MANZANITA

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Stories from the Seedbank

by Judith Larner Lowry PhD

My first opportunity to collect wild seeds, almost 40 years ago, was memorable for the strong sense it left that something of interest had just taken place. The feelings of receiving an unearned gift from a nonhuman source and of being in the right place at the right time enhanced this first small step into the mysteries that seeds inhabit.

Soon, I began following the trajectories of a number of California's native seeds through time and space. Brown, round, black, flat, shiny, dull, mottled, rough, pitted, smooth, slick, symmetric, irregular, each seed has its own unique journey from flower to seed. Viewed microscopically, they may reveal surprising characteristics, resembling mediaeval weapons, dishware, fancy hats, sections of cheese wheels, or objects from outer space.

In particular, I was captivated by the seeds of annual wildflowers. I found common ground with ethnographer David Prescott Barrows, an early student of the seed foods of the Cahuilla, who wrote in 1900, "[s]ome of the seeds are very beautiful, and possess a real fascination for the eye and touch" (Barrows 1900 and 1967). He particularly admired goldfields (*Lasthenia glabrata*), which "in mass resembles iron filings, being of a dark color and fine elongated shape."

Seeds mark a complex trail leading to many arenas, from ethnography, seed biology and plant propagation to entomology, rangeland management, and restoration. A good place to begin following that trail is with California's forblands, where annual wildflowers rely on the regular production of seeds, their storage in the soil seed bank, and their replenishment through the right environmental cues of water, light, and temperature. California's wildflower fields raise many interesting questions, intensified by the strong lure of their beauty and a sense of their fragility and imminent disappearance.

The Forblands: A Seed University

An annual flower field to study is pure gold. In too many places, where development, land use, and other changes have not yet destroyed them, noxious weeds from elsewhere either have or soon will. Though individual wildflower species may not be considered threatened or endangered, the phenomenon of the forblands is another story, one told through extensive documentation and research by Richard Minnich (Minnich 2008).

Each flower field has its own strengths, its own problems, and its own set of strategies for maintaining some portion of what once was. Some of the most dramatic places for a wildflower student to study this phenomenon are found during a wet year in the drier parts of California, where weeds may not be as happy or as tall as they

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Top to bottom: Sonoma sunshine (*Blennosperma bakeri*), blow-wives (*Achyrachaena mollis*), winecup clarkia (*Clarkia purpurea*)
Photos by John Macdonald

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Bay Natives (415-287-6755), 10 Cargo Way, San Francisco, www.baynatives.com

Berkeley Horticultural Nursery (510-526-4704), 1310 McGee Avenue, Berkeley, www.berkeleyhort.com

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Central Coast Wilds (831-459-0655), 336 Golf Club Drive, Santa Cruz, www.centralcoastwilds.com (please call before visiting)

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MEMBERSHIP

Your membership in the *Friends* of the Regional Parks Botanic Garden supports the important work of the garden in educational programs, conservation, and horticultural experimentation. Funds raised by the *Friends* help provide long-term financial security for the garden as well as new facilities and programs.

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Please make all checks payable to the Regional Parks Foundation; note whether for *Friends* membership, gift, or Endowment Fund; and send to:
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The Board of the *Friends* generally meets at the Visitor Center in the Regional Parks Botanic Garden the second Wednesday of the month at 10:00 AM. All members are welcome. Call ahead to verify meeting date and time.

FOR INFORMATION

About the *Friends* and membership: 510-544-3169, info@nativeplants.org
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are further north. Serpentinite-derived fields in northern California often resemble forb fields to the south, with occasional rather than dominant native bunchgrasses and with some species correspondences. One common denominator between the two is often the presence of large numbers of goldfields (*Lasthenia* species) and California poppy (*Eschscholzia* species).

A large part of the lifecycle of these plants is spent as seeds in the ground, waiting in the top one inch of soil for the right combination of ecological events, including water, temperature, and light, to trigger germination. This patient seed bank behind the forbland phenomenon is the key to a flower field's survival. The number of such seeds in the soil may range from 400 to as many as 18,000 per square foot. Paula Schiffman points out that "the capacity of natives to form persistent seedbanks" may be their ace in the hole. Non-native grasses, according to Schiffman, produce seeds with shorter life spans, sometimes under two years (Schiffman 2011).

Hope for the preservation and return of the forblands may partly lie in this ability to retain viability while remaining dormant for years, an attribute developed in response to our erratic climate. If enough dry years pass, weedy grass seed in the soil seed bank may lose viability, while wildflower seeds will retain it. When a wet year does occur, wildflowers, with their greater seed bank, will gain an advantage.

Though there will always be a weedy presence, it might be reduced through strategic focused management during the dry years, when there are fewer weeds to manage. This window of opportunity presents an opening for tipping the balance back in the wildflower direction, thanks to the nature and number of their seeds.

A Tale of Two Fields

For many years, I observed the spring display on one Marin ranch. A large, flat, moist field, laced with seeps, possibly in part a vernal pool, was a solid ocean of the yellow and white wildflower called meadowfoam (*Limnanthes douglasii*). Annually cut for silage in early spring, in a dry year meadowfoam appeared along the seeps and drainage ditches, while in wet years it was virtually everywhere, a creamy sea of bloom. Its consistent presence seemed to be a good example of an agricultural management plan that made a place for the survival of a native forb. By cutting

Giant field of the endangered *Lasthenia conjugens* in Solano County. Photo by Steve Edwards
Inset: Goldfields (*Lasthenia glabrata*). Photo by John Macdonald

the field after the meadowfoam flowers had ripened and dropped seed, the species returned year after year, seemingly invincible.

