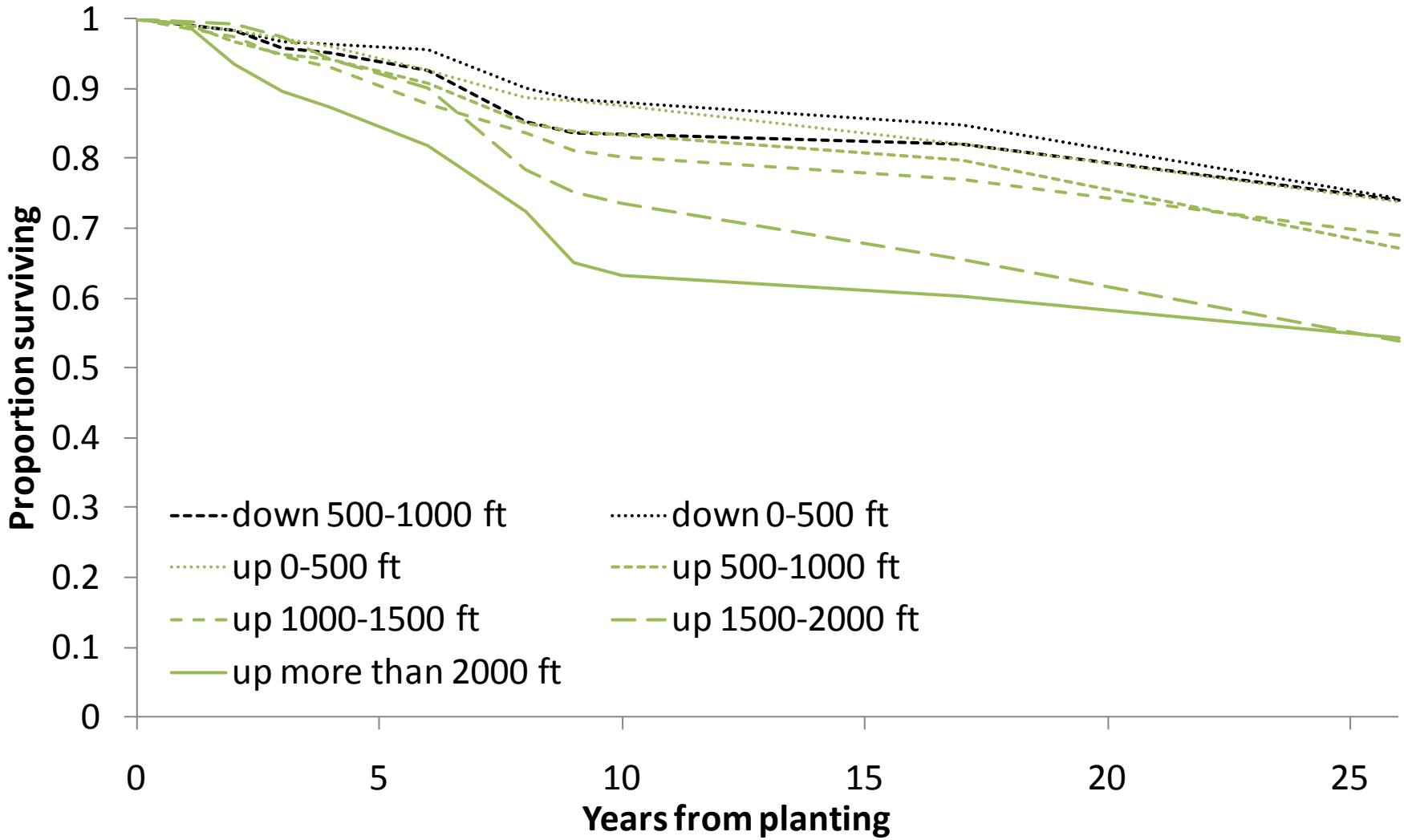
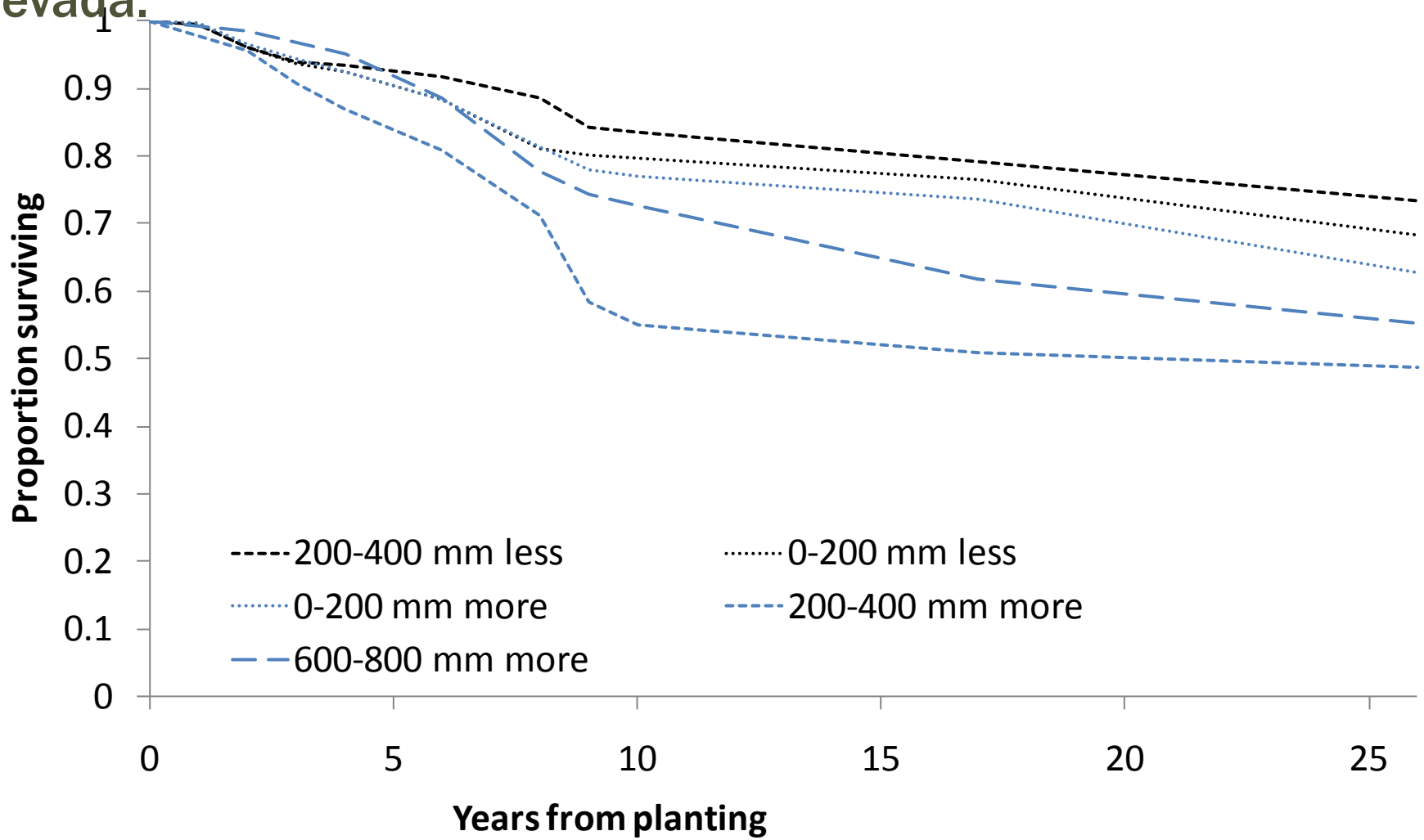
| Transverse-Peninsular Ranges | 715 | 10.5 | T-P |
| Sa. San Pedro Martir | 548 | 13 | SSPM |

