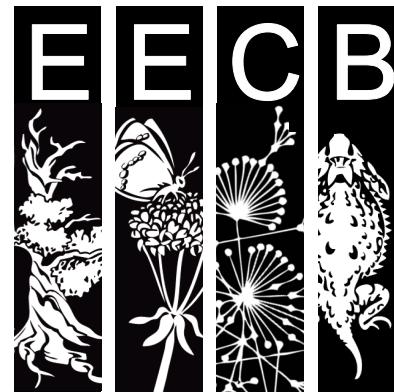
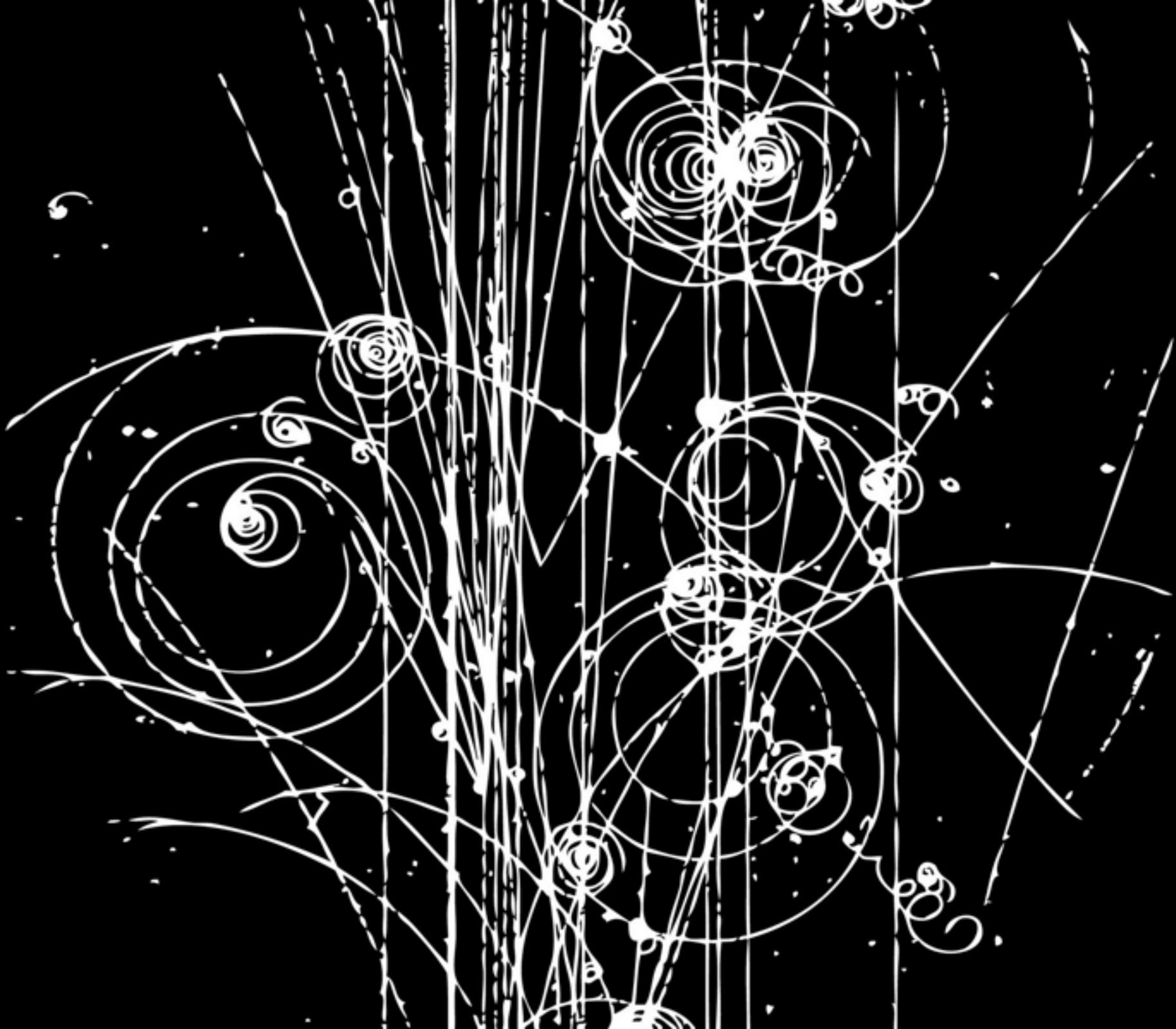


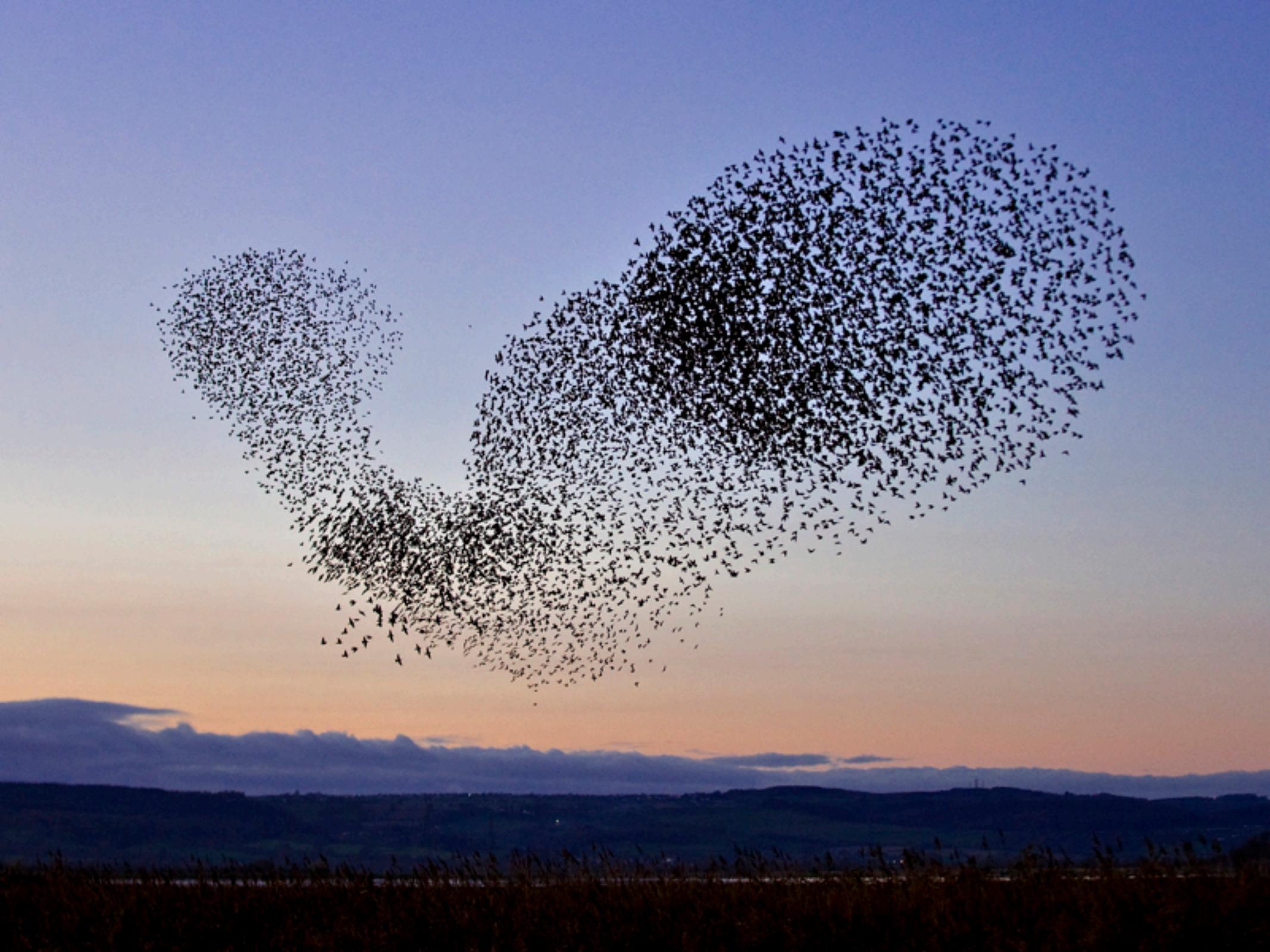
# ecogeographic patterns of seed size in *Arctostaphylos* and *Ceanothus* across California

christopher moore  
california botanical society  
graduate student symposium  
14 april 2013

program in ecology, evolution, and  
conservation biology  
university of nevada, reno











*A. manzanita* (P.V. Wells) R.L. Polk. *MANZANITA*. Ernest, 1-4 m. ST: twig (and nascent infl axis) sparsely short-nonglandular-hairy; ocre moderately glandular-hairy. LF: ovate; petiole 4-5 mm; blade 2-4 cm, 1-2 cm wide, narrowly elliptic-ovate, glaucous, gray, dull, white-campanulate, in age dark green, dull, glabrous, base truncate to rounded, tip acute, margin entire, flat. INF: + raceme, 0-1-branched, nascent infl persistent, axis 0.5-1.2 cm, > 1 mm wide, sub-nonglandular-hairy, bracts 5-10 mm, H-like, ovate, acute, green, pubescent, pubescence 2-4 mm, sparsely white-nonglandular-hairy; FL: ovary, (and if sparse) white-nonglandular-hairy. FR: 6-8 mm wide, depressed-spheric, stones free, 2a-2b. Rocky slopes, oak serpentine, chaparral, coastal forest, 500-900 m., nw KR (n Del Norte Cr.), Mar-May \*

*A. manzanita* A. Gray. ST: old at bark persistent, gray or reddish; twig (and nascent infl axis) short-nonglandular- and long-glandular-hairy. LF: spreading; blade obliquely light green, shiny, glabrous, midrib hairy, adaxially dark green, tip obtuse, margin entire, crenate; stoma absent. INF: panicle, 4-12-branched, nascent infl persistent, axis 0.5-1 cm, > 1 mm wide, bracts appressed, 0.5-2 mm, scale-like, dull, sharp-pointed, glabrous, pubescence 1-3 mm, glabrous. FL: if petals in, 6, ovary white-nonglandular-hairy. FR: 3-4 mm wide, s-cylindric, glabrous, mature splitting, stones free. 2a-2c.

subsp. *marmecimoides* (P.V. Wells) V.T. Parker et al. *MARMECIMA*. Persistent to mounted, 0.1-0.5 m. ST: old at bark reddish, grey rough or shredding. LF: petiole < 1 mm; blade 0.5-1.2 cm, 0.3-0.7 cm wide, oblong-elliptic, base rounded to wedge-shaped. Propy pines forest, chaparral, 50-200 m., n NC (Marmecima Cr.), [A. m. P.V. Wells] Mar-May \*

subsp. *marmecimoides* (P.V. Wells) J.E. Adams. *PACIFIC MANZANITA*. Persistent to erect, 0.5-2 m. ST: old at bark grey, shredding. LF: petiole 1-3 mm; blade 1.2-2 cm, 0.8-1.8 cm wide, round to round-acute; base truncate to c-lobed. Coastal prairie, maritime chaparral, closed-cone forest, 15-400 m., c NC/NCORO (Mendocino Cr.), Mar-May

*A. abramsii* Eastw. *REEDY MANZANITA*. Ernest, 1-4 m. ST: twig (and nascent infl axis) sparsely short-nonglandular-hairy. LF: ovate; petiole 5-7 mm; blade 2-4.5 cm, 1.2-3 cm wide, obtuse to acute; glaucous, base rounded to truncate or c-lobed, tip acute, margin entire, flat. INF: panicle, 2-4-branched; nascent infl persistent, bell-shaped, triangular-acute, adaxially light green, glabrous, midrib nonglandular-hairy, adaxially dark blue-green, glaucous, base lobed, tip acute, margin entire, crenate, winged with red; stoma absent. FL: ovary, 0-1 mm wide; bracts 5-10 mm, H-like, lanceolate, serrulate-pubescent, pubescence 5-8 mm, nonglandular-hairy or not. FL: ovary densely white-nonglandular-hairy. FR: 6-8 mm wide, depressed-spheric, sparsely nonglandular-hairy to glabrous; stones free. 2a-2d. San Geronimo Mts., n San Geronimo Cr., Feb-Mar

*A. oklahomensis* M.C. Vieyra & V.T. Parker. *OKLAHOMA MANZANITA*. Ernest, 1-2 m. ST: twig (and nascent infl axis) sparsely short-nonglandular- and sub-long-glandular-hairy. LF: ovate; petiole 3-5 mm; blade 1.5-2 cm, 1.2-1.5 cm wide, elliptic to ovate-elliptic, puberulent and short-glandular-hairy, in age glaucous, light green, dull, base wedge-shaped, tip acute, margin entire, flat. INF: panicle, 3-5-branched; nascent infl persistent, axis 1.5-2.5 cm, > 1 mm wide; bracts 1-3 mm, scale-like, ovate to deltoid, sharp-pointed, nonglandular-hairy; FL: ovary glabrous. FR: 3-4 mm wide, depressed-spheric, glabrous; stones free. 2a-2b. Siliceous shales, slopes, ridges, dry soil, Costa Costa Cr., Jan-Mar \*

