BOTANY NEWSLETTER JANUARY 2015

Upcoming Events
January Meeting – Jan 12, 10am – Speaker Tom Spinks
February Meeting - February 9 – Speaker TBD
Botany Certification Classes – Starting January 5 – Contact Judy Ramierez
Plant Walks – Contact Karin Vickars

January General Meeting – Tom Spinks, "Petrified Woods of the Anza-Borrego Desert"

Walnut, laurel, ash, avocado and palm trees were common a few million years ago in the Anza-Borrego desert. On January 12, Botany Society members and guests will learn about how some of these plants became petrified. Tom Spinks, a State Park Paleontology Society volunteer who is studying the curation of fossil plant materials, will reveal how the fossils are identified in his talk about the "Petrified Woods of the Anza-Borrego Desert." Between 2.5 and 4 million years ago, the climate was quite different from what it is today, and supported populations of camels, horses, sloths, mastodons and other animals. Their fossils and those of the plants are among the survivors.

The presentation will start at 10 a.m. in the Anza-Borrego Desert State Park Visitor Center at 200 Palm Canyon Drive in Borrego Springs. The public is invited, and there is no admission charge. Spinks, a retired public service economist, has a Master's degree from the University of Minnesota Department of Agricultural and Applied Economics.

PLANT WALK LEADERS NEEDED!

Share our unique desert plant world with visitors and friends of Anza Borrego Desert State Park – and raise needed funds for such projects as the Herbarium and Visitor Center Garden.

Ample opportunity for practice will be offered in the latter part of January, before extra leaders are needed in February and March for the much-awaited flowers. If you are a beginner, you will be paired with a more experienced walk leader, so you won't be on your own.

To participate in this important educational and fund-raising program, or for further information, please contact me, Karin Vickars, by e-mail: karinvickars@hotmail.com

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Botany Certification Course by Judy Ramirez, Environmental Services Intern
Preparations are underway for the 2015 Botany Certification Course that begins on January 5. Over the past two years we have been assembling a team of instructors and mentors that now includes 13 individuals who generously contribute their time and expertise to the course. Botany Society volunteers are an essential part of this team: Kate Harper will lead sessions on plant adaptations and plant communities, as well as an all-day field trip in the San Felipe Watershed. Arie Korporaal has been an incredibly valuable influence with his insistence on hands-on observation activities in the classroom, and he will also lead sessions on the geology of our desert and how that affects where which plants grow. Mike Bigelow, Marilyn Dickson, Mac McNair, and Don Rideout have each taken on the task of presenting a PowerPoint about one of our featured plant families.

For fieldwork, the class is broken into small groups, and this year for the first time we have formalized a team of volunteers serving as small group leaders. Members are Kathy Bussey, Marilyn Dickson, Paul Larson, Mac McNair, Julie Taylor, and Karin Vickars. This group has depth, not only in terms of numbers, but also of knowledge about our desert flora. The team will meet before each fieldwork session to size up the site, create a plant list, and go over the material to be covered by the class.

It's not too late to register by emailing me at judy.ramirez@parks.ca.gov.

Herbarium News by Judy Ramirez, Environmental Services Intern
Volunteers have also been busy in the herbarium. The Colorado Desert District has over 1,000 specimens from the distant past, which we call our "historic collection." In addition, we have received duplicate specimens from the San Diego Natural History

Museum that were collected by desert parabotanists and processed by the Museum. These number in the thousands and they are still arriving. Undaunted, our volunteers glue these specimens to special mounting sheets and add identifying information, a process called mounting and accessioning specimens. Before filing these specimens there is another crucially important step: checking each one to see if there has been a name change. Specimen mounters this fall include Kathy Bussey, Martha Ellul, Laura Webb, Ruth Ehly, and Mary Jo Churchwell. In addition to mounting specimens, Ruth does all the accessioning and any repairs needed. Mary Jo checks for name changes, making notations on the specimen sheets when necessary. Since April 2014, 316 specimens have been mounted, and accessioned. Since we began in 2013, 1,290 specimens have been mounted and 1,703 specimens, which include specimens previously mounted, have been accessioned.

Martha Ellul mounting a specimen in the Botany Lab.

Kathy Bussey (with backpack) guiding a small group as they complete field observations.