Focal region

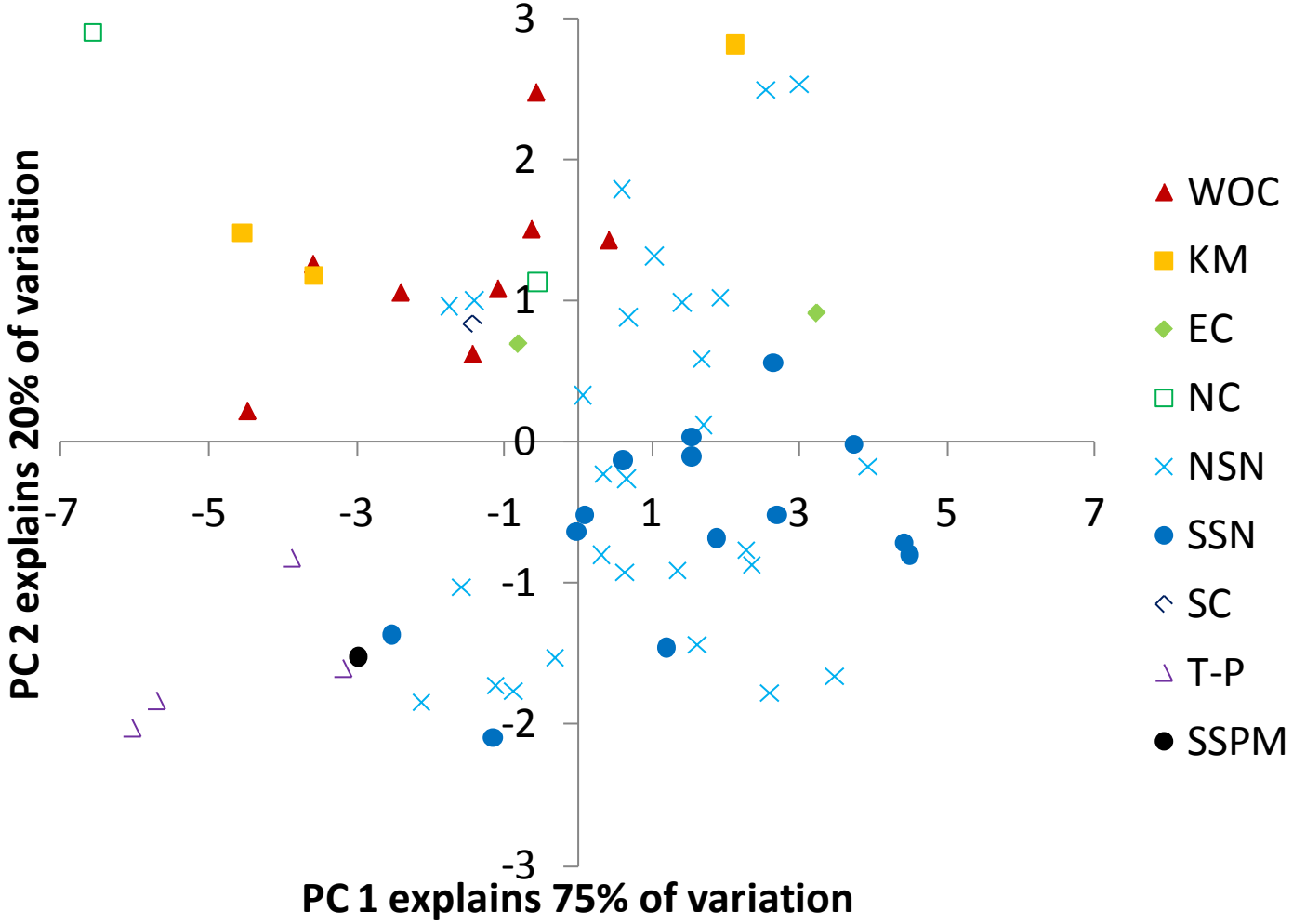
# Preliminary analysis: in the Northern Sierra Nevada, trees that came from higher elevations had higher survival.



# Preliminary analysis: There was lower survival when the planting site was wetter that the tree's home site within the Northern Sierra Nevada.