Meadowfoam, and other members of its genus, are pollen sources for a suite of native *oligolectic* (specialized) bees that require meadowfoam for the survival of their larvae, and some of which have the capacity to remain dormant in their underground nests until a good year for mead-

Peter G. Smith

Meadowfoam (*Limnanthes douglasii*), is oligolectic, with a number of native bees requiring its pollen to survive.

Jeff Manson

Horse in field with California buttercups (*Ranunculus californicus*)

owfoam arrives. In a sense, they have their own "soil seed bank." The large meadowfoam field in Marin may have contained a huge warren, a veritable city, of underground solitary bee nests, but its demise preceded general understanding of these relationships.

Some years later, the ranch changed hands, and during that transition, the land was left fallow for a year. For that reason or others that I could not determine, meadowfoam was present not as the only representative of the annual wildflower phenomenon but as one among many that spring, emerging as part of an ebullient successional mix of wildflower species that I had never witnessed in that area. I learned that in such a moist field, miner's lettuce (*Claytonia perfoliata*) may appear in full sun, drying up as meadowfoam began its March bloom, followed by goldfields, tidy tips (*Layia platyglossa*), baby blue eyes (*Nemophila menziesii*), lupines (*Lupinus* species), checkerbloom (*Sidalcea* species), bird's eye gilia (*Gilia tricolor*), Chinese houses (*Collinsia heterophylla*), farewell-to-spring (*Clarkia* species), and more. All those seeds were present, hidden in the seed bank, waiting for their chance.

After that year, a new agricultural regimen, the details of which were difficult to ascertain but appeared to include plowing, seeding, and draining, eliminated most of the wildflower species. Where dry seasons once brought more restrained meadowfoam displays, they now bring almost none. No other wildflowers have been seen in that field in over 20 years, unless wild mustard is counted a wildflower. (Some do: The Napa Valley Mustard Festival urges us not to miss "the phenomenon of mustard in bloom.")

This local bounty deserved protection and now merits restoration. During the good years of the nineties, I managed to obtain one small handful of meadowfoam seed. I did not know when I sowed it in our growing grounds that this one tablespoonful of seed would become many, thriving easily in our Demonstration Garden, in spite of the sandy soil and the lack of natural seeps and springs in our grow-out area. Meadowfoam seed oil is highly valued and is now a regular component of many cosmetic products.

The second local flower field of interest is located on a windy, serpentinite-derived ridge near Nicassio where it provides months of varied bloom. This pasture is not required to do more than feed a small herd of horses and delight the owners and their guests. Since grazing as part of restoration is being investigated as a way to help native species survive the weeds, I noticed that this small herd has a strong predilection for weedy forbs and grasses, and a disinterest in hayfield tarweed (*Hemizonia congesta*), goldfields, cream cups (*Platystemon californicus*), common stickyseed (*Blennosperma nanum* var. *nanum*), rosin weed (*Calycadenia multiglandulosa*), biscuit-root (*Lomatium*), cream-sacs (*Castilleja rubicundula* ssp. *lithospermoides*) and a host of other annual and perennial native wildflowers thriving there. This equine preference for European and Eurasian forbs and grasses may have traveled with them from Europe and Eurasia, along with the weed seeds.

As each successive wave of wildflowers in this impressive field begins to ripen its seed, another wave of blooms begins. Meadow daisy and goldfields are first. These are succeeded by hayfield tarweed, lupine, and rosin weed, ending with winecup clarkia (*Clarkia purpurea*). Blue eyed grass (*Sisyrinchium bellum*) and buttercups (*Ranunculus californicus*) accompany both phases.

By midsummer, the rainbow of color has become, in the main, a field of scratchy, dried seed stalks, ready to shatter and disappear in the heat of the sun. This transition from flower to mature seed happens slowly at first, speeding up as the season progresses. Identification of each species'

seeds becomes increasingly difficult. Without following their maturation process closely, the seeds of some can be almost impossible to recognize. The best way to track ripe seed is through consistent observation.

Jeff Manson

It took 45 minutes of searching to locate this seedhead, halfway on its journey to ripe, of cream cups (*Platystemon californicus*).

Muir's Bee Pastures: The Seed Granaries

Perhaps the most-quoted poet of the California wildflower fields is John Muir writing about the Central Valley in his essay "The Bee-Pastures." Muir's lush prose is evocative, as well as surprisingly accurate, as he walks into, wades through, sleeps on, and wakes among the flowers.

"When I first saw this central garden, the most extensive and regular of all the bee-pastures of the State, it seemed all one sheet of plant gold, hazy and vanishing in the distance, distinct as a new map along the foothills at my feet.