FALL FESTIVAL REPORT by Don Rideout

Our sixth annual Fall Botany Festival was another success. Featured speaker Greg Rubin shared some great secrets about what works and doesn't work with native plants in the garden. The plant sale was our best ever, raising about $1,100 after all costs were covered. Living Desert Museum donated some great rarities, including Desert Holly (*Atriplex hymenelytra,* rarely seen in the garden) and Mecca aster (*Xylorhiza cognata,* a close cousin to our local Orcutt's aster). Other great specimens included the non-native Baja Ocotillo (*Fouquieria diguetii*). We sold some plants so fast on Friday that we started taking follow-up orders from people who were not able to get everything they wanted. That has boosted our total profits by an additional $300.

Thanks go to everyone who helped, especially with the plant sale. For next year, I'm looking for an assistant or two to help with buying and picking up plants, and who might be interested in taking over the Fall Festival some time down the line. If you are interested, please get in touch with me at don@rideouts.net.

SECOND SEASON of the ABDSP BOTANY STUDY GROUP
By Joanne Ingwall, Botany Study Group Leader

In 2014, twenty-nine certified Botany Society members participated in a self-directed series of 12 classes designed to expand our knowledge of botany and make us better able to fulfill our mission. The specific goals of the Botany Study Group are to study selected topics in depth and to study topics not covered in the Botany Certification Course so as to improve our ability to educate the public on desert plant walks, document changes in the flora of the ABDSP and serve as early warning sentries for invasive plants in the ABDSP and its immediate environs. Classes were 2.5 to 4 hours long every Monday in November, December and April, bracketing the Botany Curriculum taught January-March. Members both researched and led the discussions.

Using over a dozen botany textbooks and monographs, books such as *Gathering the Desert* by Gary Paul Nabhan, videos from the Coursera on-line class *What a Plant Knows*, and field trips as learning tools, we have studied:

- the properties of fruits, roots and stems;
- tropisms or how plants interact with their environment;
- transpiration and how water moves up a tree;
- plant toxins;
- the community of invasive species now in the Borrego Valley; and
- the characteristics and ethnobotany of the following plants and plant families:
    - Agavaceae (Agave);
    - Arecaceae (Palm);
    - Asclepias (Milkweed);
    - Cucurbitaceae (Coyote Melon);
    - Euphorbiaceae (Chamaesyce);
    - Fabaceae, subfamily Mimosoideae; genus *Prosopis* (Mesquite);
    - Fagaceae (Oak);
    - Fouquieriaceae (Ocotillo);
    - Larrea tridentata (Creosote);
    - Simmondsiaceae (Jojoba);
    - Solonaceae (nightshade plants).

As you can see from the photo, our discussions have been enjoyable as well as educational!

Book Review – Wildflowers of Orange County and the Santa Ana Mountains by Robert L. Allen and Fred M. Roberts. Reviewed by Don Rideout

Those who were at our December General Meeting heard Fred Roberts discuss the various species of oaks native to our region. Afterwards he sold copies of this somewhat misnamed book. While there are lots of references to locations in Orange County, the plant descriptions are applicable to a much larger swath of cismontane southern California. While desert plants are mentioned, the focus is species of the coast, foothills and mountains.

The real strength of the book is in the species descriptions. While some books give very brief and cryptic discussion of a plant's characteristics, this book provides a nicely detailed account in full words and sentences. Excellent photos are accompanied in some cases by line drawings to illustrate flower structure. Occasional tables compare the features of closely related taxa, such as the Plagiobothrys (popcorn flowers). Highly informative sidebars describe ecological relationships between plants and animals. For example, three entire pages are devoted to insects and birds associated with cacti. Where photos of the fruit or other minute features are important diagnostically, these

are included. Photos of dissected flowers and fruit are also provided. In summary, this is a complete reference book for the southern California native plant lover.

Sahara Mustard Weed Eradication Task Force
Minutes from a recent task force meeting are available on the Botany website via this link. Included with the minutes is a BioControl Program Proposal.

New Newsletter Editors
Don and Sheila Rideout have stepped up to be the new Newsletter editors, taking the place of Toni Alexander who is presumably now collaring lions in the Seregetti. You may also notice that you are receiving the newsletter in a slightly different form. Instead of getting the newsletter as an email attachment, you will be receiving an email with a link in it. Clicking on the link will take you to the Botany Society's web page where the newsletter will be published. We are always looking for articles of interest and notices for coming events that we can include in the newsletter. If you have something to contribute, please email it to don@rideouts.net.