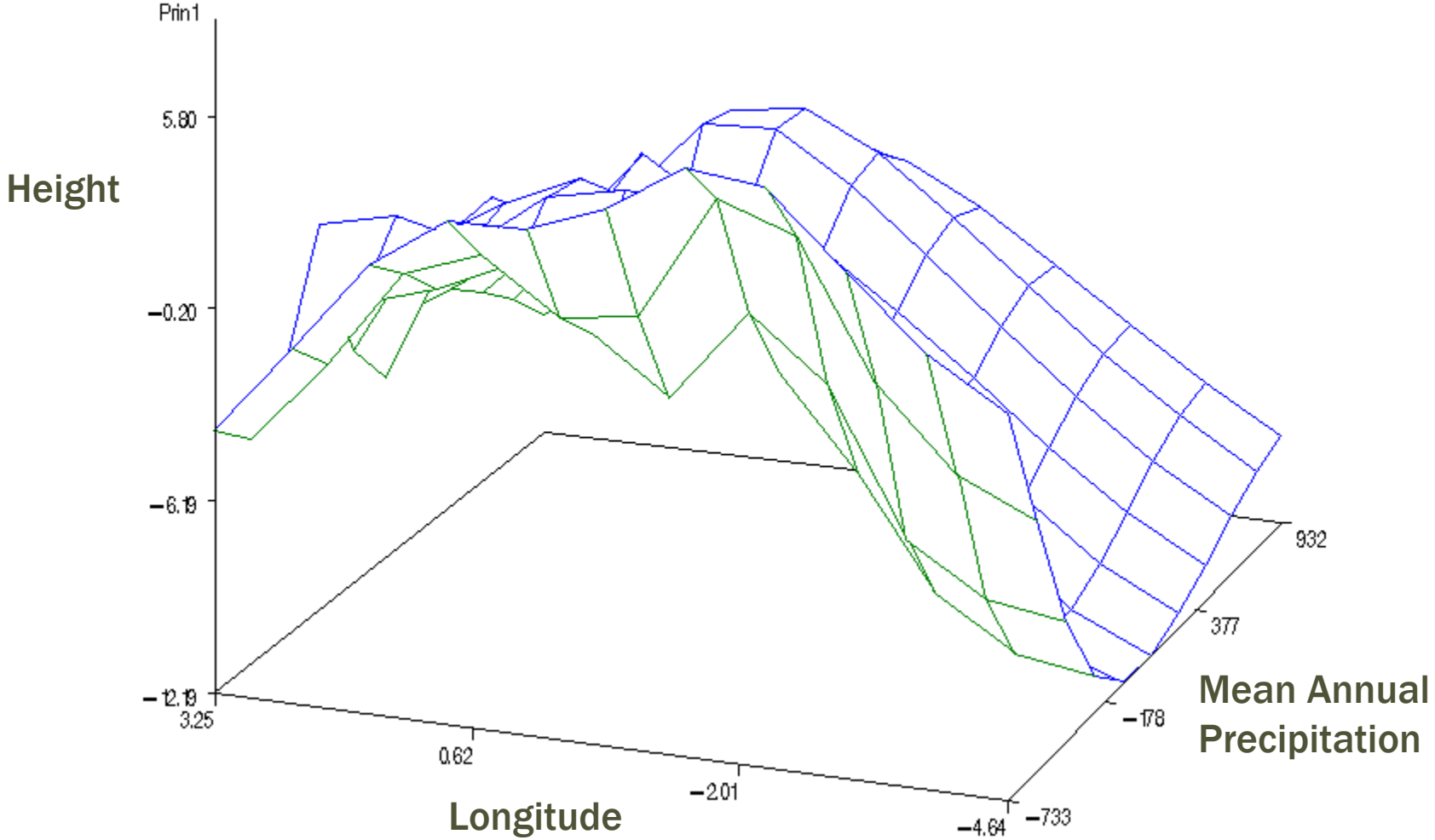
# Preliminary analysis: differences between the regions are illustrated in a Principal Components Analysis.



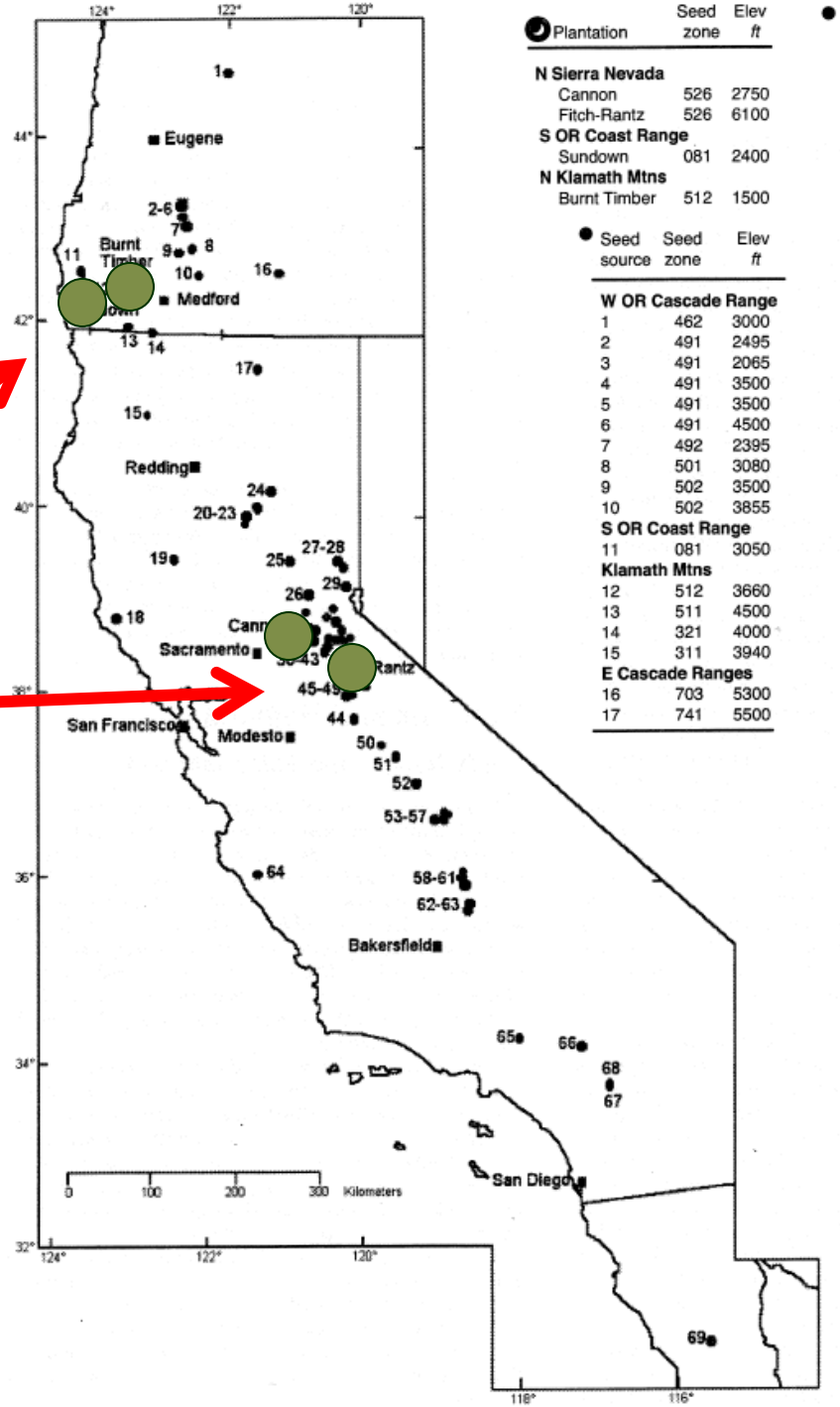
## Preliminary analysis: stepwise multiple regression shows a negative linear effect of changes in MAP and a negative quadratic effect of changes in longitude on tree height.

| | Change in… | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Elevation | | Mean Annual Precipitation | | Mean Annual Temperature | | Latitude | | Longitude | | |
| Height in- | Linear | Quad. | Linear | Quad. | Linear | Quad. | Linear | Quad. | Linear | Quad. | $R^2$ |
| 1984 | ****+ | | **– | | | | | | | – | 0.3673 |
| 1985 | ****+ | – | – | | | | | | | *– | 0.4244 |
| 1986 | ***+ | *– | *– | | | | | | | ****– | 0.5214 |
| 1987 | | | *– | | | | | | | ****– | 0.4336 |
| 1989 | | | **– | | – | | | | | ****– | 0.4886 |
| 1991 | | **– | *– | | | | | | | ****– | 0.5399 |
| 1992 | | **– | **– | | | | | + | | ****– | 0.6023 |
| 1993 | | **– | **– | | | | | | | ****– | 0.5912 |
| 2000 | | **– | **– | | | | | + | | ****– | 0.6295 |
| | | | | | | | | | | | |
| PCA | | | **– | | | | | | | ****– | 0.4761 |
| | <.0001 **** | | .0001-.001*** | | .001-.01** | | .01-.05* | | ns +,- | | |

# Preliminary analysis: a graph illustrating the negative linear effects of a change in MAP, and the negative quadratic effect of a change in longitude.