*A. esenbeckii* P.V. Wells. *OAK MANZANITA*. Ernest, 1-4 m. ST: old at bark persistent, gray, shredding (smooth). TW: twig (and nascent infl axis) sparsely short-nonglandular-hairy. LF: overlapped, petiole < 2 mm; blade 1.5-3 cm, 1.5-2.5 cm wide, ovate to round-ovate, dark green, + shiny, sparsely short-nonglandular-hairy or glabrous, base deeply lobed, crenate; tip obtuse, margin entire, flat. INF: + raceme, 0-1-branched; nascent infl persistent, axis 0.5-1 cm, > 1 mm wide; bracts 4-8 mm, H-like, involucellate to ovate, glaucous, pubescence 0-2 mm, glabrous. FL: ovary glabrous. FR: 5-8 mm wide, depressed-spheric, glabrous; stones free. 2a-2b. Dacite (volcanic) outcrops, chaparral, 30-375 m., s CCo (w Los Osos Valley, San Luis Obispo Co.), Dec-Feb \*

*A. eropaeoides* Wieg. & H. Schreik. (p. 701). Other names: *eropaeoides*, *eropaeoides* and *eropaeoides* (all taxa) sparsely short-nonglandular- and long-glandular-hairy. LF: ovate, petiole 3-4 mm, blade 2-3 cm, > 1 cm wide, narrowly or obtusely pointed, tip acute; glaucous, dull, appressed-pubescent, in age ± glabrous to sub-glabrous, flat. INF: panicle, 4-7-branched; nascent infl persistent, axis 1.5-2.5 cm, > 1 mm wide; bracts spreading, rigid, lance-linear, acuminate, green, long-glandular-hairy, pubescence 3-8 mm, glandular-hairy. FL: ovary densely nonglandular-hairy to glabrous; stones free or fused. 2a-2b. Valleys, slopes, esp. chaparral, woodland, 280-300 m., s PR, San Luis Obispo Co. (San Luis Mtn.) [A. v. Roof] Jan-Mar \*

*A. pacifica* Roof. *PACIFIC MANZANITA*. Persistent, 0.1-0.5 m. ST: old at bark grey, hairy; twigs (and nascent infl axis) short-nonglandular-hairy. LF: spreading; petiole 2-4 mm; blade 1.2-2 cm, 0.5-1 cm wide, elliptic, adaxially light green, adaxially dark green, base wedge-shaped, tip acute, margin entire, pubescence 0-1 mm, 0-1-branched; nascent infl persistent, axis 0.5-1 cm, > 1 mm wide; bracts 0.5-1 cm, scale-like, rigid, wedge-shaped, glabrous, pubescence 0-1 mm, glabrous. FL: ovary glabrous. FR: 6-8 mm wide, spheric, pubescence 0-1 mm, glabrous; stones free. 2a-2b. Sandstone outcrops, chaparral, forest, San Luis Obispo Co. (San Luis Mtn.) [A. v. Roof] Jan-Mar \*

*A. pajaroensis* (J.E. Adams) J.E. Adams. (p. 300). *MONTAÑITA*. Ernest, 1-4 m. ST: old on gray bark developing very overlapped; petiole < 2 mm; blade 2-4 cm, 1-2 cm wide, oval to triangular-acute, adaxially light green, glaucous, midrib nonglandular-hairy, adaxially dark blue-green, glaucous, base lobed, tip acute, margin entire, crenate, winged with red; stoma absent. INF: panicle, 2-5-branched; nascent infl persistent, axis 1-1.5 cm, > 1 mm wide; bracts 5-10 mm, H-like, lanceolate, serrulate-pubescent, pubescence 5-8 mm, nonglandular-hairy or not. FL: ovary densely white-nonglandular-hairy. FR: 6-8 mm wide, depressed-spheric, sparsely nonglandular-hairy to glabrous; stones free. 2a-2d. San Jose outcrops, chaparral, < 750 m. s-e CCo, s Salville (Pine Mtn.), Feb-Mar \*

*A. pajaroensis* (J.E. Adams) J.E. Adams. (p. 701). *PALMILLO MANZANITA*. Ernest, 1-4 m. ST: twig densely short- and long-nonglandular-hairy. LF: overlapped; petiole < 2 mm, non-glandular-hairy, blade 2.5-4.5 cm, 2-3 cm wide, ovate, glaucous-green, dull, glabrous, base lobed, crenate to acute, margin entire, flat. INF: panicle, 3-5-branched, nascent infl persistent, axis 1-1.5 cm, > 1 mm wide, densely short-nonglandular-hairy, adaxial margin entire, flat. FL: ovary, 0-1 mm wide, densely short-nonglandular-hairy, adaxial margin entire, flat. INF: panicle 3-5-branched; nascent infl persistent, axis 0.5-1.2 cm, > 1 mm wide; bracts 1-2 mm, H-like, lanceolate, acute, glaucous, base lobed, tip acute, margin entire, flat. FL: ovary glabrous. FR: 6-10 mm wide, depressed-spheric, sticky; stones free. 2a-2b. Siliceous shales, slopes, ridges, dry soil, Costa Costa Cr., Jan-Mar \*

*A. parryana* Lemmon. *ST*: twig (and nascent infl axis) sparsely short-nonglandular- and sub-long-glandular-hairy. LF: ovate; petiole 3-7 mm; blade 1.5-3 cm, 1.5-2.5 cm wide, oblong-acute to widely elliptic, puberulent and short-glandular-hairy, in age glaucous, light green, dull, base wedge-shaped, tip acute, margin entire, flat. INF: panicle, 3-5-branched; nascent infl persistent, axis 1.5-2.5 cm, > 1 mm wide; bracts 1-3 mm, scale-like, ovate to deltoid, sharp-pointed, nonglandular-hairy; FL: ovary glaucous. FR: 7-10 mm wide, spheric, glabrous; stones free. 2a-2b. 1-2 m, San Jacinto, Santa Rosa, San Ysidro mts., Jan-Mar

subsp. *parryana* *PARRY MANZANITA*. Mounded, per 0.5-1 m. LF: green. 2a-2b. Openings in chaparral, forest, 1500-3400 m., TR, San Jacinto, Santa Rosa, San Ysidro mts., Jan-Mar

subsp. *tomentosa* J.E. Keeley et al. *INTRICATE MANZANITA*. Ernest, 1-2 m. hair prominent. LF: green. 2a-2b. Mounds, Chaparral, 2100-2300 m., Selle, Mar-Apr \*

*A. parvula* Greene (p. 701). *GREENLEAF MANZANITA*. Ernest, 1-2 m; hair 0 or often flat, obscure. ST: twig (and nascent infl axis) short-glandular- or densely short-nonglandular-hairy. LF: ovate, pubescence



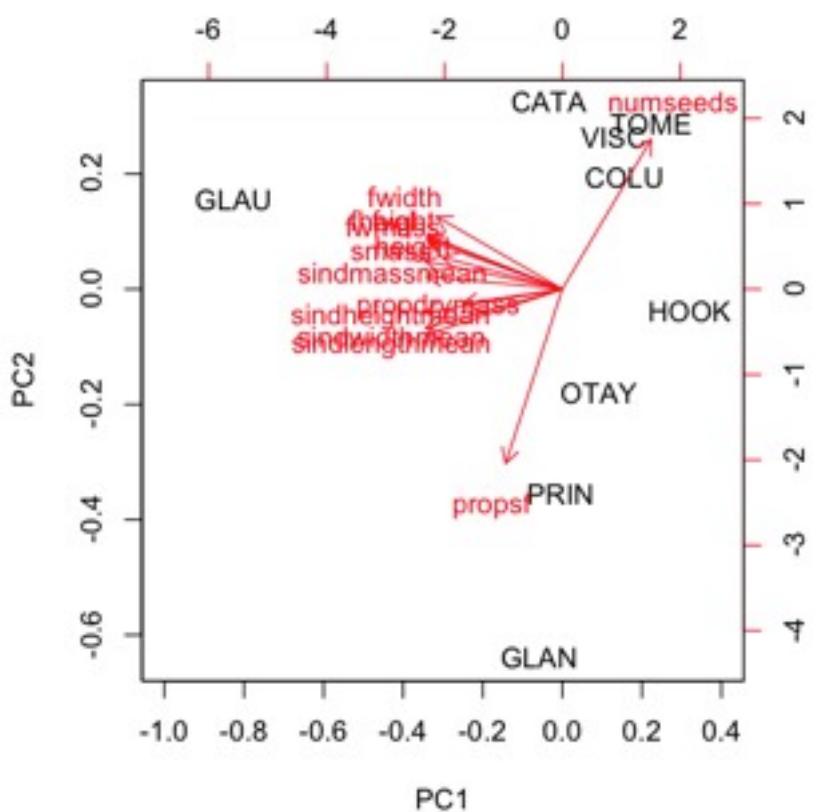
# morphometric analysis

## measured characters

- i. fruit polar diameter (mm)
- ii. fruit equatorial diameter (mm)
- iv. fruit wet mass (g)
- v. fruit dry mass (g)
- vii. no. seeds / fruit
- ix. individual seed mass (g)
- x. individual seed height (mm)
- xi. individual seed width (mm)
- xii. individual seed length (mm)

## derived characters

- iii. fruit volume ( $\text{mm}^3$ )
- vi. dry:wet mass (g)
- viii. total seed mass (g)
- xiii. seed:fruit mass (g)

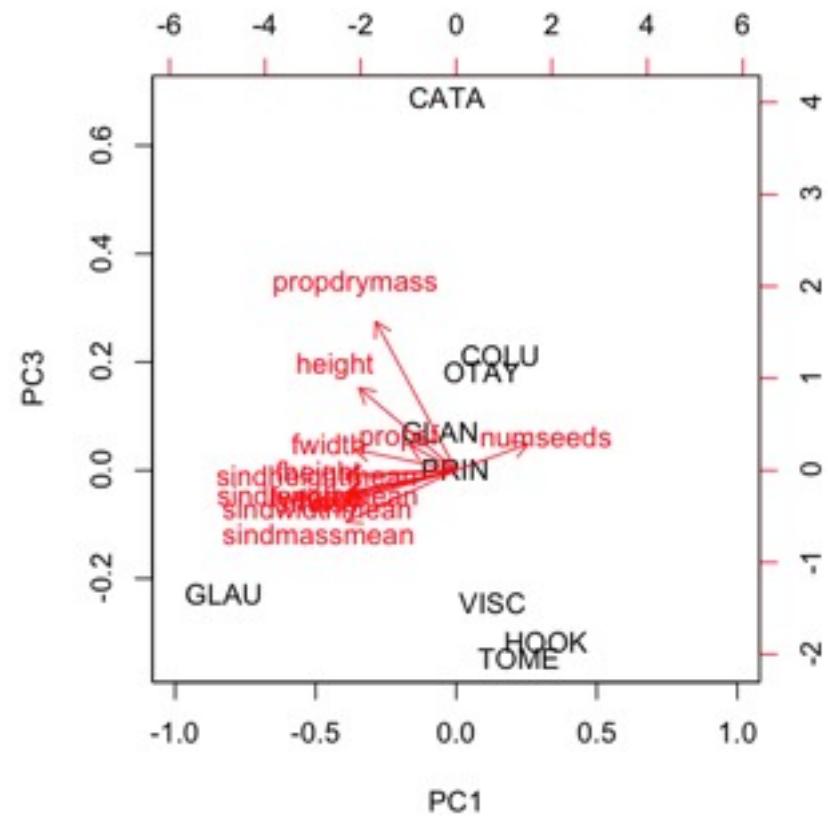
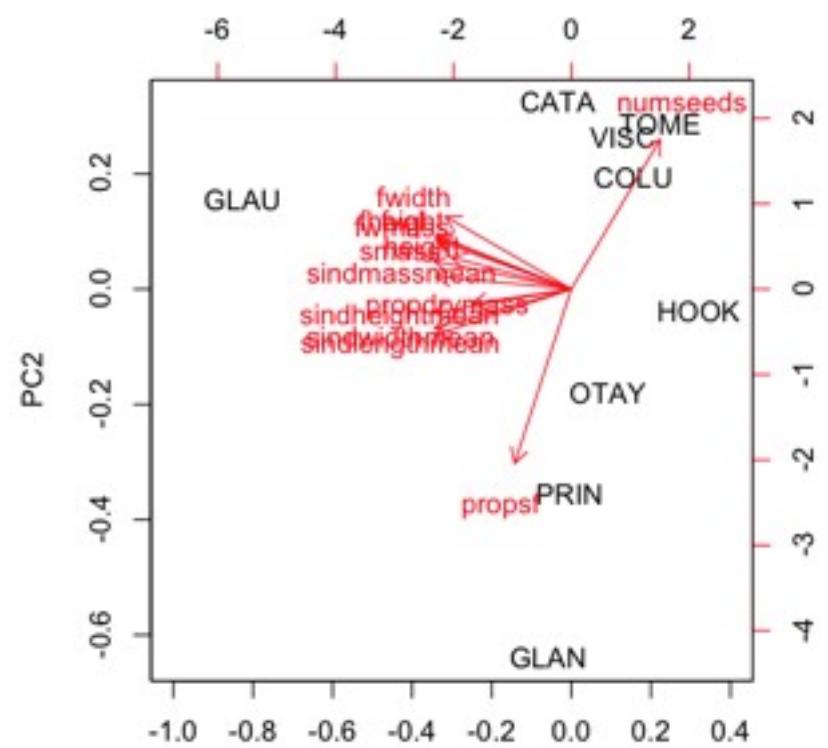