Include by link only

Sahara Mustard Weed Eradication Task Force

Minutes of Meeting 12/11/14

Present: Sam Webb, chair; Frank Harris, ABDNHA; Joe Hopkins, ABDSP; Dick Walker, self; Mike Bigelow, Botany Society; Ashley Kvitek, ABF; Danny McCamish, OWSVRA; Chris McDonald, UCCE; and Susan Gilliland, De Anza, TCDC.

The meeting was called to order by Chair Sam Webb at 1:05 p.m. The March minutes were approved as written.

Sam asked for Sahara Mustard reports. Ashley said ABF has joined the State Park in the eradicating the mustard by establishing the second Saturday of the month from 8 a.m. to noon for volunteers to gather to attack the weed. The location of the pulling will be announced at each session.

Danny announced that the off-road State Park has found scattered Sahara Mustard plants in the washes, and has pulled about 10 pounds in the last two weeks.

Dick Walker reported that he has submitted a new proposal to Republic Services for another season of free dumping the pulled mustards and is awaiting approval. He does not anticipate a problem. The free access to the landfill would start February 1 and up to the middle of May. He also wants to check to make sure that the original seasonal limit of 350 bags is still in effect.

Susan has already seen Sahara Mustard at DeAnza this year, which is heavily watered on the golf course and is where the mustard mainly grows. She added that the growth, going back to October, is not anywhere near what was present last year. She also joined the Tubb Canyon Conservancy Board this year, and will be working with the AmeriCorps team one day a week this year.

Susan said this year's arrival of the AmeriCorps weed warriors, acting in concert with ABF, is scheduled for January 15. They plan to stay until March 30. While their main mission is to get rid of Sahara Mustard, they are prepared to aid the park wherever needed. They will have two days off a week, and work three days with the State Park and two days for the Tubb Canyon conservancy group. Susan also said that David Garmon has sent the Task Force a copy of a new Tubb Canyon project involving a DNA analysis of the mustard to determine just where the plant originated, making it possible for the first time to establish an enhanced ability to locate effective biological agents aimed at reducing the threat of Sahara Mustard in desert ecosystems in the American Southwest. (A copy of the report is appended to these minutes.)

Ashley announced that ABF has joined the State Park in weeding invasives this season, and has had two sessions already. Volunteers will be directed to pull the mustard and/or any other invasive that needs attention. The sessions will be on the second Saturday each month from 8 a.m. to noon. Sam pointed out that the Task Force has an extensive list of volunteers who are willing to pull invasives, and will provide it to ABF, and in addition will send out an email message to people on the list advising them that ABF will be staging the work sessions if they are available on the designated Saturdays. She said if the park needs more help with invasives, ABF will add another day's work session. Sam asked if ABF is using a liability waiver form, and Ashley said yes, a one-day waiver plan that is much simpler than the lengthy form that was used in

past years and discouraged some volunteers from joining the work crews.

In more news from ABF, Ashley said two conservation ecology grants of $1,500 each have been awarded to graduate students Daniel Winkler and Sarah O'Neill. Sarah is from UC-Riverside, and Daniel is from UC-Irvine. Both are PhD candidates, and they will do research on the Sahara Mustard.

Sam also brought up recent discussion regarding whether the Task Force should become attached to the Tubb Canyon conservancy group or whether it should continue to stand alone as a clearing house for information on the mustard and other invasives campaign. He asked for opinions, and got three recommendations for an independent policy. Sam said he was of the same opinion and asked for a vote to that effect. The proposal got a motion, a second and then won approval.

Chris asked about the long-term future of the Task Force and whether we should do some pro-active planning to avoid a situation in which a new invasion catches us off-guard and way behind from the start.

Sam agreed to put the topic on the agenda for the next meeting at which we could have a major discussion.

Chris also observed that the Sahara Mustard has been beaten back by 3 hard years of drought, and warned that the upcoming season is critical to the effort to keep the plant on the defensive. If we are not vigorous in stamping out the plant wherever we find it, it could gain new life during a season of our assuming that the plant cannot reverse its tumble toward demise. One year of some rain combined with a failure of vigilance could launch a re-invigoration of the pest, he said.