Four planting sites total




| Plantation | Seed zone | Elev ft |
|---|---|---|
| **N Sierra Nevada** | | |
| Cannon | 526 | 2750 |
| Fitch-Rantz | 526 | 6100 |
| **S OR Coast Range** | | |
| Sundown | 081 | 2400 |
| **N Klamath Mtns** | | |
| Burnt Timber | 512 | 1500 |

| Seed source | Seed zone | Elev ft |
|---|---|---|
| **W OR Cascade Range** | | |
| 1 | 462 | 3000 |
| 2 | 491 | 2495 |
| 3 | 491 | 2065 |
| 4 | 491 | 3500 |
| 5 | 491 | 3500 |
| 6 | 491 | 4500 |
| 7 | 492 | 2395 |
| 8 | 501 | 3080 |
| 9 | 502 | 3500 |
| 10 | 502 | 3855 |
| **S OR Coast Range** | | |
| 11 | 081 | 3050 |
| **Klamath Mtns** | | |
| 12 | 512 | 3660 |
| 13 | 511 | 4500 |
| 14 | 321 | 4000 |
| 15 | 311 | 3940 |
| **E Cascade Ranges** | | |
| 16 | 703 | 5300 |
| 17 | 741 | 5500 |

| Seed source | Seed zone | Elev ft |
|---|---|---|
| **North Coast Range** | | |
| 18 | 094 | 1500 |
| 19 | 371 | 4500 |
| **N Sierra Nevada** | | |
| 20 | 524 | 2330 |
| 21 | 524 | 3775 |
| 22 | 524 | 5250 |
| 23 | 524 | 5500 |
| 24 | 523 | 6100 |
| 25 | 525 | 4380 |
| 26 | 525 | 3965 |
| 27 | 772 | 5880 |
| 28 | 772 | 6475 |
| 29 | 772 | 6400 |
| 30 | 526 | 2530 |
| 31 | 526 | 2800 |
| 32 | 525 | 3000 |
| 33 | 526 | 3400 |
| 34 | 526 | 4000 |
| 35 | 526 | 4500 |
| 36 | 526 | 4650 |
| 37 | 525 | 5000 |
| 38 | 526 | 5100 |
| 39 | 526 | 5265 |
| 40 | 526 | 5600 |
| 41 | 526 | 5925 |
| 42 | 526 | 6600 |
| 43 | 525 | 7000 |
| 44 | 531 | 3160 |
| 45 | 531 | 4000 |
| 46 | 531 | 4720 |
| 47 | 531 | 5450 |
| 48 | 531 | 6250 |
| 49 | 531 | 6950 |
| **S Sierra Nevada** | | |
| 50 | 532 | 6070 |
| 51 | 532 | 6055 |
| 52 | 533 | 5860 |
| 53 | 534 | 5565 |
| 54 | 534 | 5710 |
| 55 | 534 | 6565 |
| 56 | 534 | 6660 |
| 57 | 534 | 7615 |
| 58 | 534 | 6725 |
| 59 | 540 | 6265 |
| 60 | 540 | 5915 |
| 61 | 540 | 6100 |
| 62 | 540 | 6265 |
| 63 | 540 | 6300 |
| **South Coast Range** | | |
| 64 | 120 | 5800 |
| **Transverse-Peninsular Ranges** | | |
| 65 | 993 | 6950 |
| 66 | 994 | 6720 |
| 67 | 997 | 5950 |
| 68 | 997 | 7500 |
| **Sa San Pedro Martir** | | |
| 69 | — | 8200 |

Cannon

# Future planting site at the USDA-FS PSW Institute of Forest Genetics, Placerville

Harrel- 16,000 trees planted in 1992

OCR (80, 511)

NCR (91, 301-303, 311, 312, 322, 332, 340, 371-372, 390)

ECR (732, 741-42 771-72)

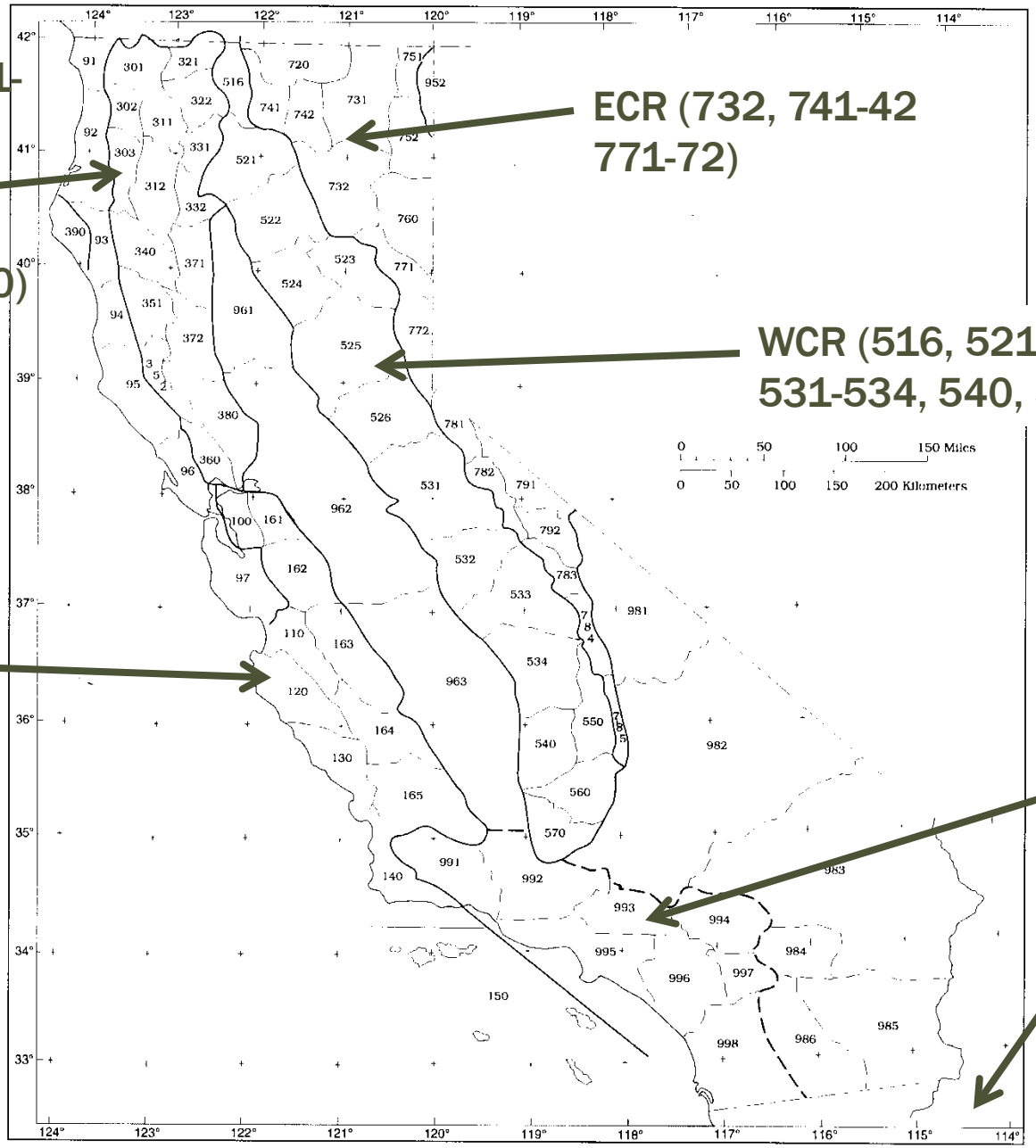
Harrel source locations (124 total)