principle component analysis

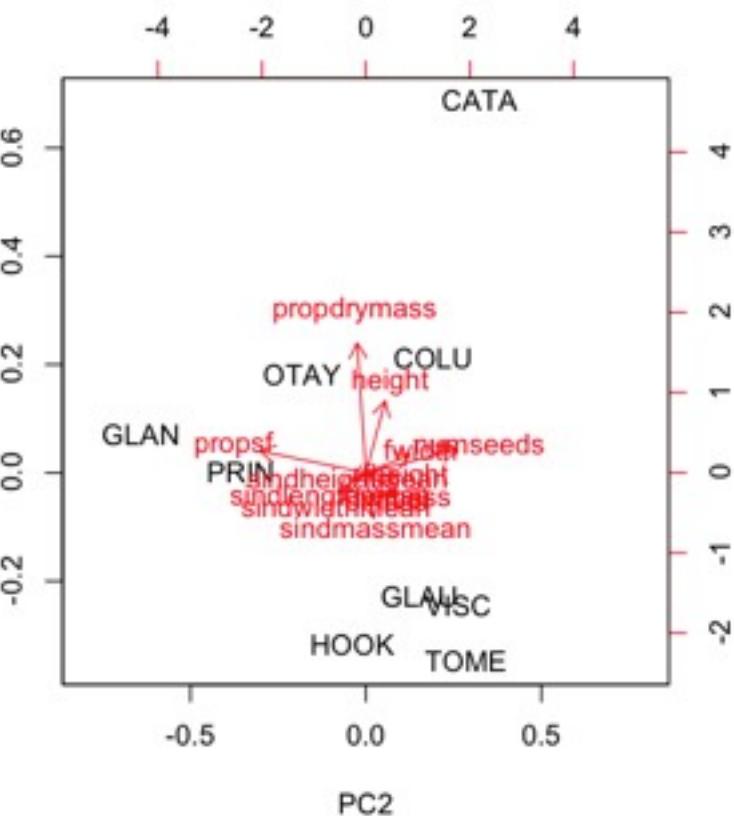
-9 taxa

-13 traits

-PC1, PC2, and PC3 collectively explain 77, 90, and 96% of the variance



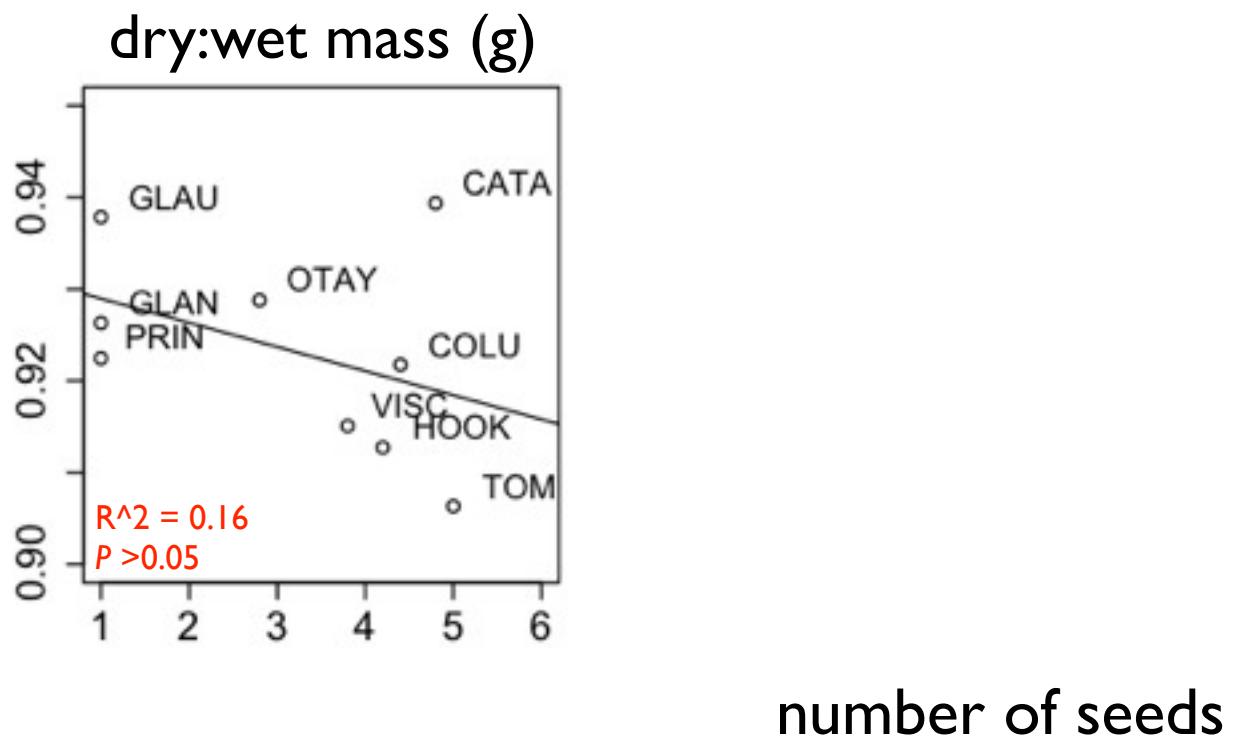
**principle component analysis**  
**-9 taxa**  
**-13 traits**  
**-PC1, PC2, and PC3 collectively explain 77, 90, and 96% of the variance**



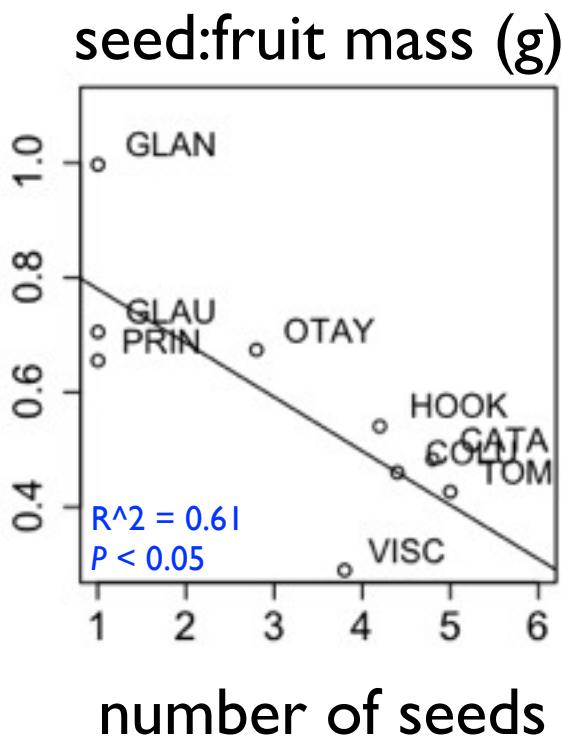
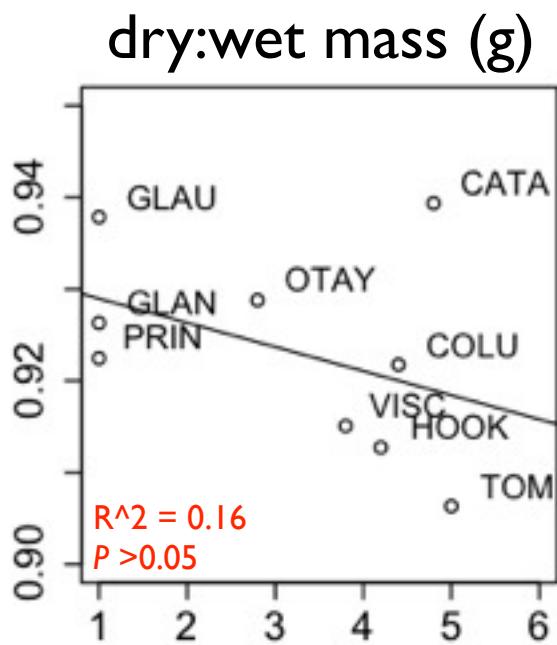
# some pairwise comparisons

number of seeds

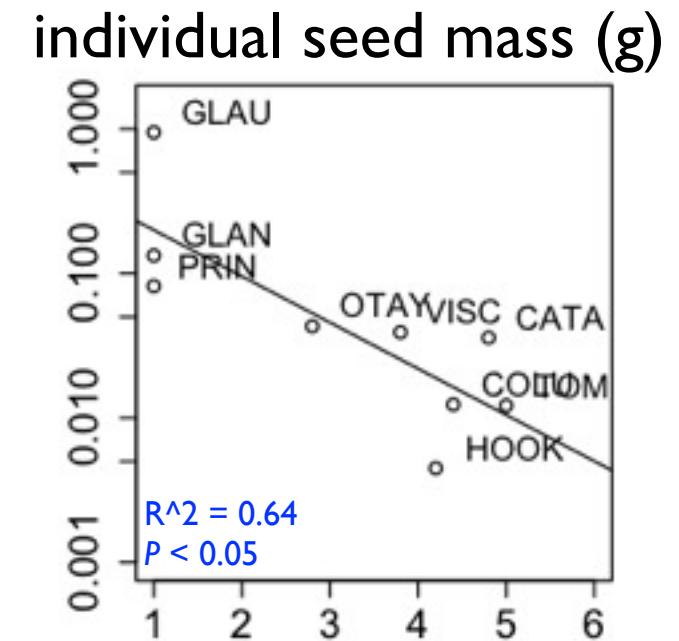
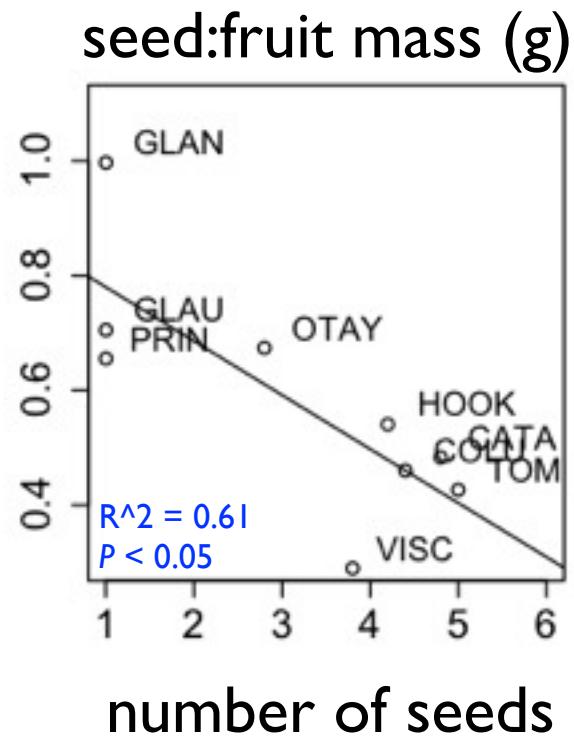
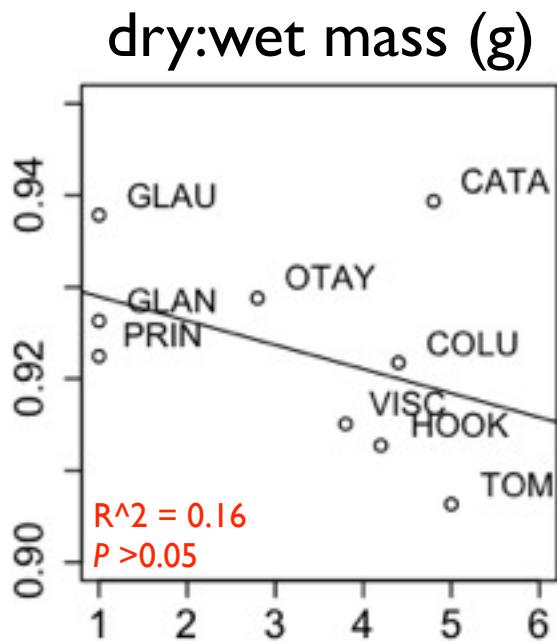
# some pairwise comparisons