Descending the eastern slopes of the Coast Range…I at length waded out into the midst of it all. All the ground was covered…with radiant corollas, about ankle-deep next the foot-hills, knee-deep or more five or six miles out.…

Sauntering in any direction, hundreds of these happy sun-plants brushed against my feet at every step, and closed over them as if I were wading in liquid gold.…

The great yellow days circled by uncounted, while I drifted toward the north, observing the countless forms of life thronging about me, lying down almost anywhere on the approach of night. And what glorious botanical beds I had! Oftentimes on awaking I would find several new species leaning over me and looking me full in the face, so that my studies would begin before arising." (Muir, 1894)

Muir was ahead of his time, first in giving value to and understanding the wildflower field phenomenon, and then in fearing its demise. Also prescient is his attempt to imagine a way to maintain the flower fields in their unspoiled state while providing for human needs. He would have understood the overworked word "sustainability," for that is what his imagination sought—the benign use of the flower fields as one giant honey production area.

With that goal in mind, his essay is a hopeful piece of market research in which he evaluates the land from the point of view of a bee. He calls the California counties he travels the "bee-lands," rating which are the most "honeyful." Muir was cognizant of the differences between the "wild" bees and the Eurasian honeybee (*Apis mellifera*), something that is still to this day a surprise to many (though less so now thanks to the untiring efforts of bee researchers Robbin Thorp, Joan Leong, Gordon Frankie, and others).

Muir was understandably unaware of the extent of California's list of 1600 native bee species. He could not have understood the relationships between certain native bees and certain widespread wildflowers like meadowfoam, goldfields, and meadow daisy. Research indicates that for these and other plant species with oligolectic bee relationships, pollination may be more complete and as a result seed production higher when native bees are present (Thorp and Leong 1998).

Pattie Litton

Cream cups (*Platystemon californicus*) on Mt. Burdell, April 2011

Rosie Andrews photos

Redmaids (*Calandrinia menziesii*) at Black Diamond Mines Regional Preserve, part of EBRPD, spring 2015

Still, Muir missed an already well-established means for combining human sustenance with the natural values of wildflowers. For millennia, throughout California, nutritious wildflower seeds by the ton were gathered and consumed by most indigenous tribes. The beauty of the flowers was a harbinger of nutritious seed crops to come, their diversity a possible factor in maintaining high levels of health.

Researcher Heather B. Thakar (2014), working in three middens on the Santa Barbara Channel Islands, found evidence of the long-term use of "small starchy oily seeds" including miner's lettuce, clover (*Trifolium* species), goosefoot (*Chenopodium* species), tarweed (*Hemizonia* and *Madia* species), Canary grass (*Phalaris californica*), and redmaids (*Calandrinia menziesii*).

Evidence from both ethnographic literature and archaeological findings indicates that hundreds of species provided grain crops for indigenous peoples, without seeding, weeding, plowing, watering, or fertilizing, using fine-tuned burning, a uniquely Californian form of permaculture.

Edible wild seeds were toasted, ground, and then used in a variety of ways. Eaten dry, mixed with other foods including acorn, mixed with liquid and boiled into porridge, used as seasoning, mixed with water to make drinks, or baked into large bread-like loaves, these seed foods became collectively known to Europeans as "pinole." Their use required an impressive range of seed gathering, seed cleaning, and seed preparation techniques, some of which are still practiced. Mentioned by many of the early European diarists, small seeds were sometimes listed before the all-important acorn. In his diary of the 1770 Portolá expedition to San Francisco Bay, explorer Pedro Fages noted, "There is abundance of all seeds needed for their use, and many acorns." (Heizer 1951, p. 260)

Over 100 years ago, samples of seeds eaten by California tribes were collected by anthropologists and deposited with the Phoebe A. Hearst Museum of Anthropology at U.C. Berkeley. Recently, they were analyzed by M. Kat Anderson, ethnoecologist with the Natural Resources Conservation Service, and senior seed botanists Jim

John Macdonald

Redmaids (*Calandrinia menziesii*)

Effenberger, Don Joley, and Deborah J. Lionakis Meyer. These samples provide an invaluable look at the past and a look into future possibilities as well. As guides for restoration projects, they add a unique historic dimension, telling us where chia (*Salvia columbariae*) still grew in 1903, and which tribes ate it. They tell us that the Sierra Miwok in Tuolumne County, the Chukchansi in Madera County, and other tribes as well ate seed of winecup clarkia (*Clarkia purpurea*). Tribes in Inyo County gathered seeds of blazingstar (*Mentzelia albicaulis*), and others ate bushy blazingstar (*Mentzelia dispersa*). At least one tribe, the Sierra Miwok, ate seed of blow-wives (*Achyrachaena mollis*) which seems an unlikely choice, given its proclivity for blowing away.

Some collected samples contain up to a dozen different species, including some non-natives. Altogether, 187 species were identified. Sometimes it seems that any seeds you wonder about, and some you did not wonder about, were food. Why some were eaten and others not is a matter for speculation. If four species of clarkias were found in these samples, it seems reasonable to assume that other clarkia species were gathered as well, which is borne out by ethnographic literature. The importance of members of the Asteraceae family, from sunflower to mule's ears to tarweed to goldfields, could lead to assumptions about the edibility and historic use of other Asteraceae as well. The bee-pastures were rich and diverse granaries indeed. We may never know all the species that were actually used, or all the reasons why the seeds of some species were chosen foods while others were not.