WCR (516, 521, 523-526, 531-534, 540, 550)

SCR (120)

TPR (992, 993, 994, 997)

MEX- Sierra San Pedro Martir



# Next steps…

- Provenance tests can provide the necessary information for determining seed transfer guidelines
  - Measure tree performance in novel climates
  - Could provide relevant information for understanding tree responses to climate change!

Thanks to-
Annie Mix
Robyn Scibilio
Thomas Blush
Courtney Canning
Shani Sarena

Collaborators-
Victoria Sork (UCLA)
Paul Gugger (UCLA)
Christina Liang (PSW)

# Thanks to…

- Jim Jenkinson
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- Jim Baldwin
- Tom Ledig
- Michael Landram
- Matthew Bokach
- Phil Cannon
- Institute of Forest Genetics
  - Paul Hodgskiss
  - Roger Stutts
  - Dave Johnson

USFS-WO Climate Change Program

Forest Service Forest Inventory and Monitoring Program

FS Region 5 Genetics Program

# Recent & Ongoing Fire/Climate Research at PSW Redding

**Carl N. Skinner**

Research Geographer

**USDA Forest Service, Research & Development**

***Pacific Southwest Research Station***

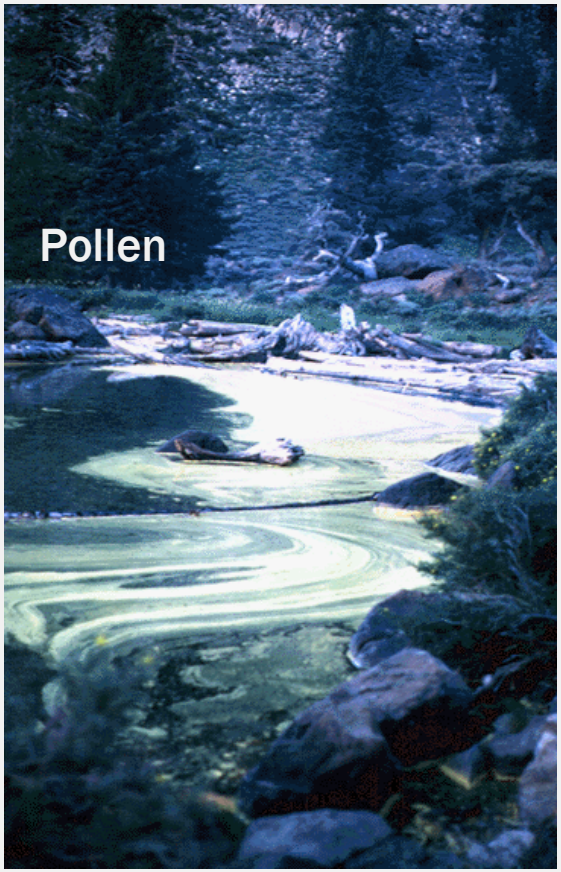
# Scales of Inquiry

- Sediment Cores – 1000s yrs
  Long-term climate/veg/fire variation
- Tree-rings – 100s yrs
  Climate/fire/forest variation
- Fire & Climate Records – 10s yrs
  Historical climate/fire/vegetation

# Collaborators

- **Sediment Cores**
  - Cathy Whitlock – Montana St. Univ.
  - Christy Briles – Univ. Colorado, Denver
- **Tree-rings**
  - Alan Taylor – Penn. St. Univ.
  - Valerie Trouet – Univ. Arizona, LTRR
  - Scott Stephens – U.C. Berkeley
  - Kerry Metlen – The Nature Conservancy
- **Contemporary Records**
  - Louise Loudermilk – Southern Res. St, Athens, GA
  - Rob Scheller – Portland St. Univ.
  - Peter Weisberg, Univ. Nevada, Reno
  - Jian Yang, Univ. Nevada, Reno
  - Andrew Carleton, Penn. St. Univ.
  - Jay Miller, USFS-R5, F&A, McClellan
  - Hugh Safford, USFS-R5, Ecology Prgm, Davis