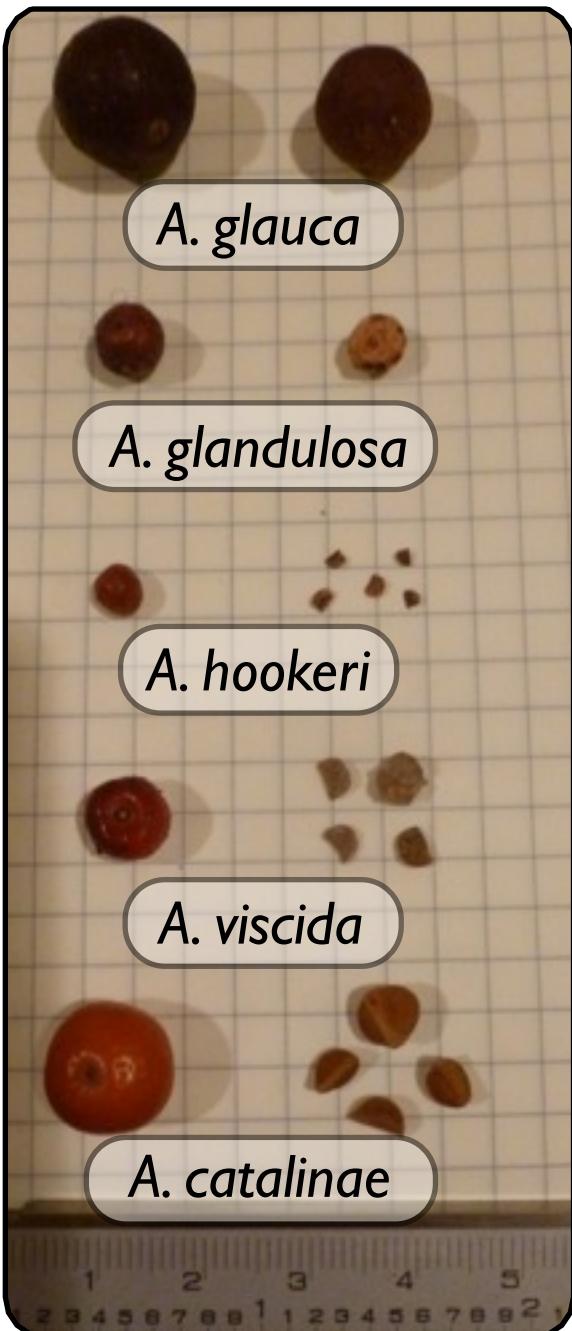
# some pairwise comparisons



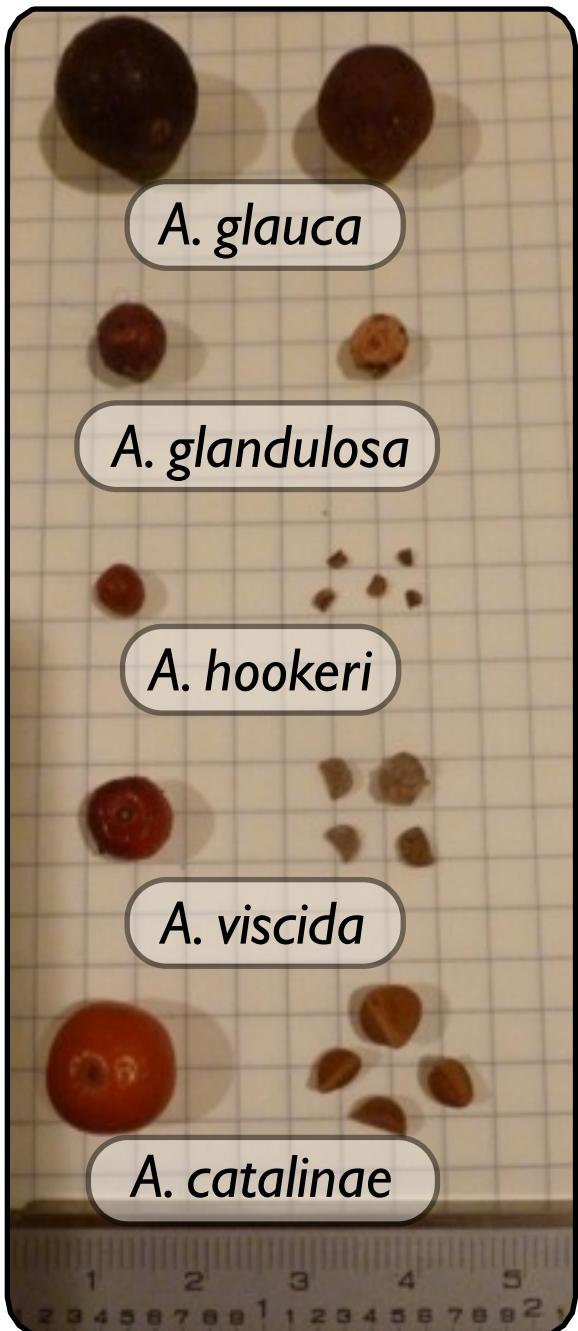
# some pairwise comparisons



# examples of manzanita fruits and seeds



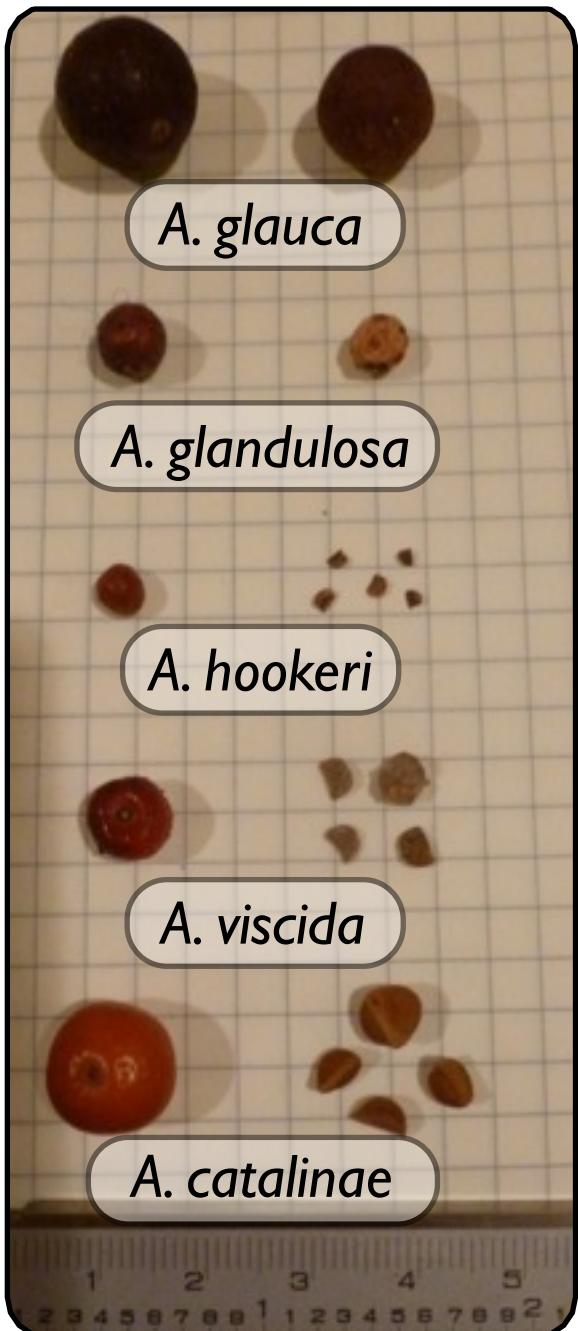
# examples of manzanita fruits and seeds



fruity → nutty

- i. > wet mass
- ii. more mesocarp
- iii. lighter in colour
- iv. distinct seeds
- i. drier fruit
- ii. less mealy
- iii. darker in colour
- iv. fused seeds

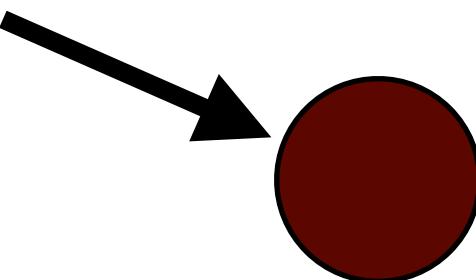
# examples of manzanita fruits and seeds



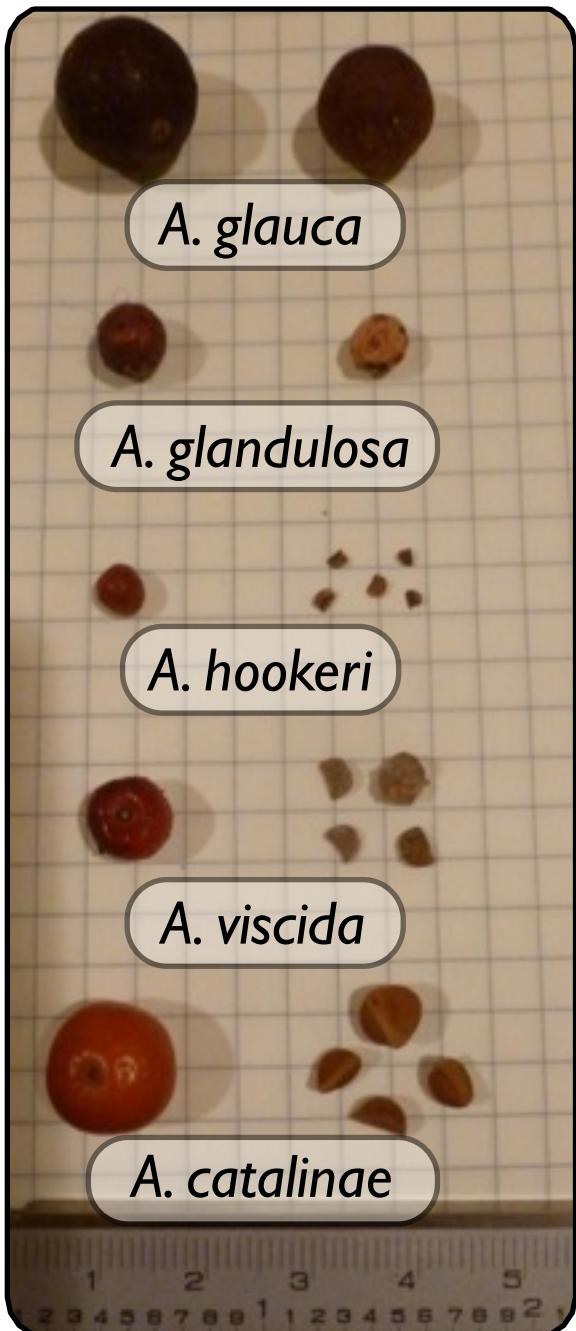
fruity → nutty

- |                        |                       |
|------------------------|-----------------------|
| i. > wet mass          | i. drier fruit        |
| ii. more mesocarp      | ii. less mealy        |
| iii. lighter in colour | iii. darker in colour |
| iv. distinct seeds     | iv. fused seeds       |

dispersal



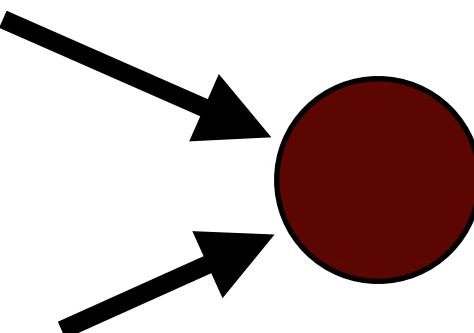
# examples of manzanita fruits and seeds



fruity → nutty

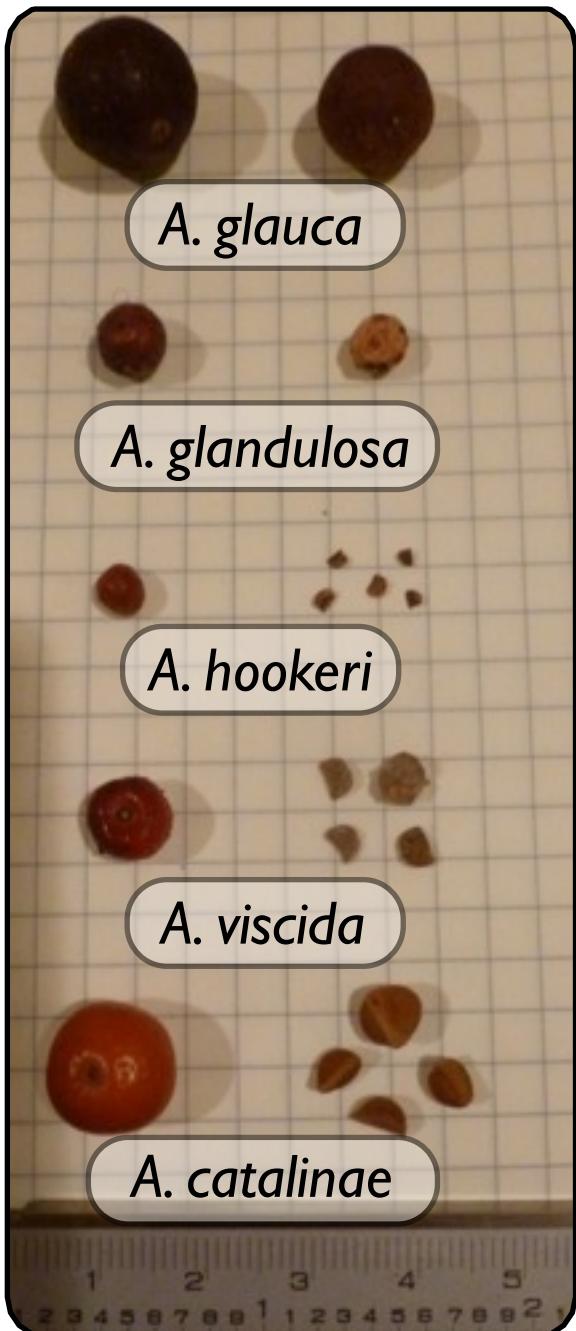
- |                        |                       |
|------------------------|-----------------------|
| i. > wet mass          | i. drier fruit        |
| ii. more mesocarp      | ii. less mealy        |
| iii. lighter in colour | iii. darker in colour |
| iv. distinct seeds     | iv. fused seeds       |