Three species frequently mentioned throughout ethnographic literature as well as regularly found in these samples are redmaids, tarweed, and chia (*Salvia columbariae*), all eaten by many Californian tribes. Anthropologist Anna Gayton describes the Yokuts' perception of the flower fields: "Winter rainbows forecast plentiful seed crops, for they were seen as four bands of color (magenta, blue, yellow, and orange) of four flowers whose seeds were prized" (Gayton 1946). Redmaids are magenta, chia is blue-purple, tarweed and goldfields are yellow, and perhaps fiddleneck (*Amsinckia* species) is the orange species whose seeds were valued.

The invasion of California by plants from elsewhere was well under way by the time of these collections in the early 1900s, and their presence is reflected in these samples. Anthropologist Pliny Goddard in 1903 bought redmaids seed from a member of the Hupa tribe, who had collected them many years ago but no longer did so at the time of purchase. The weeds, said Goddard, "have so crowded out and mingled with the native plants used for this purpose that the Hupa do not now attempt to gather the seeds" (Goddard 1903). Still, 112 years later, there are enough wildflowers present in California to keep us in suspense, waiting for a "good flower year."

John Macdonald

Californian chia (*Salvia columbariae*)

Redmaids is the only wildflower to move of its own accord into our growing grounds at Larner Seeds, and we have grown it ever since. It still turns up in agricultural fields throughout California. Its appearance is the more surprising given its ground-hugging habit, easily overtaken by taller species. Appearing here in mounds of otherwise unvegetated subsoil left over from building projects, possibly the seed was present in the seed bank from long ago. A prolific seed producer, it is not difficult to gather enough of this species to experiment with its shiny black seeds, which when toasted and then ground contain enough oil to be formed into tasty seed balls.

John Macdonald

Chinese houses (Collinsia heterophylla)

Californian chia (*Salvia columbariae*), not the *S. hispanica* offered by health food stores, is found in numerous samples in Goddard's study, many from locations in Northern California where it is rarely found today. It prefers open ground, easier to find in southern California. Chia is frequently mentioned by early explorers, was gifted by the indigenous people to priests and explorers, and is important in indigenous stories—the Sun gambles with chia, and Coyote ate up all the chia in town (Lowry 2012). Drought causes chia to be shorter in stature, but its presence in the southern counties—in Joshua Tree, the Carrizo Plain, the Red Hills, and other dry, sandy places—seems so far to be consistent. Anything *Salvia hispanica* does, *Salvia columbariae* can do better: make a porridge, make water taste better, make smoothies, make wildflower seed cookies.

Hayfield tarweed (*Hemizonia congesta* ssp. *lutescens*) is a hardy species that thrives with drought and grazing. Found in the serpentine field described above, it grows as thickly as a farm crop, providing the opportunity to gather a single species in the traditional manner of employing a seed beater and burden basket, (though a squash racquet and stainless steel bowl were substituted). This method takes advantage of the characteristic possessed by most wildflowers of indeterminate flowering and seed production. Flowers at the base of the flower-stalk bloom and drop seed first, while flowers at the tip may still be in bud. The use of seed beaters instead of cutting and removing the entire plant gives all the seed a chance to ripen. The ripe seed, with gentle encouragement, drops into the container, while the unripe seed is left on the seedstalk to complete its journey to maturity.

The pungent aroma of hayfield tarweed is classic California, and though some deplore its presence in pastureland, others relish it. A spring-flowering form begins in May and is still blooming in June, while a summer- and fall-blooming form will appear later. The *Marin Flora* (Howell 2007) calls them "the golden link that binds with flowers and verdure the end and the beginning of successive rainy seasons."

Missing Heaven

Longtime residents near the meadowfoam field, when questioned, report little knowledge of that monumental display's ups and downs. I might think I imagined how it used to look, but for our annual seed harvest here. Meadowfoam seeds, and the other representatives of the rainbow, still wait in the seed bank, but for how long?

Meanwhile, the owner of that field casts about for a profitable way to use it. Muir described "experiments in a kind of restless, wild agriculture" as taking swipes at the glory of the honey fields. Rows of annual vegetable crops are appearing, which, with their cultural requirements, may be one of the best ways to ensure that wildflowers are on the way out. Meanwhile, the handful of seeds I borrowed from that field has reproduced and multiplied with almost no care for twenty years (Larner Seeds Records, 1995 to 2014).

I am surprised when some of my employees tell me that they themselves have never seen a good example of forblands in bloom. Luck is required, as well as vacation time. Beware of incurring future regrets: I should have taken more strolls through that rainbow field. It was as close to heaven as even Muir could wish.

John Muir was right about many things, but in one respect he misjudged. When describing the destruction of the flower fields, he imagined the following: "Then, I suppose, there will be few left, even among botanists, to deplore the vanished primeval flora." He turned out to be very wrong about that.

For the last 38 years, Judith Lowry has been the proprietor of Larner Seeds, specialists in gathering, growing, and harvesting California native plants and seeds. She also consults and designs backyard restoration gardens, gives talks and workshops, and is the author of numerous articles for magazines and journals, from Orion *to* Bay Nature. *Lowry has written three books,* Gardening with a Wild Heart, The Landscaping Ideas of Jays, *and most recently,* California Foraging.

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Rock Garden Opening *by Rosie Andrews*

Teresa LeYung-Ryan

Left to right: Don Fuller, gardener and curator of the Southern California section; Phil Johnson of Phil Johnson Landscaping; East Bay Regional Parks General Manager Robert Doyle; Ward 3 EBRPD Board Member Dennis Waespi; Bonita Garden Club Vice President Georgia Madden; Botanic Garden Director Bart O'Brien; Bobbi Feyerabend; Friends Board President Rosie Andrews; Barbara Friede; Beverly Becker. Bobbi, Barbara, and Beverly, along with Georgia, represented the Bonita Garden Club.