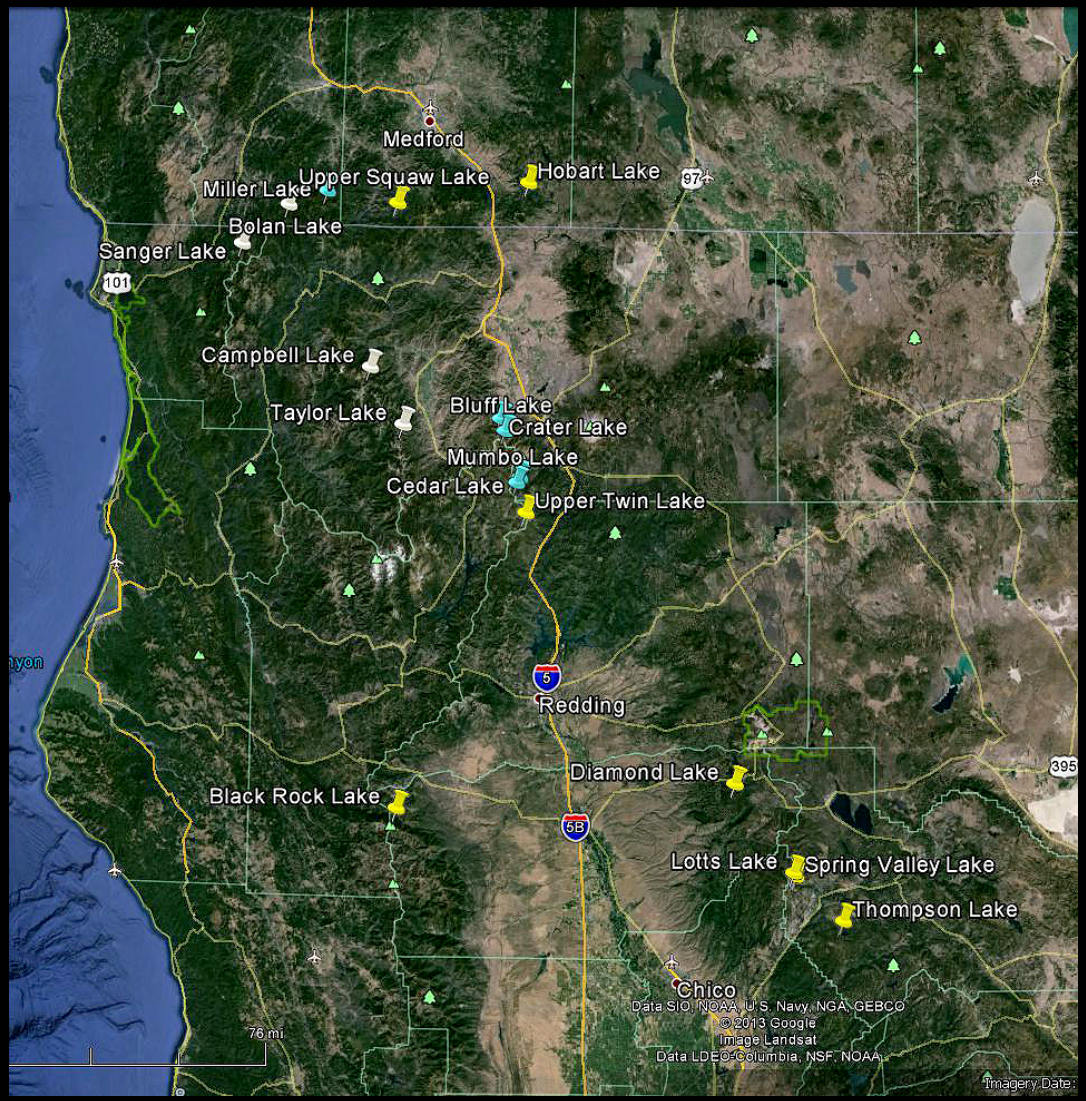
# Sediment Cores – 1,000s of Years




## Northern Calif. & SW Oregon

Extract charcoal, pollen, and macro fossils from sediment cores taken from montane lakes to study the long-term variation of vegetation and fire over the Holocene.

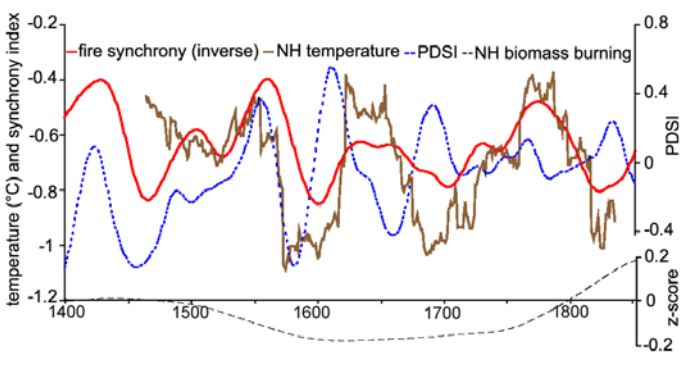
# Study Sites


Medford
Hobart Lake
Upper Squaw Lake
Miller Lake
Bolan Lake
Sanger Lake
101
97
Campbell Lake
Taylor Lake
Bluff Lake
Crater Lake
Mumbo Lake
Cedar Lake
Upper Twin Lake
5
Redding
Diamond Lake
395
Black Rock Lake
5B
Lotts Lake
Spring Valley Lake
Thompson Lake
Chico
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Google
Image Landsat
Data LDEO-Columbia, NSF, NOAA
76 mi
Imagery Date:

- Climate is always changing – sometimes faster than others.
- Until 20th Century, charcoal always entering lakes.
- Charcoal is entering lakes at post-glacial rates in late 20th Century.
- Fire can be catalyst for major vegetation change during rapidly changing climate.
- Sites of high productivity are relatively unstable (low resilience) to climatic change compared to sites of low productivity.