dispersal



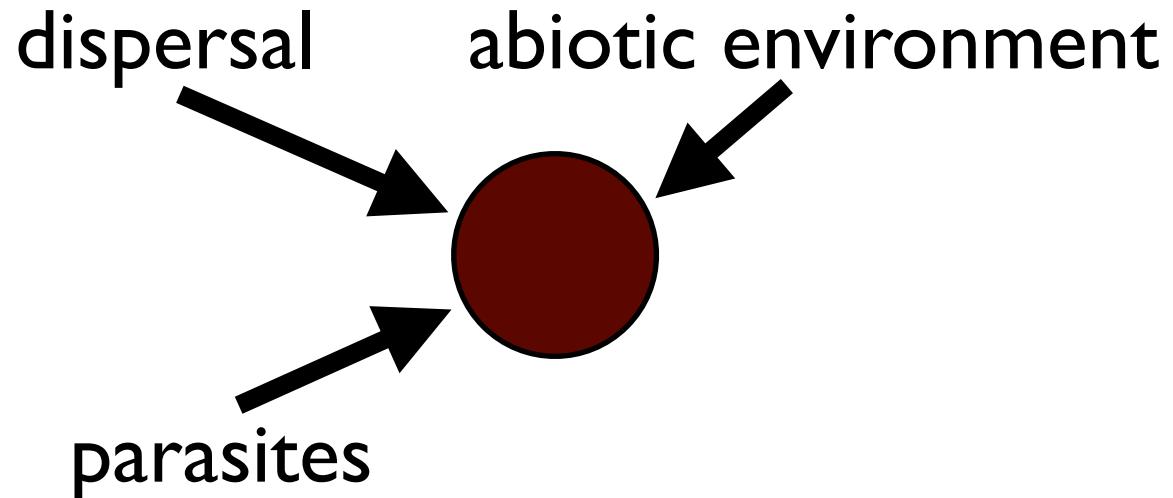
parasites

# examples of manzanita fruits and seeds

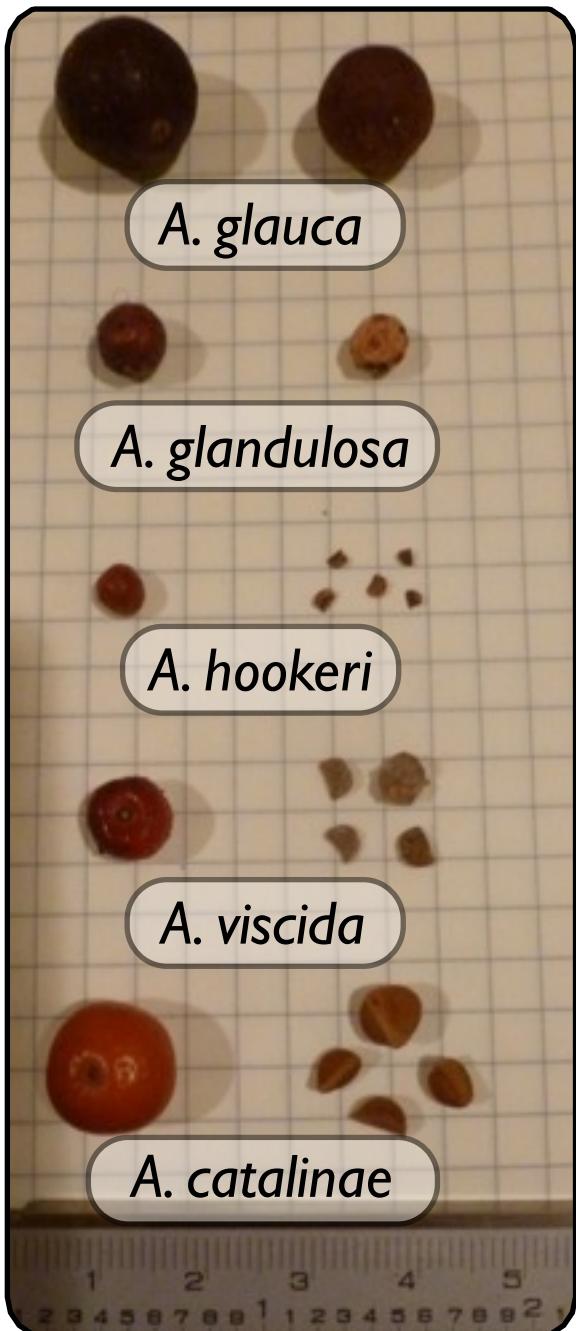


fruity → nutty

- |                        |                       |
|------------------------|-----------------------|
| i. > wet mass          | i. drier fruit        |
| ii. more mesocarp      | ii. less mealy        |
| iii. lighter in colour | iii. darker in colour |
| iv. distinct seeds     | iv. fused seeds       |

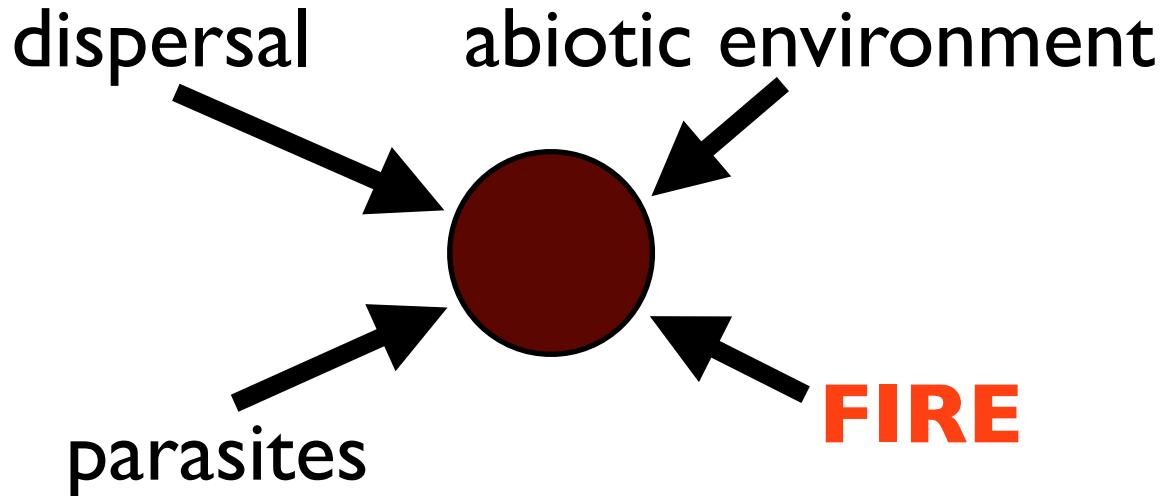


# examples of manzanita fruits and seeds

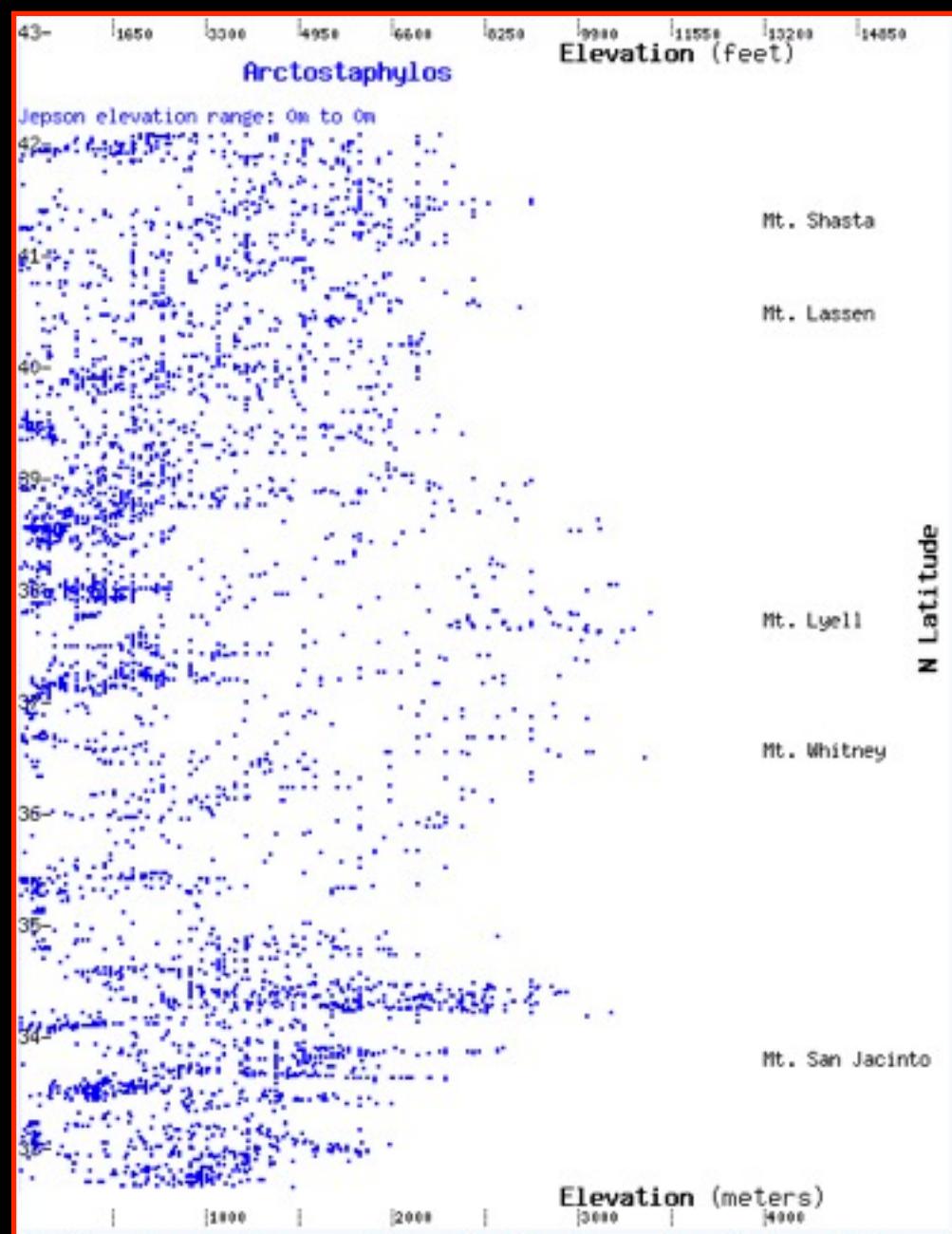
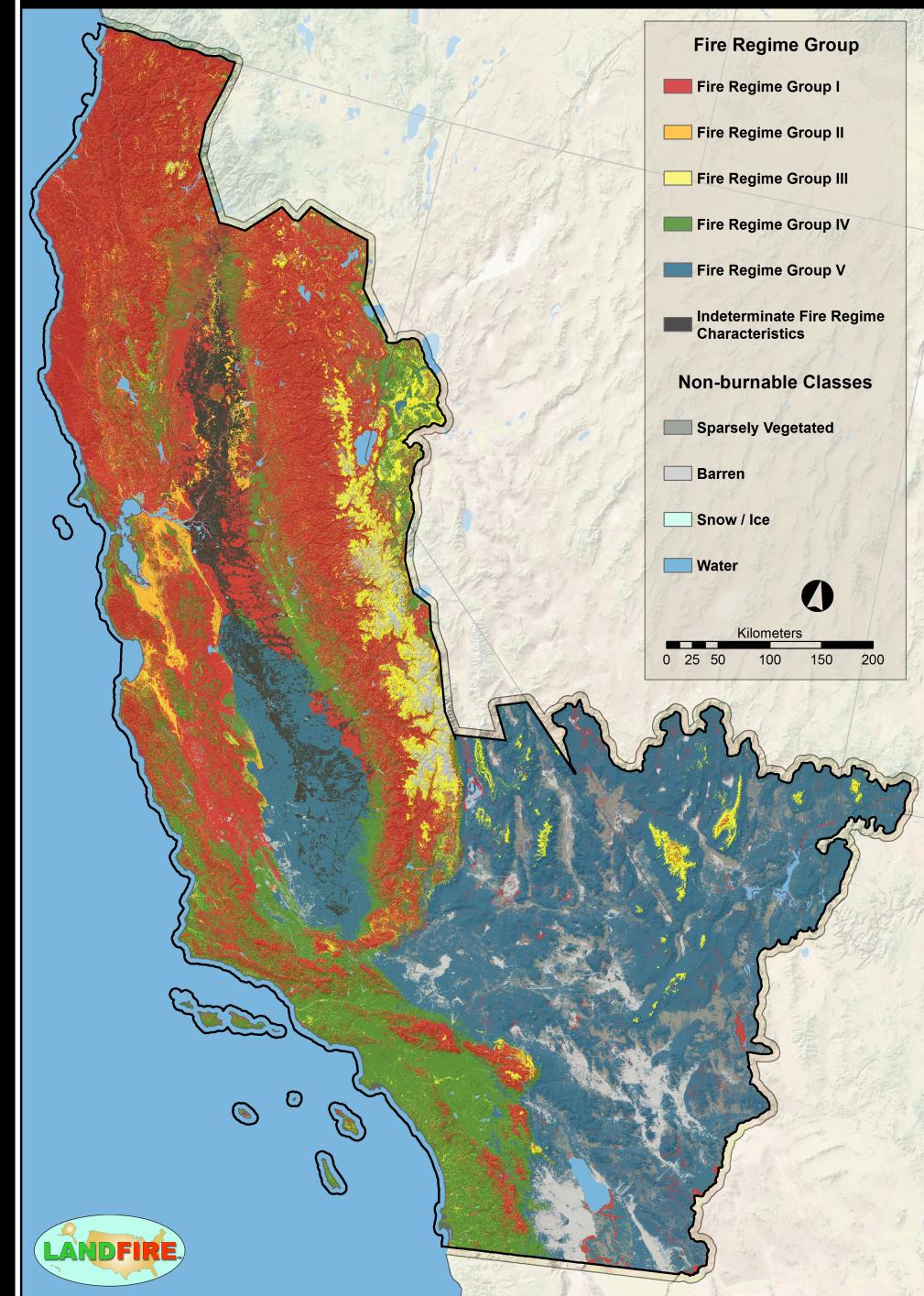