The morning of May 13th was a time to celebrate as a joyful crowd gathered for the opening of three new rock gardens in the Southern California section of the garden. Personnel from the garden and other parts of the East Bay Regional Parks District, representatives of the Regional Parks Foundation and the EBRPD Board of Directors, Friends' members, volunteers, and other garden supporters, were all on hand to show appreciation for this wonderful addition to the garden and the generosity of those who made it possible.

In opening comments to those assembled, Garden Director Bart O'Brien thanked the many people who had assisted in bringing the project to completion, with a special thanks to Phil Johnson and his crew, who managed the construction and rock work in the new beds, for their exceptional skill and ability, and for working so well with the garden staff.

Over 300 cubic yards of custom soil mix and 116 tons of boulders were used to create the new gardens. In some places in the beds there is now a functional, well-drained soil depth of over six feet. In addition to their aesthetic value, rocks provide wonderful planting niches for plants and cool places for plant roots to grow. Over time the improved soil conditions and rockwork in these new beds will allow the garden staff to grow unique collections of plants from Southern California chaparral, desert, and mountain habitats, as well as those from the northwestern Baja California portion of the Californian Floristic Province. The outcrops have already become home to a number of species never before grown in the Botanic Garden, among them Guadalupe Island senecio (*Senecio palmeri)*, Baja buckeye (*Aesculus parryi)*, Baja sage (*Salvia chionopeplica)*, Claire's mahonia (*Berberis claireae)*, and Guadalupe Island everlasting (an undescribed new species of *Pseudognaphalium* from Guadalupe Island).

East Bay Regional Parks General Manager Robert Doyle spoke to those gathered and took the opportunity to share plans for the park district and the botanic garden, including the exciting news of plans for a new visitor's center for the garden. He joined the other speakers in

Teresa LeYung-Ryan

Left to right: Barbara Friede, Beverly Becker, Bobbi Feyerabend, Georgia Madden

thanking the Bonita Garden Club for the gift that endowed the new gardens.

Georgia Madden, Bobbi Feyerabend, Barbara Friede, and Beverly Becker of the Bonita Garden Club were all on hand to join in the celebration, share stories, and provide some background for the $90,000 gift the club made to the garden in January of 2014. Club Vice President Georgia Madden explained that a bequest from Frances Whyte, an active club member from 1972 until her death in 2009, provided the funds for the project. Ms. Madden described Mrs. Whyte, a Bay Area native whose talent for golf led her to win 20 club championships over six decades at Oakland's Sequoyah Country Club, as "witty, elegant, an avid orchid collector, and a really rigorous parliamentarian," who made sure club meetings followed the rules. After her death, her fellow garden club members were stunned to learn she had entrusted them with a significant bequest to provide funding on her behalf to local horticulture and education endeavors. The entire club worked hard to select organizations with "well-defined missions and a strong community spirit," and with that in mind, approached the garden with the offer of a grant.

In our 75th Anniversary year, the Regional Parks Botanic Garden was thrilled to be included in the list of recipients and to have a chance to honor Mrs. Whyte's legacy by creating new and exciting additions to the garden, which will continue to grow and evolve in the years ahead.

Rosie Andrews has been a docent at the garden since 2009 and is currently President of the Friends *and Managing Editor of the* Manzanita.

Pattie Litton

One of three newly renovated rock beds made possible by a very generous gift from the Bonita Garden Club.

Seeds: The Key To Success for the Land Plants *by Glenn Keator, PhD*

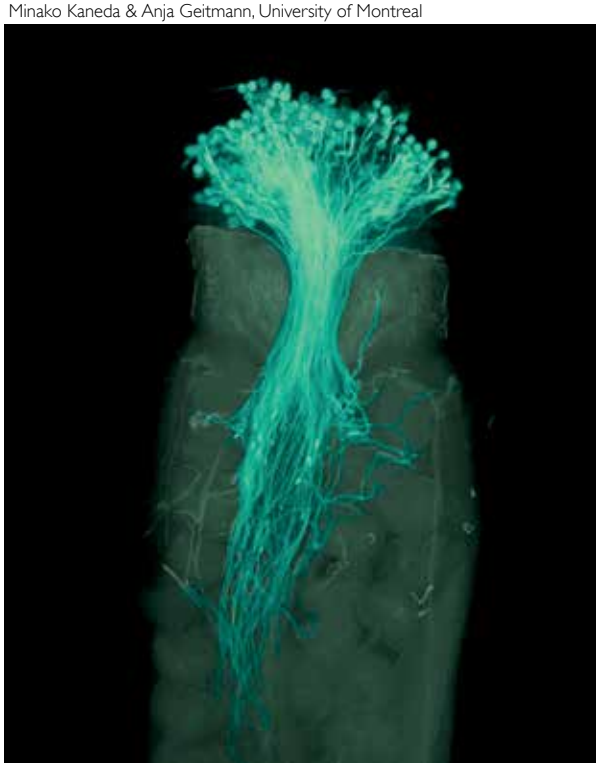
Two major evolutionary developments, the seed and the flower, have transformed the land plants into wildly successful organisms that dominate most all the earth's terrestrial ecosystems. This essay will look at what a seed is and what its advantages are.