At this point, he added, the region has not had enough rain to get the mustard going again. But he said Culp Valley is now full of greenery, and he suspects that the mustard could erupt there this season. The desert floor is dry, but nevertheless the plant could gain a foothold in the washes, where even light rains can produce germination of both the invasive mustards and native wildflowers. In such circumstances, the easiest and best tool for weeding is the Hula hoe into February. Using the hoe means mustard warriors don't have to do a lot of bending over to pull individual plants, he pointed out. From germination to seed, he said, takes 60 to 90 days, and that leaves considerable time for attack projects that don't involve bagging.

To get a blanket coverage, you might need up to a full inch of rain, he added. With a full inch of moisture, the plant could roar right back. Wildflowers need at least a full inch of rain to encourage germination, he said.

Frank asked what the mustard is doing in Arizona. Chris responded that he has seen it spreading to areas where neither he nor others have seen it before. Up Highway 15 it is moving toward Las Vegas. In Southern Arizona, it is everywhere, he reported. It's also in Phoenix, Havasu, Yuma and Parker as well. As far as the wider region is concerned, it is from the California coast into Texas. The northern extent is Southern Colorado and Utah. The southern extent is somewhere in Baja and to central Mexico.

He's found it in the Santa Barbara area, and there is a new population in the Sacramento area. In the regional area, it does not appear that it is moving too much. It does not seem to be heading toward northern Colorado because it does not do well in the Rocky Mountains. Chris said he noticed an odd behavior where last year where the mustards that grew kept their seeds, failing to release them. He mentioned areas like Riverside, Temecula and Murrieta. So far, he said he has been unable to find the reason for this behavior. The Sahara Mustard likes cooler weather, and in crucial areas like our desert it can germinate anywhere from October to 'Marchish'. That is the time period to really stay alert, he said. If you press a mustard stalk and get only a tiny bit of milk, the

plant is probably not very viable. But if you get another one where the seed pods are getting a little brown, he said, that one can be a real threat, and the blossoms and seeds need to be bagged.

Ants eat the mustard seeds, he said, but prefer the native plant seeds if they can find them. The seeds are round and move around easily because of their shape and also with the winds. When they get wet, they stick to everything, enhancing the travel factor.

Sam said in 2005, a year after a big fire in 2004, he saw a noticeable increase in mustard plants. Chris said it had been in this area for decades, and most people had just not regarded it yet as a threat. He added that the newly regarded threat, the invasive Canary Island Knapweed (*Volutaria canariensis*) will require a close watch. It is only known to exist in the Canary Islands and Borrego Valley, he said, and suggested that we have stepped into a Black Hole. It may have a dark future in Borrego, he said, but on the other hand, it may not ever become a threat like the Sahara Mustard. The problem is, he added, is that we won the lottery—unfortunately.

Minutes Submitted by Mike Bigelow

Biocontrol Proposal

Seeking Biocontrols to Enable a Long-term Solution for Sahara Mustard (*Brassica tournefortii*) Invasion in North American Deserts

2014 March 27

J. David Garmon, MD, Carl Bell,
Travis E. Huxman, Ph.D., Jon P. Rebman, Ph.D.,
Robert L. Staehle, Lori L. Paul, RVT

The estimated damage from invasive species worldwide totals more than $1.4 trillion – 5% of the global economy. — The Nature Conservancy

Sahara mustard (*Brassica tournefortii*) is rapidly decimating North American deserts in the United States and Mexico by entirely replacing native wildflowers and vegetation, including creosote and cactus, with dense fields of mustard. This invader is highly adaptable and resilient, allowing it to swiftly expand its range through aggressive survival strategies. Sahara mustard first arrived in the United States in the 1920's (documented by J. B. Feudge, #1660, RSA, Feb. 1927) presumably as a contaminant with date palms imported from the Middle East into California's Coachella Valley.

Since 1997, Sahara mustard's expansion has dramatically accelerated, gaining a chokehold on once-vibrant wildflower fields in the Anza Borrego Desert and other regions of the greater Mojave and Sonoran Deserts. While hand-pulling and close surveillance has gained the upper hand against this invasion in limited areas such as Tubb Canyon (near the town of Borrego Springs, California), an effective biocontrol method is required to produce a long-term solution. We propose to take the first definitive steps toward

effective biocontrol of this pernicious species.