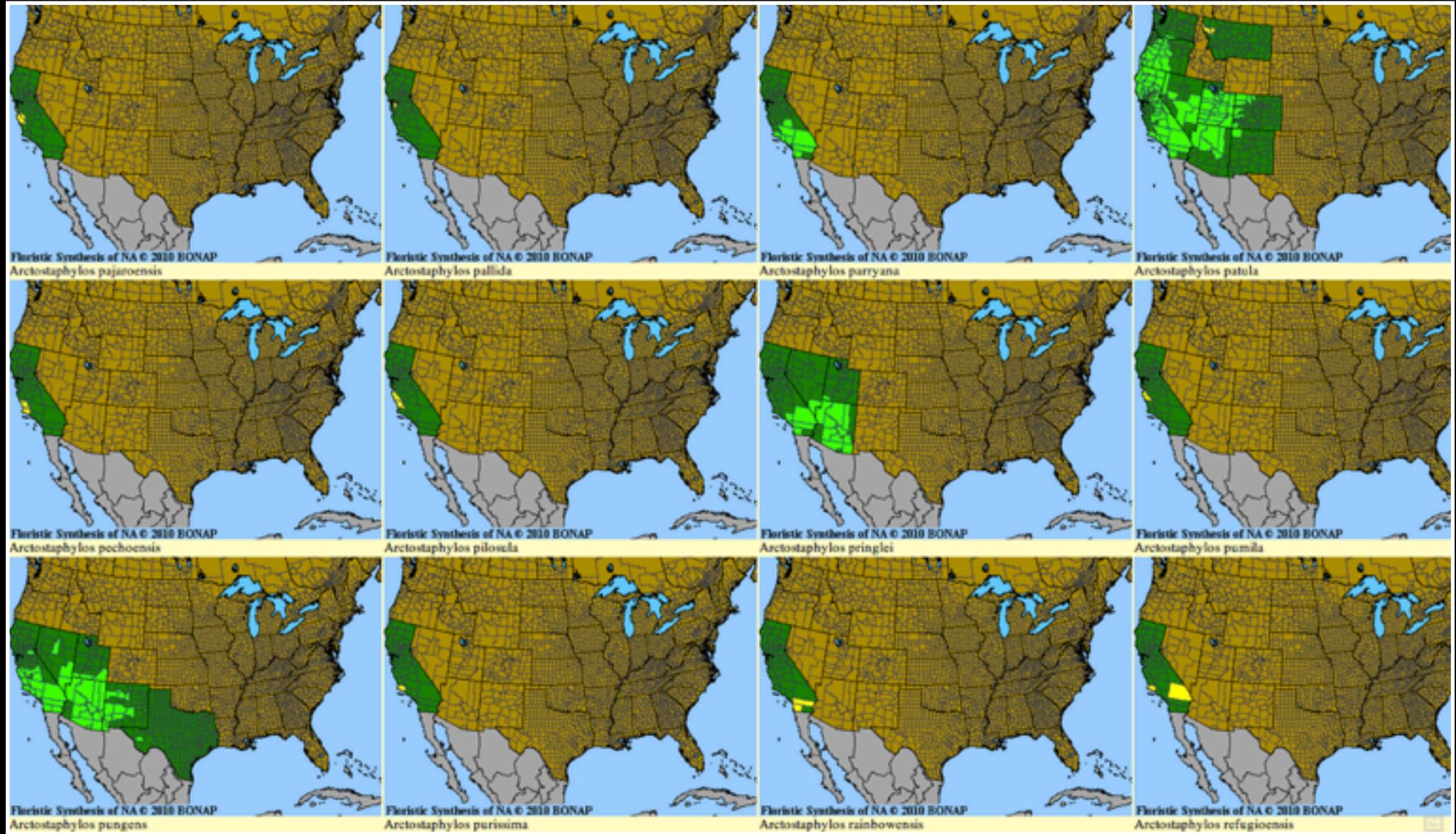
fruity → nutty

- |                        |                       |
|------------------------|-----------------------|
| i. > wet mass          | i. drier fruit        |
| ii. more mesocarp      | ii. less mealy        |
| iii. lighter in colour | iii. darker in colour |
| iv. distinct seeds     | iv. fused seeds       |



## LANDFIRE Refresh Updates: Fire Regime Groups for the Pacific Southwest



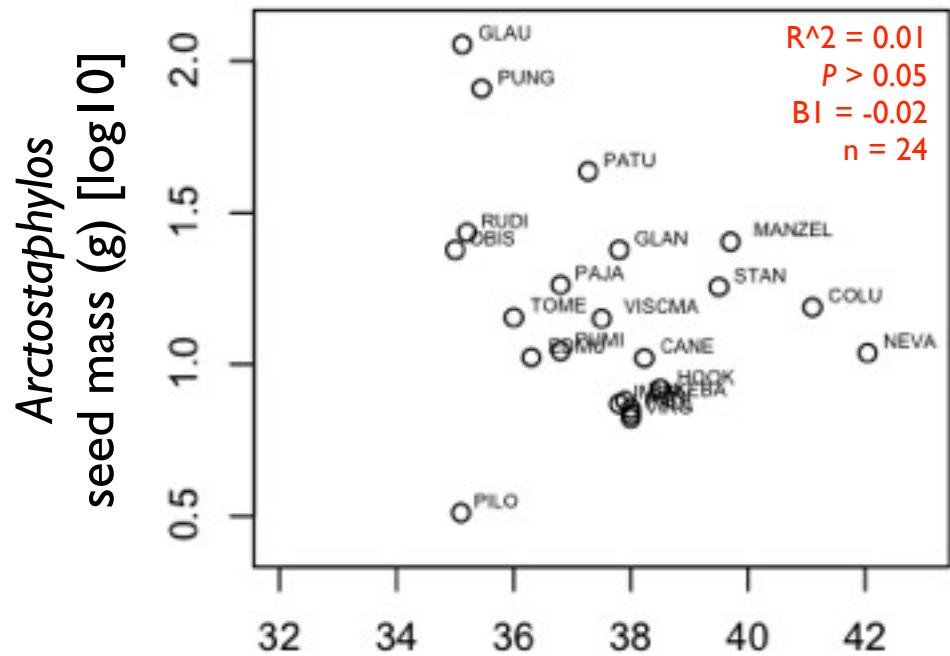


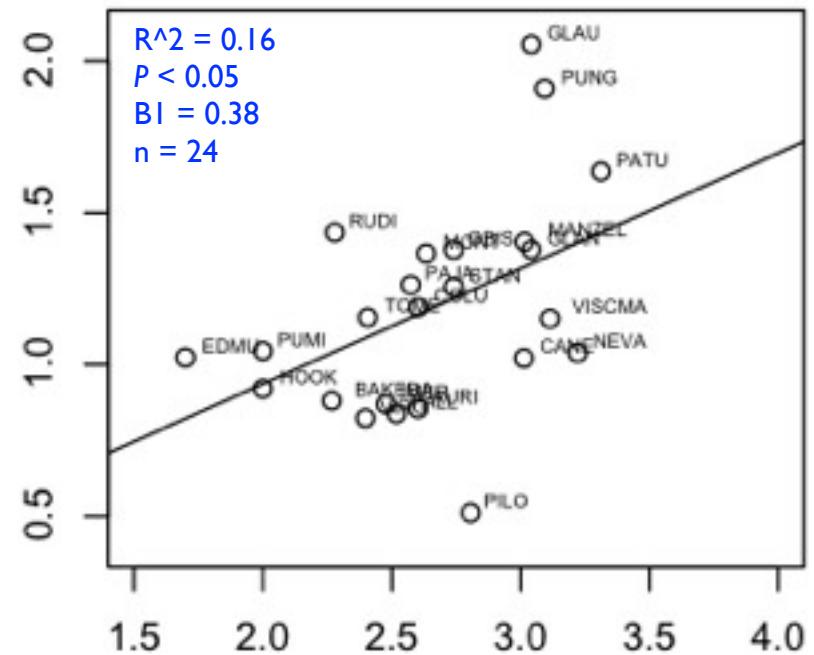
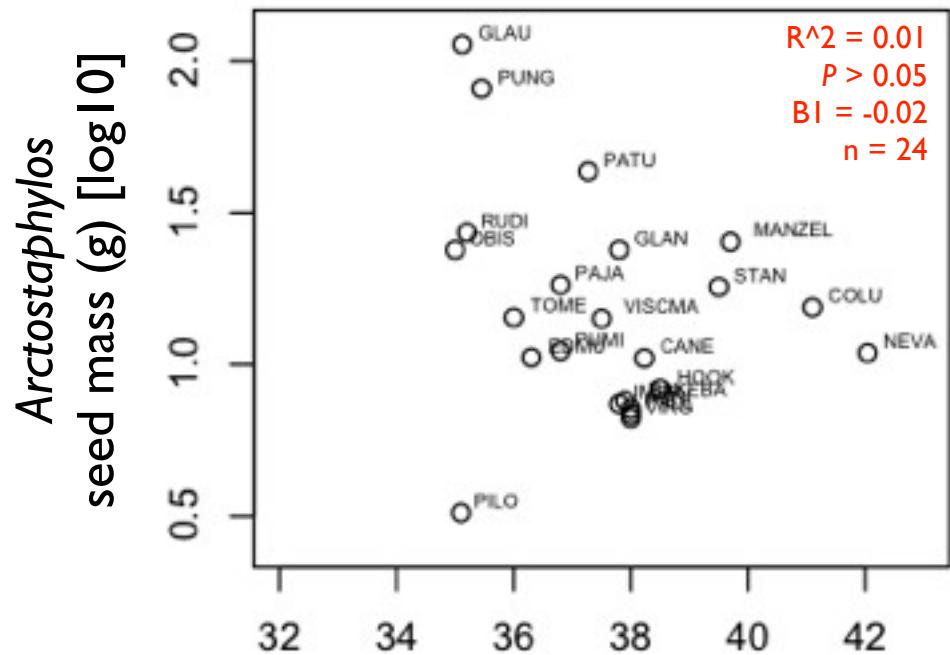
*Ceanothus*  
seed mass (g) [log10]