Before seeds, plants reproduced by tiny, microscopic spores that could not survive unless they soon found favorable conditions. In plants like the mosses, liverworts, horsetails, and ferns, the spores grow into an alternate plantlet that produces the sexual part of the life cycle—eggs and sperm. In order to succeed, water is absolutely necessary, sometimes restricting fertilization to a very short window of opportunity.

The seed negates these problems. Seed production starts with microscopic pollen grains, produced in prodigious numbers in the case of wind pollination and in somewhat smaller numbers in insect- and bird-pollinated plants. At the same time as pollen grains are produced, tiny ovules on the parent plant make a tiny female plantlet (embryo sac) that produces eggs. Unlike the tiny separate plants of spore bearers, which have limited resources to nurture the eggs, seed plants are substantial enough to nourish the eggs inside the ovules, sometimes for a long gestation, before fertilization occurs, increasing the probability of success.

Meanwhile, some of the pollen grains find a landing place close to the ovules—in the case of flowers, on the stigma. Although pollen grains themselves are as fragile as spores, when they find the right partner, they grow a slender pollen tube that is nurtured by the tissue of the parent plant they land on (in the case of flowers, the tissue of the style). Not only is this process responsible for the pollen tube's growth, but it mitigates against the wrong pollen on the wrong plant—foreign pollen on a flower's stigma cannot grow a tube and soon dies.

Minako Kaneda & Anja Geitmann, University of Montreal



Epifluorescence micrograph of pollinated pistil of rockcress (*Arabidopsis thaliana*). The teal blue spheres represent pollen grains, each of which forms a tube that grows into the pistil and towards an ovule where it delivers the two sperm cells that accomplish the double fertilization of the female gametophyte.

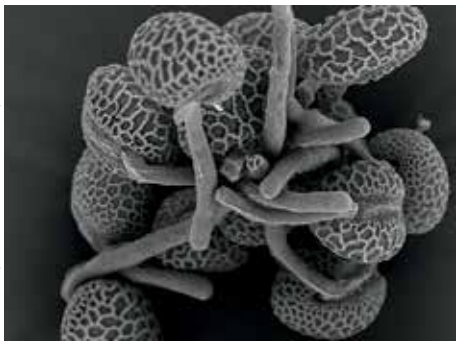
The pollen tube's journey is one of nature's miracles, as the tube may sometimes grow many inches long before reaching an ovule inside the flower's ovaries. As the pollen tube nears its destination, guided by hormones, a nucleus inside the tube divides to form sperm, which are released for fertilization next to the ovule's egg. Sperm no longer need water to swim in; they're delivered by the pollen tube to exactly where they need to be, making fertilization a possibility any time of the year.

Once the egg has been fertilized, it grows into an embryo inside what becomes the seed (the term "seed" applies to ovules that have been successfully fertilized). The seeds remain on the original parent plant for an extended gestation, allowing the embryo inside to grow to optimal size before the seed is shed.

Even after the seeds are shed, they have a built-in food supply to nourish the embryos long enough for germination to take place when the time is right, thus assuring the likelihood the baby plants will succeed. A typical seed consists of an outer seed coat, which protects it from the elements, a layer of *endosperm* or nutritive tissue to sustain the embryo, and the embryonic plant itself. Germination is typically delayed until the right mix of soil moisture, temperature, and day length come together.

Seeds have reinvented the plant world, with a whole array of innovations that streamline fertilization, utilize animals for pollination, and assure the greatest chance of survival for the next generation.

Anja Geitmann, University of Montreal



Scanning electron micrograph of lily pollen tubes germinating from pollen grains in a nutrient medium.

Glenn Keator is the chairman of the Friends *Advisory Council. He is a popular instructor of botany and field trip leader in the Bay Area, and he teaches the docent training course at the Regional Parks Botanic Garden. He is the author of a number of books on native plants.*

Starting from Seed at Native Here Nursery: A Conversation with Charli Danielsen

by Sue Rosenthal

Charli Danielsen started Native Here Nursery for the East Bay Chapter of the California Native Plant Society in 1994. Founded to support conservation and restoration, Native Here exclusively provides locally native plants grown from seed and cuttings collected under permit in Alameda and Contra Costa counties for restoration projects, public agencies, and home gardeners. Charli volunteered as nursery manager from Native Here's inception until 2013, and she and her husband John continue as active nursery volunteers.

Charli Danielsen and Margot Cunningham at Native Here Nursery sowing grass seed collected in the wild Janice Bray photo

SR: What inspired you to start Native Here Nursery?

CD: When I was CNPS state president [in 1986], there was heightened awareness of what horticultural native plants were doing to wild populations when they were planted nearby. I figured that the simple solution was to make non-horticultural local plants available for revegetation projects and also encourage people with gardens on the wildland interface to go that way rather than use hybrids and plants domesticated elsewhere that could do strange things to the gene pool. It seemed to me the simplest thing was to collect nearby wherever you're planting. And like all simple solutions, it's kind of intricate to carry out. And lots of fun! I love it.

SR: Why did you decide to grow plants for the nursery from seed rather than from cuttings?