# FINDINGS

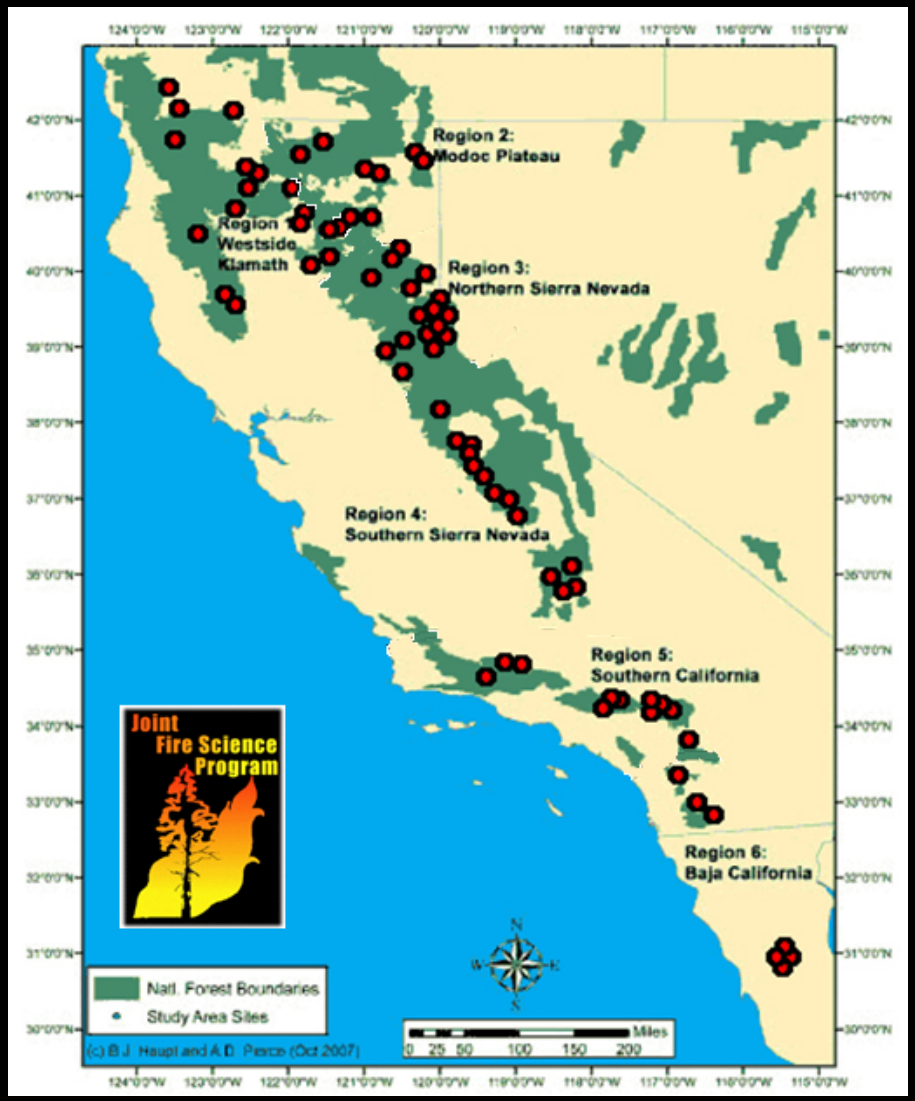
# Tree Rings – 100s of Years

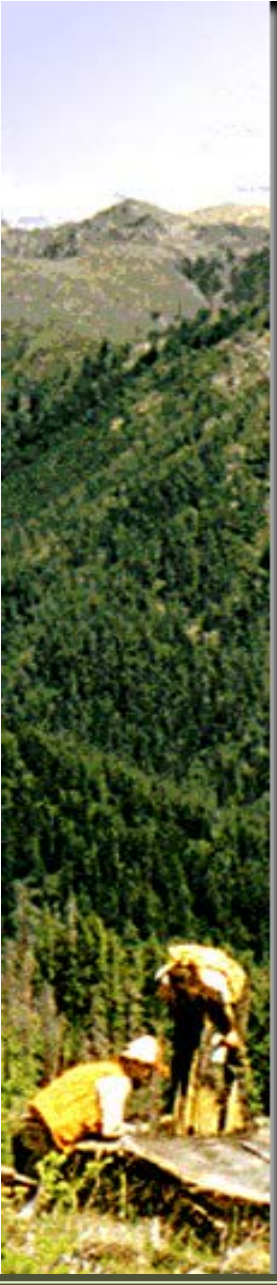


## Fire and Forest Dynamics

We have collected  and dated 1000s of samples from dozens of sites from SW Oregon through California into northern Baja California (West Coast Mediterranean Climate area).

# Study Sites

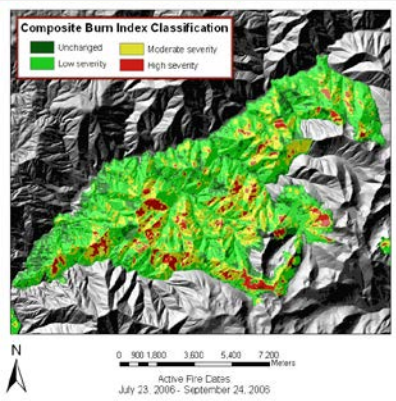

Region 2:
Modoc Plateau
Region 1:
Westside
Klamath
Region 3:
Northern Sierra Nevada
Region 4:
Southern Sierra Nevada
Region 5:
Southern California
Region 6:
Baja California
Joint
Fire Science
Program
Natl. Forest Boundaries
Study Area Sites
(c) B.J. Haupt and A.D. Pierce (Oct 2007)
Miles
0 25 50 100 150 200

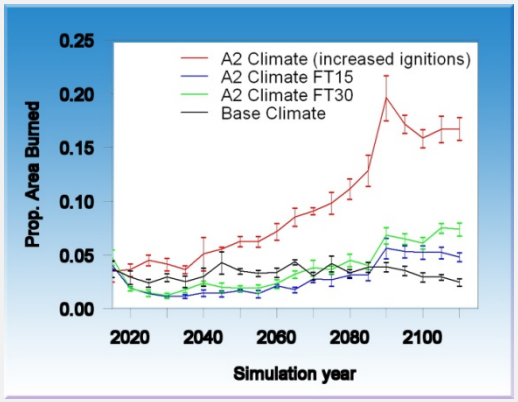


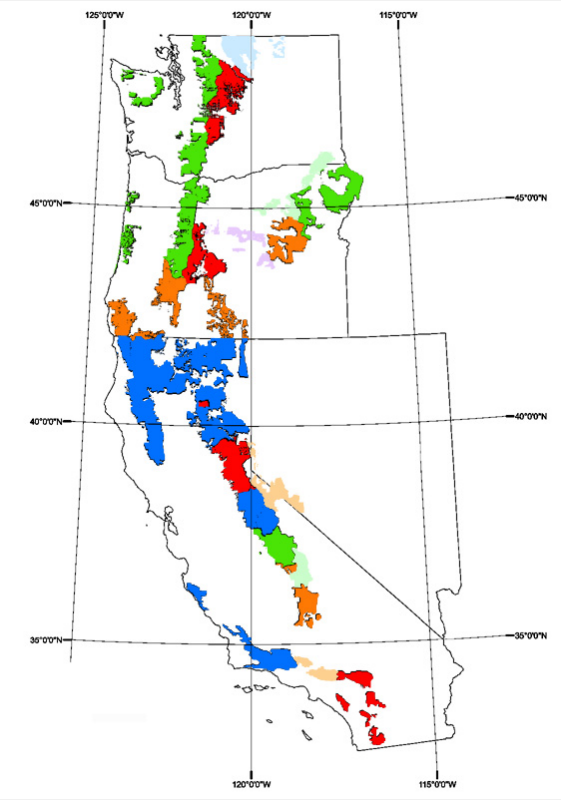
- Below subalpine environments, fires were generally frequent unless fuels were not continuous regardless of climatic conditions.
- Fire severity patterns varied more than fire frequency.
- Topography was important driver of fire size.
- Topography was an important driver of severity patterns and subsequent habitat patterns.
- Montane shrub fields burn less frequently, but more severely than adjacent conifer areas.
- Shrubs tend to occupy areas of landscapes that burn more severely.

# FINDINGS

# Historical & Contemporary Records – 10s of Years




## Fire & Climate

Studying trends in fire size, severity, and cause over the 20th Century. Testing ecological effects of fuel treatments and their ability to reduce fire hazard. Modeling potential influence of climatic change on ignition patterns and potential for carbon storage.