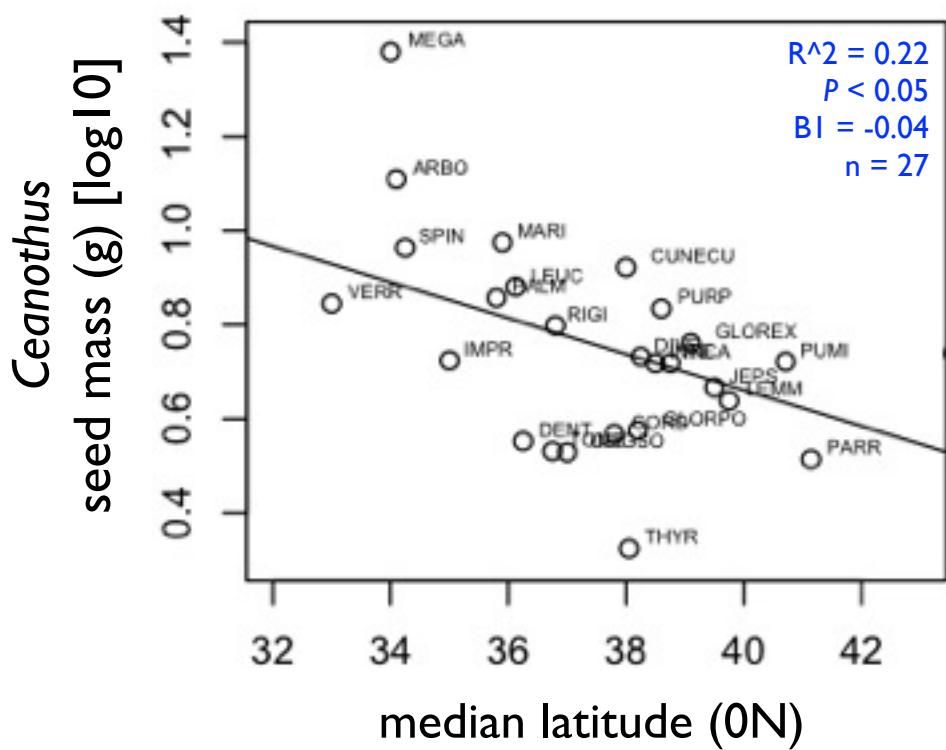
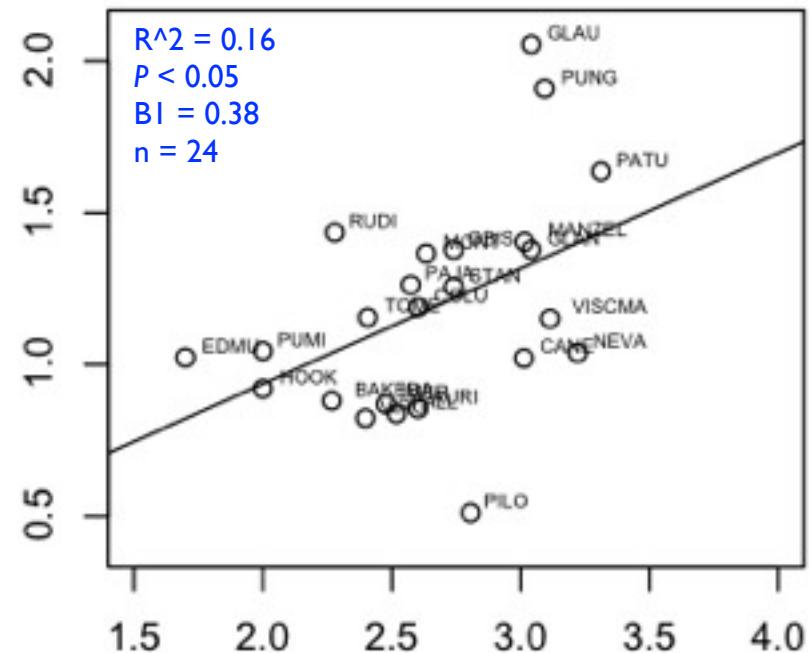
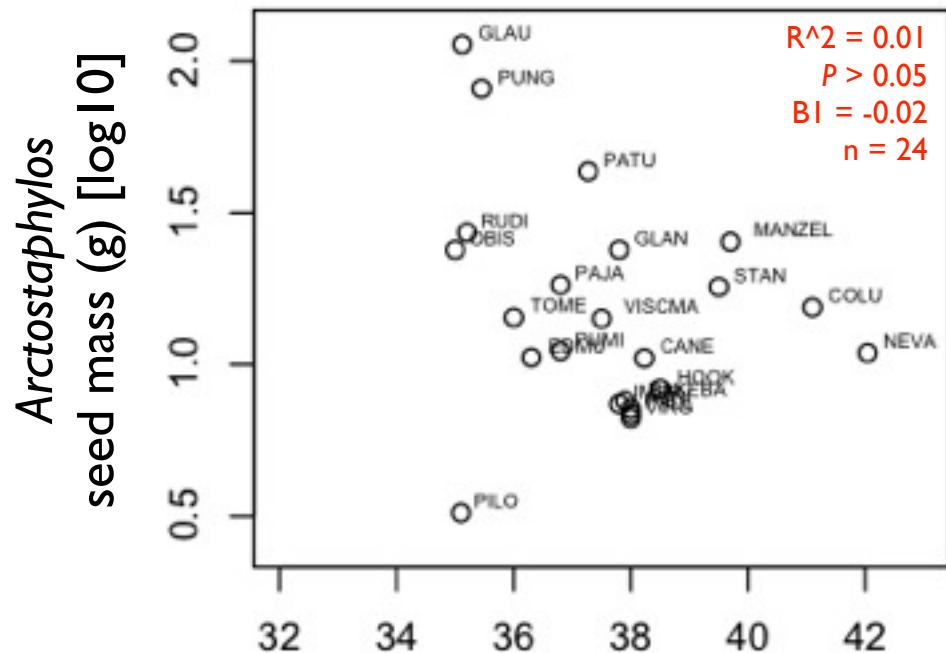
*Arctostaphylos*  
seed mass (g) [log10]

median latitude (0N)

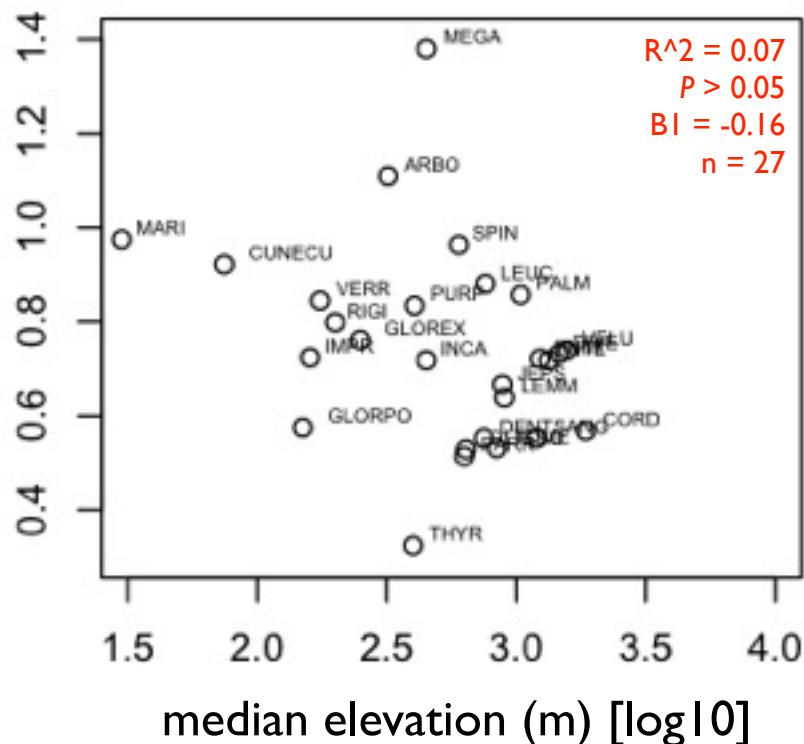
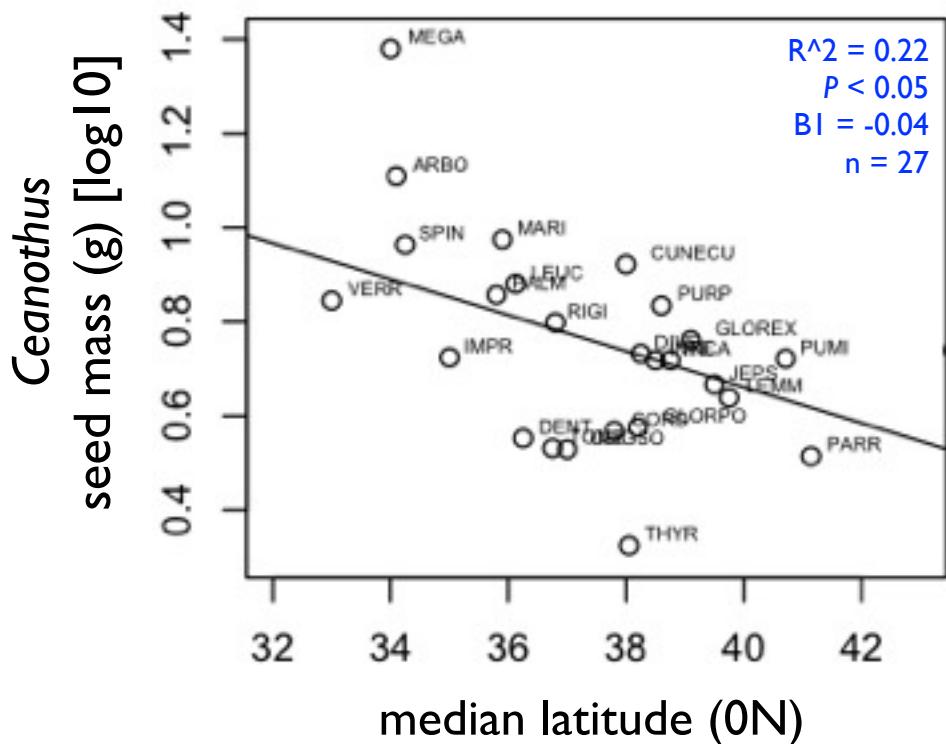
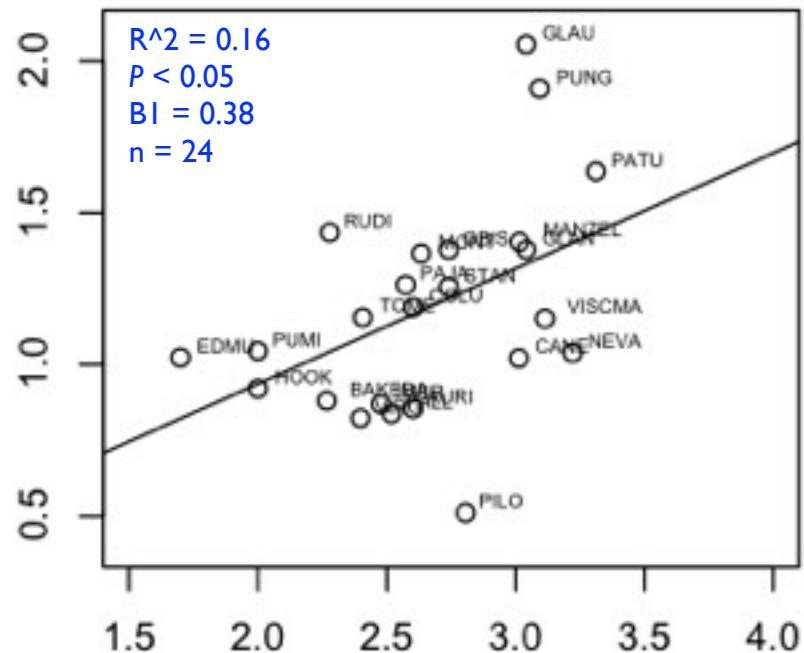
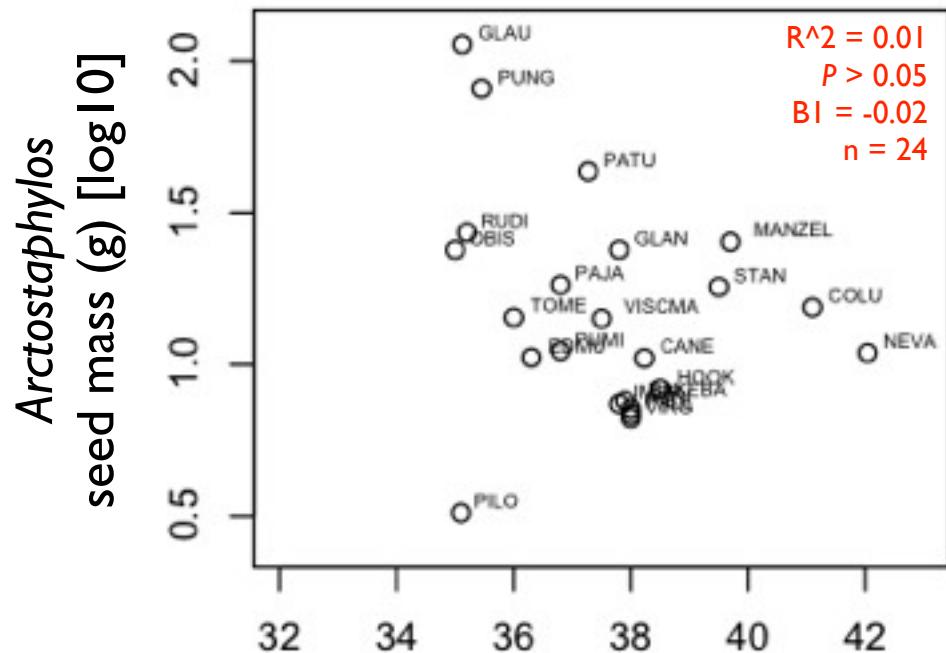
median elevation (m) [log10]