CD: Well, we do some cuttings. But because it is a chapter nursery and so much was done by cuttings for the chapter's regular plant sale, we decided we'd be the seedling operation. There are also some genetic reasons. When you're propagating by cuttings, you're essentially cloning the plant. When you're doing seeds, you're collecting samples from a number of individuals within a population, and you're more likely to get the full range of genetic possibility within that population, which enables the seedlings to adapt more to conditions and changes.

SR: What are some of the challenges of growing from seed?

CD: It's hard to figure out why certain plants come up one year and not the next. Sometimes it's our processing, sometimes it's timing, and sometimes I think some plants' seed viability is very dependent on weather conditions in a given year. I was perfectly happy to try other people's protocols—retain the ones that worked and experiment and divert from the ones that didn't. My motto is a kind of adaptive management: If something doesn't work, don't repeat it, try something else.

There are always surprises. When we sowed seed of *Abronia* [sand verbena], we'd get pots full of *Amsinckia* [fiddleneck] seedlings instead. I found that very tiny annual seeds like *Amsinckia* would stick to the fuzzy *Abronia* seeds, and they'd germinate before the *Abronia*. I experimented and found that soaking the *Abronia* seeds in warm water floated off the non-target seeds.

SR: Does it take longer to grow a plant from seed than from cuttings?

CD: It's about the same. You put it in, it germinates, and then you can sell it in smaller containers. When you're doing a cutting, you pretty much have to sell it as a gallon. So especially for restoration, if people want less expensive, smaller plants, growing from seed is great.

SR: And how do you actually collect the seed? Do you have a particular protocol you follow?

CD: The simple answer is: dry-looking seeds go into coin envelopes, fleshy seeds go into Ziplock bags. Most of the fleshy seeds need to be cleaned by soaking in a mild peroxide solution before you put them in the medium for stratification [a seed treatment that simulates winter conditions with a combination of moisture and

chilling to break dormancy and allow germination]. I mostly use straight peat for stratification unless it's something that needs a little scarification [abrading or softening the coat of a hard seed to hasten germination], then I'll add some sand.

When we're collecting, we try not to get off trail much, just for the conservation ethic it shows. You don't want a bunch of people tramping off through the chaparral to find just the right plant. And the tricky part with a group of collectors is to avoid inadvertently picking off the same plant if they're strung out in an area. In some ways it's faster and more efficient if only two people go collecting, or three at the most. But then you lose the educational aspect of teaching more people to do it.

SR: How do you determine what and how much you collect?

CD: It's kind of random. When we get organized, it helps if whoever's managing the nursery has a pretty good idea of what's selling, what people are asking for that we don't have, what will complement the inventory. However, there are some constraints on what we can grow based on where the nursery is located and how things will do that come from different habitats.

SR: How do you know when seed is ripe for collecting?

CD: Some of that we've learned through trial and error. Like anything, it's easy if you happen to have that wiring and skill set and natural power of observation. You have to be a fairly detailed observer to see differences. And a lot of it is really tactile: You can read about it until you're blue in the face, but "papery"? You don't know papery until you touch papery. The big display plants at the nursery have been really great for teaching people to collect seed because they can handle it, feel it.

SR: What happens to the seed after you've collected it?

CD: After a collecting trip, which can take three to seven hours, we enter the information in the database and decide what to do with the seeds. With seeds from fleshy fruits that need to be stratified, my thing is to clean them and get them into that medium as soon as possible. If you can't, it's just like cuttings: You put them in the fridge overnight and then deal with them the next day, as soon as possible. Things that sit in plastic bags just mold, and you've wasted your time. Dealing with the fleshy fruits is the hardest thing when you come back tired from a day of collecting. Dry fruits are no big deal: You just file them for sowing later.

Dara Emery's book [*Seed Propagation of California Native Plants*, 1988] is my bible for seed treatments. He's never steered me wrong.

Janice Bray

Charli Danielsen and Gregg Weber on a seed collecting trip at Wildcat Canyon Regional Park

Some seeds like to be sown immediately; they respond really well. And some seeds like a little resting period before they're sown. I have been following the biodynamic calendar's recommendations for days to work with plants, as well as the old Farmer's Almanac principle of sowing on the waxing moon. We've had excellent results. Sometimes the seedlings are up before the moon is full, although there are other seedlings that don't come up at all.

The bulk of the sowing happens in November through February. Now [early April, when our interview took place] it's time to start collecting again. My birthday's at the end of April, and my first collection is usually the week of my birthday. We collect the bulk of the seed in May through October. So between sowing and collecting, we only get to take March off!

SR: Is there anything else you've discovered or learned about growing plants from seed?

CD: Yes: I've quit appreciating flowers! While others are appreciating flowers, I'm thinking it's a little too early because the seeds haven't yet formed.

Native Here Nursery is located at 101 Golf Course Drive in Tilden Regional Park in the Berkeley Hills. Each year Native Here holds a weekend-long Plant Fair; this year it will take place on October 3 and 4. For regular hours of operation and more information about the nursery and the Plant Fair, visit nativeherenursery.org.

Sue Rosenthal is a longtime volunteer for the Botanic Garden and the California Native Plant Society as well as a research editor for Bay Nature.