Sahara mustard exhibits phased germination (not all seeds present in a single location will germinate at the same time), allowing it to get a head start on shading out native seedlings and to take advantage of intermittent optimal weather for seedling growth. Sahara mustard "steals" subsurface water from adjacent plants through a very deep, carrot-like taproot while its leaves are shaped to direct rainfall towards its central core and away from plants under its leaves or around its perimeter.

Individual Sahara mustard plants quickly produce flowers and myriad seedpods. Even when uprooted and left on the ground the fleshy taproot can continue to nourish the plant and complete its life cycle, producing thousands of seeds in just a few weeks. A large mustard plant can produce over 16,000 seeds, each with a sticky, mucilaginous surface. Seeds are dispersed via wind (often after the parent plant dies and becomes a far-ranging tumbleweed) and by adherence to wildlife (including bird feet and feathers), human footwear, and vehicle tires; thus enabling unintended transport of Sahara mustard seeds to new locations.

Few animals eat Sahara mustard, and none in large quantities due to its high oxalic acid content and the tiny, stiff urticating hairs on stems and broad leaves. Conversely, many desert natives are browsed by both vertebrates and insects, including voracious caterpillars during periodic mass irruption cycles. As a consequence, type conversion of native flora to a monoculture of Sahara mustard results in a desert "silent spring" where the diversity of wildlife is drastically reduced -- from insects, amphibians and reptiles to small and large land mammals, songbirds (including quails), and even raptors -- with many native species completely extirpated due to loss of either forage or forage-dependent prey.

Loss of spectacular desert wildflowers, iconic desert wildlife, and scenic vistas to Sahara mustard threatens the economic survival of communities that derive significant income from tourism.

Unfortunately, because this invasive species had been present at low densities in desert washes for decades (since at least 1927) without significant ecological damage, and because Sahara mustard was not a direct threat to agricultural crops, no immediate action was taken when a devastating change seems to have occurred around 1997, reportedly in Riverside County, California. Suddenly, Sahara mustard began exploding beyond isolated washes and rapidly began moving deep into native desert vegetation, often radiating out from roadsides and popular trails. It also began appearing at higher locations on hillsides and among boulder fields where the plant had not been previously observed.

Park agencies and other desert landowners sounded an alarm about Sahara mustard's

dramatic expansion around 2003, but lacked adequate funds and dedicated staff for a swift response to this impending natural disaster. Insufficient research and belated direct action did little to slow, much less halt, the ever-expanding encroachment of Sahara mustard into fragile desert ecosystems. This lack of response grew critical by the mid-2000s when Sahara mustard began taking over pristine wildflower fields and popular recreational destinations. See the 2008 (before) and 2010 (after) photos, taken in Anza-Borrego Desert State Park.

Control of Sahara mustard with herbicides is possible in limited situations, but not over the vast expanses this weed now inhabits in fragile desert ecosystems, ranging from the Torrey Pines of coastal California to the deserts of west Texas, from Utah to central Mexico. In a desperate holding action initiated by Tubb Canyon Desert Conservancy (TCDC) in 2011 in collaboration with AmeriCorps, Anza Borrego Desert State Park, the Anza Borrego Foundation, and other partners, Sahara mustard has been largely eliminated from a few accessible sectors of desert by intensive hand-removal of maturing mustard plants, followed by careful surveillance. However successful on a small scale, this labor-intensive approach will not in the long run win the war against this foreign invader.

Sahara Mustard has become an ecological disaster across the entire desert Southwest—from the coast of California to the deserts of west Texas, from Utah into central Mexico. What options remain?

Biocontrol

Biological control programs have proven to be an effective method that can reduce or eliminate populations of ecologically and agriculturally harmful invasive species. While manual methods of removing Sahara mustard have proven effective in relatively small, well-defined areas, human-power and herbicides are insufficient to halt, or even slow, the extent, or the current rate, of destruction of native desert ecosystems by Sahara mustard. *The only realistic hope of reversing the progress of Sahara mustard in the United States at this point in the invasion lies in discovering the biological agents that keep this species in check in its native habitat*. Sahara mustard remains in balance within its native range that extends from southern Europe and North Africa into the near East.

In spite of notable failures involving poorly planned release of biological control agents (the introduction of giant cane toads in Australia and mongooses to Hawai'i come to mind), biological control of highly destructive invasive species, when properly researched and carefully applied, have been very successful.