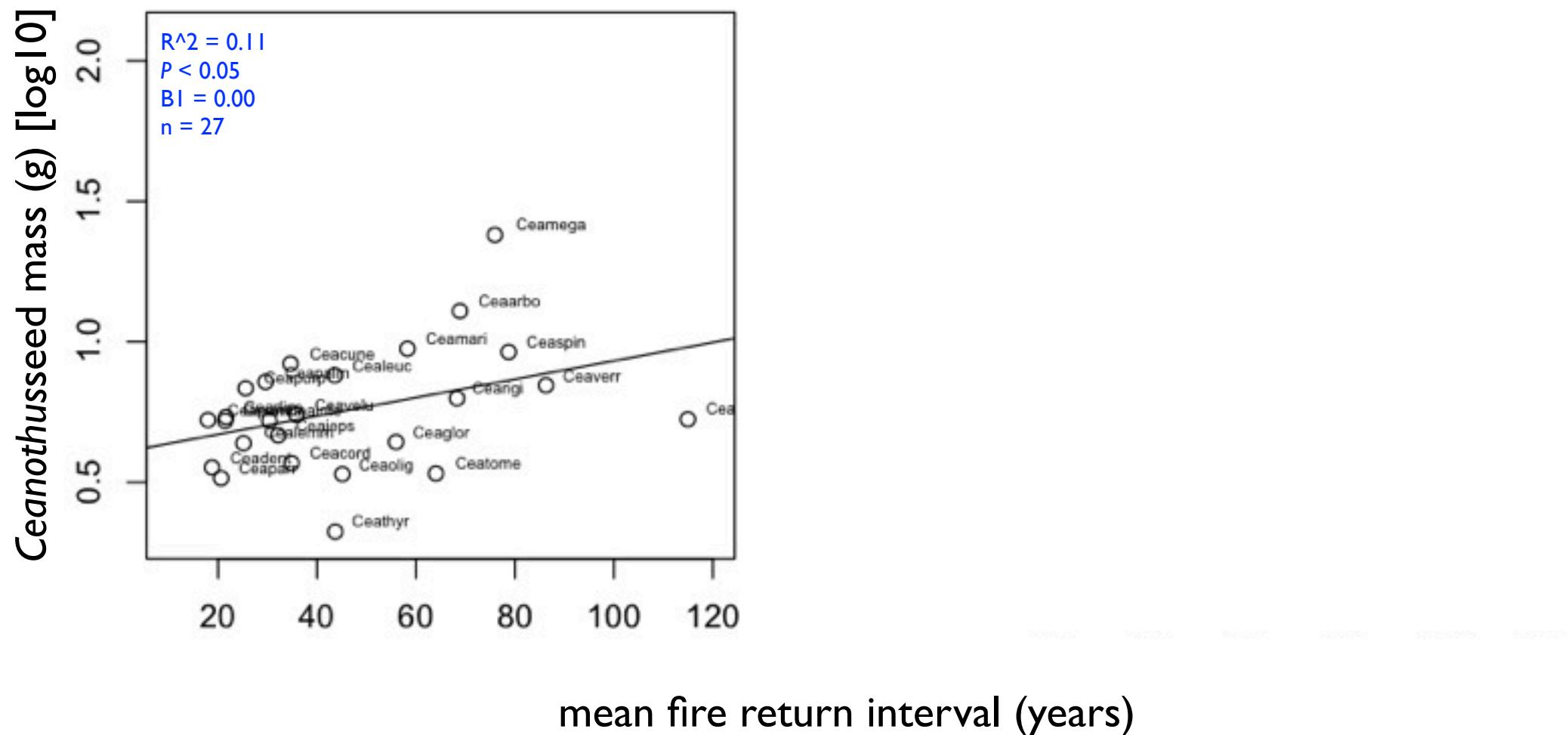


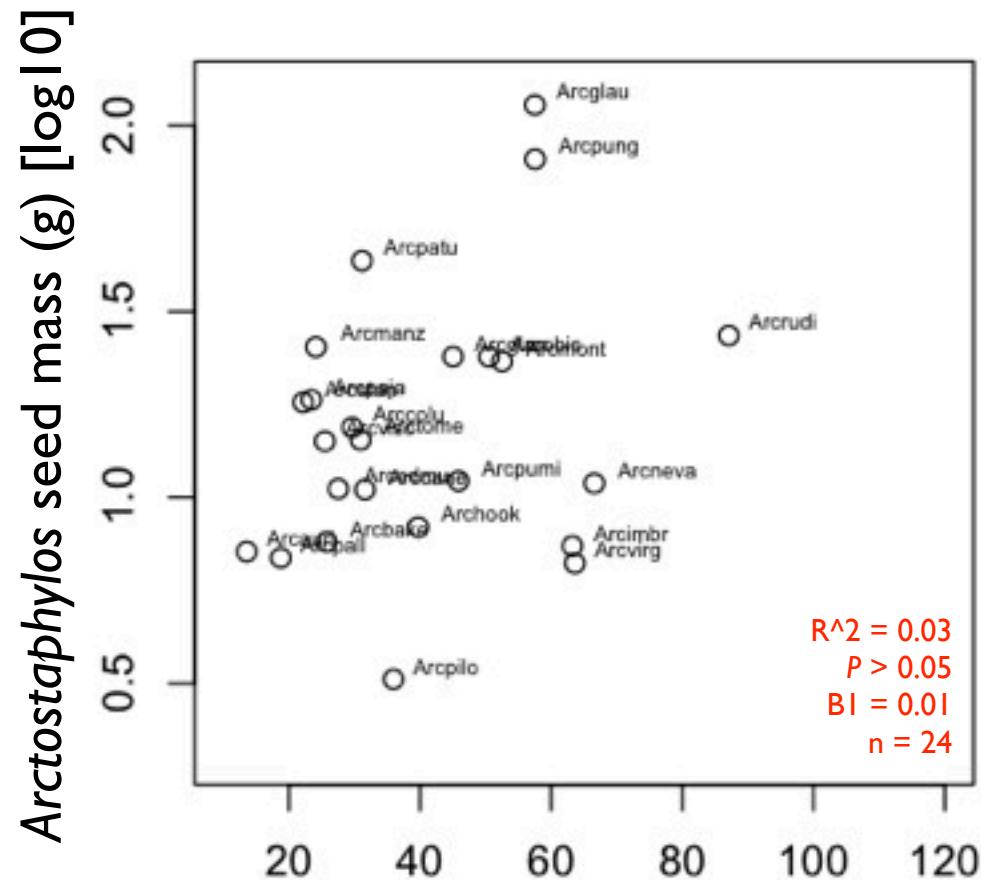
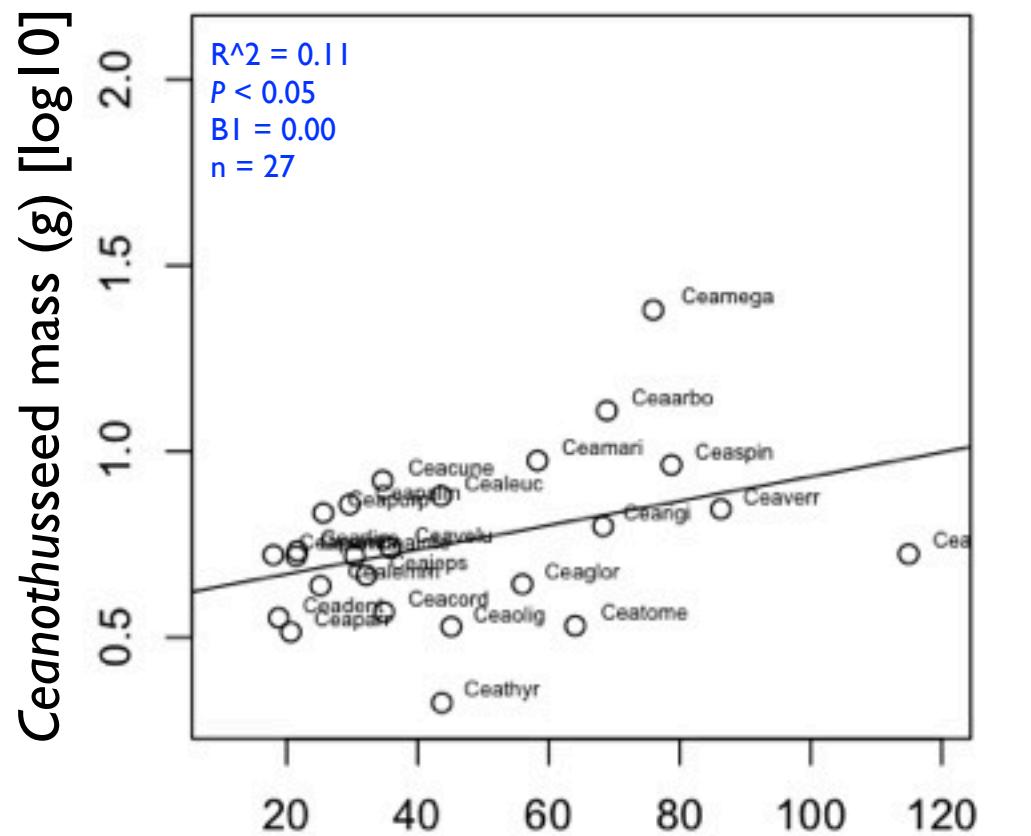


median elevation (m) [log10]



**mean fire return interval (years)**



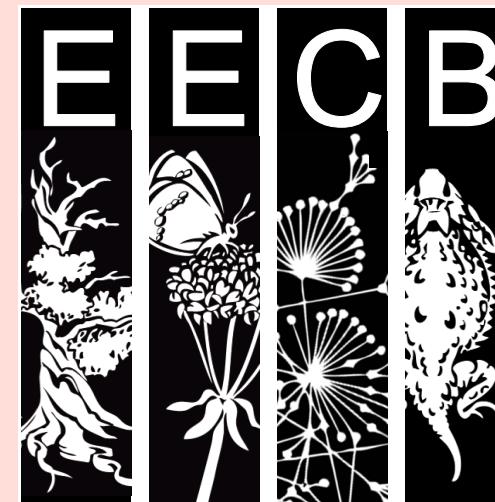
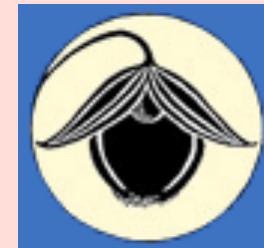


# acknowledgements

## research and ideas

steve vander wall, jeanne chambers, kevin badik, diana jolles, matt forister, guy hoelzer, scott mensing, tom parker, mike vasey, jon keeley, kevin burls, jacob dittel, angela hornsby, beth leger, sarah barga, amy seaman, lindsay dimitri, mark enders, ben waitman, josh jahner

## funding and data





thank you / questions

# photo credits

- bubble chamber: <http://lebbeuswoods.wordpress.com/2012/04/18/science-to-art/>
- flock: Zippo at <http://hqworld.net/gallery/>
- dandelion: jena4renna at deviantART.com
- seeds and fruit: Kimberly Holbrook at <http://www.fsd2010.org/program/holbrook.htm>

RESEARCH  
PAPER



## Global patterns in seed size

Angela T. Moles<sup>1,2\*</sup>, David D. Ackerly<sup>3</sup>, John C. Tweddle<sup>4,5</sup>, John B. Dickie<sup>4</sup>, Roger Smith<sup>4</sup>, Michelle R. Leishman<sup>2</sup>, Margaret M. Mayfield<sup>6</sup>, Andy Pitman<sup>7</sup>, Jeff T. Wood<sup>8</sup> and Mark Westoby<sup>2</sup>

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### ABSTRACT

**Aim** To provide the first global quantification of the slope and shape of the latitudinal gradient in seed mass, and to determine whether global patterns in seed mass are best explained by growth form, vegetation type, seed dispersal syndrome, or net primary productivity (NPP).

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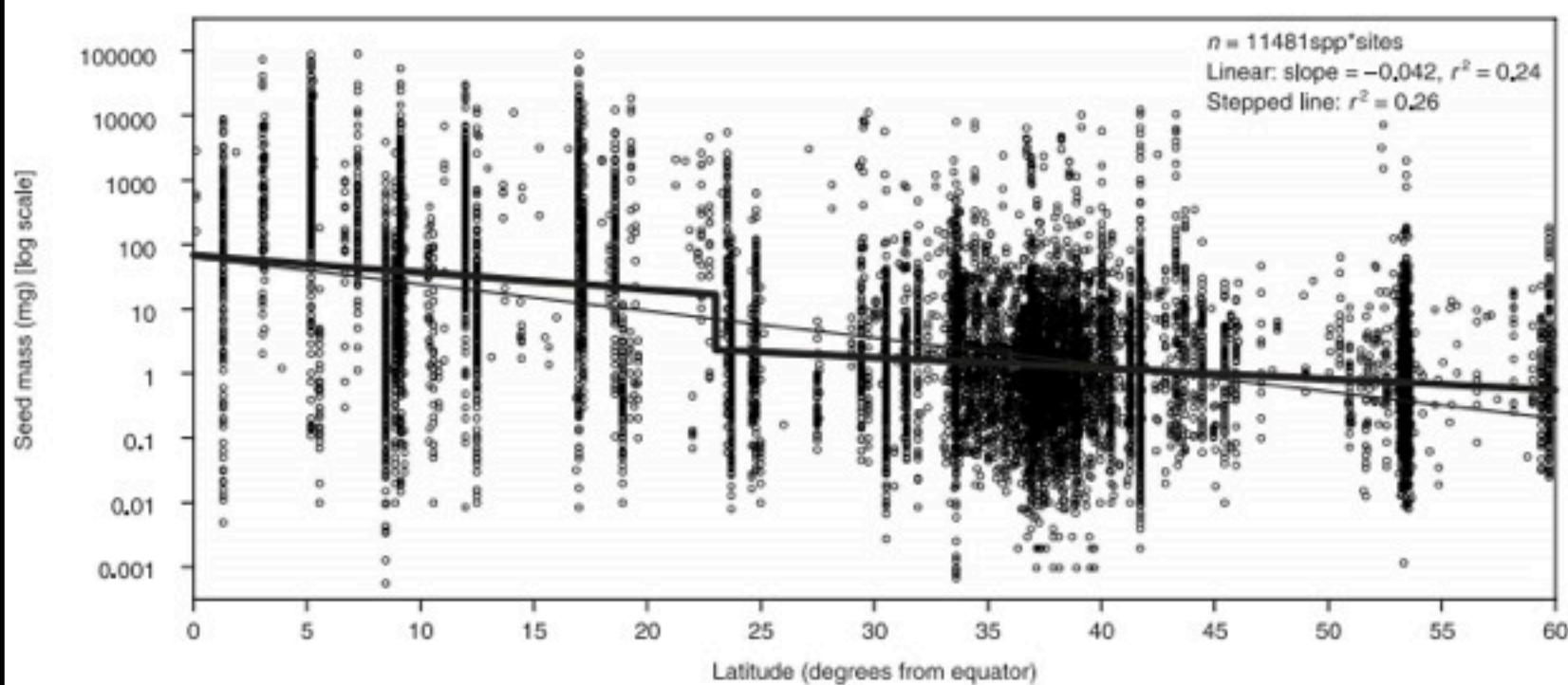
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  - i. individual
  - ii. population
  - iii. species
  - iv. community

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dispersal syndromes are phenotypic correlations of diaspore traits matched to the physical and biological properties (e.g., viscosity, behavior, physiology, morphology) of dispersal vectors

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  - a fire-adapted plant