A New Statewide Long-term Seed Banking Project *by Bart O'Brien*

In the face of global climate change, inexorable population growth, and the loss of intact, fully functional ecosystems, it should come as no surprise that increasing numbers of conservationists and scientists are acknowledging the desirability of long-term seed banks of genetically representative samples of plant populations. Such collections serve as backup insurance for the wild populations from which they were harvested. Should a wild population that had been seed-banked disappear, the banked seeds could be used to regenerate that lost population if, or when, conditions become more favorable. If there are no long-term genetically representative seed collections, once lost, a population could never be recovered.

Starting with Russian scientist Nikolai Vavilov's world-wide seed collections of wild-occurring food crops and their close relatives in the early 1900s, seed banks have been used to assist with the preservation of the genetic diversity of many of the world's most important food crops and their close relatives. It is, however, a comparably recent development that long-term seed banks have been employed as a viable conservation tool for the preservation of wild land plants that have little to no known economic value. Some of these seed banks have captured the imagination of the public as the popular press weaves thought-provoking tales: a frozen seed storage vault on Svalbard Island off northernmost Norway for the world's crop plants; the Millennium Seed Bank Partnership (located in West Sussex and coordinated by the Royal Botanic Gardens, Kew, England), with a goal to bank 25% of the world's flora, especially the world's most threatened and useful plants, by the year 2020.

www.viralnova.com/

Svalbard Global Seed Vault

Though modest in comparison, our California seed banking efforts continue to be at the cutting edge. The earliest of these is the long-range seed germination experiment set up by Dr. Fritz Went and Dr. Philip Munz in 1947 and scheduled to run for 360 years—ending in the year 2307! Due to its long-term nature, this experiment was turned over to the National Center for Genetic Resources Preservation in Fort Collins, Colorado (NCGRP) and is still going strong. Many seeds were germinated from its most recent "grow-out".

Perhaps the newest and most comprehensive effort to seed-bank California's flora is the California Plant Rescue (CaPR) project. CaPR is a statewide coordinated effort to gather genetically representative seed collections from plant populations throughout the state as well as from northwestern Baja California, Mexico. The initial participant organizations of the CaPR project include: the California Native Plant Society, the California Natural Diversity Data Base, the Center for Plant Conservation, the Rancho Santa Ana Botanic Garden, the Regional Parks Botanic Garden, the San Diego Botanic Garden, the San Diego Zoo, the Santa Barbara Botanic Garden, the University of California Botanical Garden, the University of California Davis Arboretum and Public Garden, and the University of California Santa Cruz Arboretum.

These long-term seed collections will be housed in secure seed banks for conservation and research purposes. Currently, the majority of California's wild land plant species are being held in a small number of long-term seed banks: the Rancho Santa Ana Botanic Garden, the Santa Barbara Botanic Garden, the San Diego Zoo Institute for Conservation Research, the University of California Botanical Garden, the University of Cali-

John Macdonald

Tricolored gilia (*Gilia tricolor*)

fornia, Santa Cruz Arboretum, the National Center for Genetic Resources Preservation in Fort Collins, Colorado, and the Rae Selling Berry Seed Bank in Portland, Oregon.

What do we mean by long-term? L-O-N-G! Seeds stored at very low temperatures can be stored nearly indefinitely. However, the seeds are still respiring and will eventually use up their stored resources and then die. This is why these long-term conservation collections are closely monitored with subsamples being pulled from the collection and subjected to periodic germination trials. Once the seeds in germination trials begin to exhibit loss of vitality, the collection must be germinated, grown to maturity, and the new seeds harvested, cleaned, tested, and placed back in long-term storage.

How does one go about collecting genetically representative seed collections? Studies indicate that one can capture the vast majority of the genetic diversity in a plant population by collecting seeds from about 50 individuals and keeping the seeds from individual plants separate from one another. Collecting from additional individuals in the population is nearly always desirable. One normally collects no more than 10% of the seeds available on a particular individual, to avoid adversely affecting the genetic diversity of that plant population.

California is ahead of the curve on long-term seed banking of wild species. The CaPR project will bring greater focus on such collections and plans on immediately working on banking some of the rarer and more threatened species populations (as opposed to plant species that are already listed by governmental agencies) as these plants and populations typically do not garner as much attention. Watch for more information about CaPR and seed banking activities in the not too distant future.

R. C. Johnson

Packages of native North American accessions in cold storage at the Western Regional Plant Introduction Station

Royal Botanic Garden Kew

At the Millennium Seed Bank at Wakehurst Place, the seeds must pass a series of stringent tests.

FINAL MANZANITA FOR 2015

This year we broke with tradition and devoted our annual resources for *Manzanita* to producing two issues—the 75th Anniversary Edition and this issue on Seeds. *Manzanita* will return to our quarterly format in 2016, so look for your next issue at the beginning of next year. —*Manzanita Editorial Group*

Friends of the
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REGIONAL PARKS Foundation
Supporting East Bay Regional Parks

East Bay Regional Park District

FALL PLANT SALE – OCTOBER 3, 2015

The fall plant sale is held at the Garden on the first Saturday in October, from 10 a.m. to 3 p.m. (Friends members only from 9 to 10 a.m.) The fall sale offers the full range of California native plants, but specially features manzanitas (*Arctostaphylos* spp.), California wild lilacs (*Ceanothus* spp.), buckwheats (*Eriogonum* spp.), sages (*Salvia* spp.) and a wide array of subshrubs, shrubs, and trees that, for optimal success, are best planted in the fall.