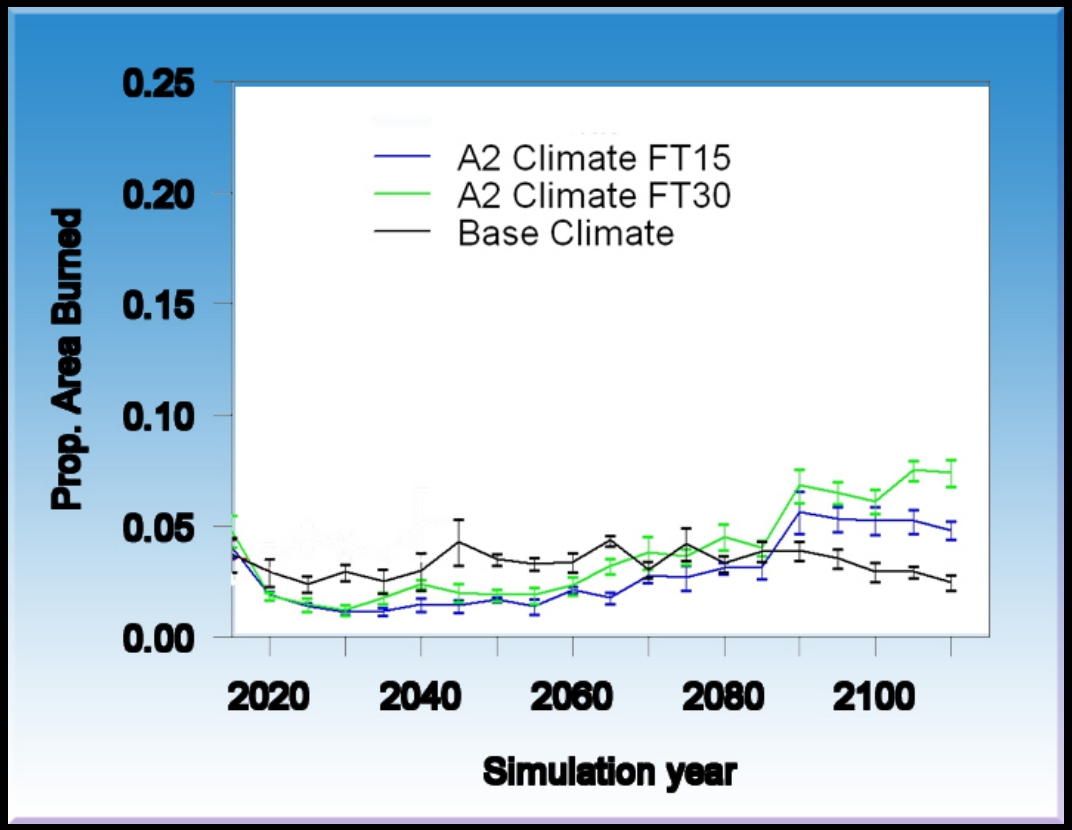
- Fuel treatments reduce fire hazard if they follow the basic principles.
- As climate warms, fuels treatments become more important in forest resilience and carbon storage in trees.
- Lightning caused fires are accounting for a greater proportion of area burned in recent decades.
- Summer precipitation is becoming more important in determining large fire years.
- Montane areas occupied by shrubs in early 20$^{th}$ C, appear to burn more severely today.
- Climatic drivers of fire activity vary with latitude.

# FINDINGS

# Fuel Treatments Work

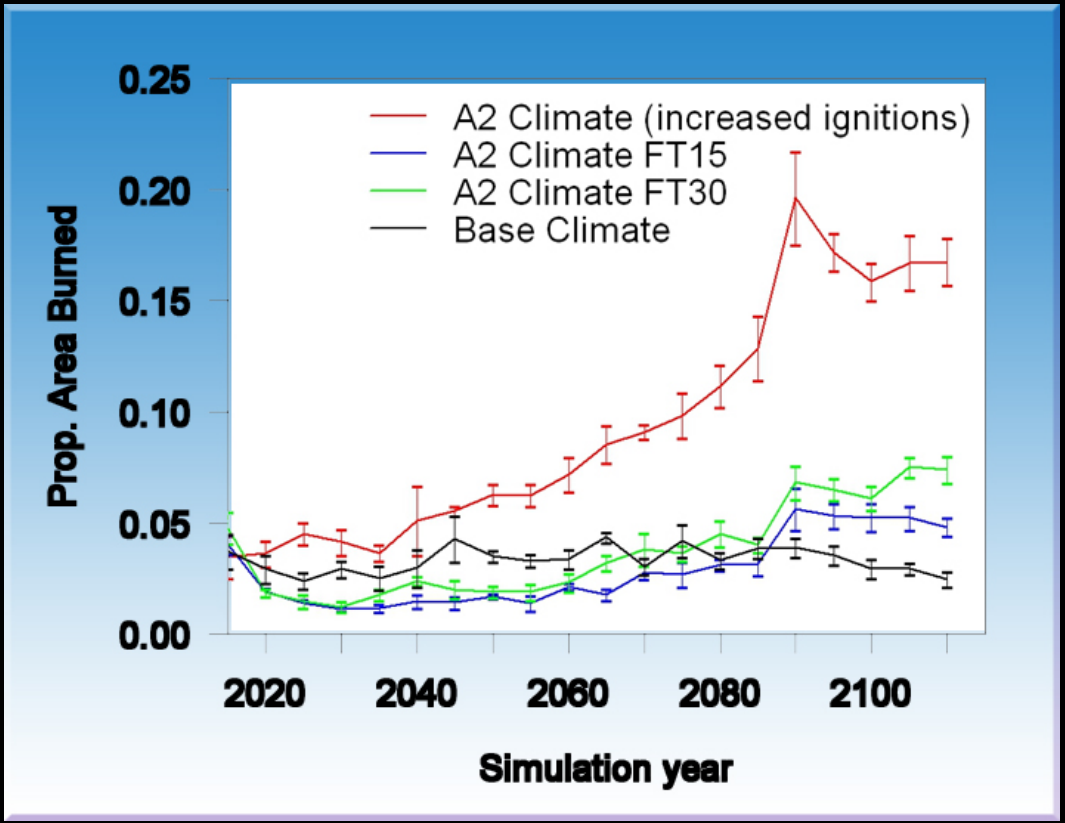
- <u>Basic Principles</u>
  - Surface Fuels
  - Ladder Fuels
  - Crown Fuels
  - Keep Large, Resistant Trees
  - Treatments Strategically Distributed

# Fuel Treatments More Important As Climate Warms




Scheller et al. SNPLMA Final Report 2012

# Fuel Treatments More Important As Climate Warms




Scheller et al. SNPLMA Final Report 2012

# Shrubfields and Fire Severity

# Shrubfields and Fire Severity

# Shrubfields and Fire Severity

- Topography Important for Fire Severity
- Shrubfields Generally Occupy Areas that Burn Severely
- Shrubfields in Early Photography Can Indicate Areas Likely to Burn Severely
- Shrubfields & Climate Change

Taylor et al. - In Preparation

# For More Information

- PSW Publications
  http://www.fs.fed.us/psw/publications/

- Sierra Nevada / Cascade Range Science Synthesis
  http://www.fs.fed.us/psw/publications/reports/psw_sciencesynthesis2013/

- Tree Search – Publications with USFS Scientist Authors
  http://www.treesearch.fs.fed.us/

# Thank You!

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