In the case of invasive plants, the track record is very good of getting control of the weed without coincident damage to native and useful (i.e. crops, landscape ornamentals) plants. For example, alligator weed (*Alternanthera philoxeroides*) from South America was introduced into North American bogs and waterways where it quickly formed impenetrable, spreading mats of growth in streams and lakes that prevented light penetration and reduced oxygenation, killing native aquatic plants, fishes and other aquatic species. Alligator weed also provided ideal habitat for breeding mosquitoes and clogged irrigation and flood control facilities. In an early, 1963 biocontrol program, the alligator weed flea beetle (*Agasicles hygrophila*) was released in Florida, and brought this invasive weed's population under control. Because of this success, and subsequent organisms released that feed on alligator weed, Florida was able to ban the use of highly toxic herbicides that had formerly been used to control alligator weed only three years after the flea beetles had been introduced.

[http://www.sms.si.edu/IRLSpec/Agasicles_hygrophila.htm]

Highly invasive species like Sahara mustard (*Brassica tournefortii*) for which herbicides are not a viable option and which are "immune" to native control factors in an introduced environment, are extremely challenging to control and unlikely to be totally eradicated by stop-gap measures such as hand-pulling. Furthermore, the longer the control of this foreign plant is delayed, the greater the loss of habitat and the larger the possibility of reaching a "tipping point" where ecological catastrophe results and native biodiversity is overwhelmed. Sahara mustard's rapid takeover of native desert plant regimes, including annual wildflowers fields, in both low and high deserts, drives an urgent need to identify effective biocontrol agent(s). In order to find useful biocontrol agent(s) in the shortest possible time, detailed DNA analyses of Sahara mustard populations in both the United States and in the species' native range (Saharan Africa and the Middle East) are required as soon as possible.

Carpe DNA

Advances in DNA sequencing over the last two decades have fundamentally changed the process of locating biocontrol agents for invasive species. Current technology provides an unprecedented opportunity to pinpoint exactly where in its vast native habitat the Sahara mustard now spreading across North American deserts originated, thereby enhancing our ability to thoroughly search in that region for effective biological agents that will reduce the threat of Sahara mustard to our desert ecosystems.

Prior to the application of DNA sequencing, the process of looking for biocontrol agents was little more than trial and error, often under haphazard conditions in the field. Researchers would search the native range of an invasive species, which could cover tens of thousands of square miles and contain many populations of a particularthat speciess, in hopes of locating a biological agent that appeared to be keeping some populations of the invasive species in check. It would then take years to test the newly found biological agent(s) against the invasive species found in the non-native location. If a found agent was not effective against the particular populationvariant of the invasive species, it was back into the field to repeat the entire expensive and lengthy process over, and possibly over, again.

The obvious downside to this hit-and-miss approach is that, unless one is very lucky, it can take many years of expensive searching and testing to find a biological agent that is effective against a specific population strain of an invasive plant, particularly if that invasive species has a native range covering millions of square miles, or if the species has been altered by human intervention. If one is not lucky (and how often does the marble land in Red 36 on the roulette table?), this process could take decades to find an effective biologic agent. In the case of Sahara mustard, that is likely to be decades too late.

DNA sequencing has brought a laser-like focus to what was until very recently a trial and error process. Using DNA sequencing, it is now possible to pinpoint the specific, genetically identifiable population variant that the invasive species came from, and therefore its specific geographic origin, which provides a targeted location for biocontrol searches.

The modern process begins with a Phase I genetic analysis of hundreds of samples of the invasive species from the non-native habitat, i.e., the place where it is causing habitat destruction, such as the Southwestern United States. This genetic analysis produces a

number of critically important pieces of information, the first being to establish the level of homogeneity in the invasive population. Homogeneity refers to the genetic similarity of all the plants being tested. If the tested plants are identical in their genetic sequence, they are said to be homogenous and therefore are all descended from a common origin.

Another possible finding from the DNA sequencing of Phase I is that the invasive plants may represent two or more populations of the same plant species but with different geographic origins. Each population of plants would be homogenous within itself but genetically distinct from its close relatives. The implication here is that the invasive species was introduced to the non-native range on more than one occasion and from more than one point of origin.

Phase II of this process begins in much the same way as Phase I, except that this time the DNA being sequenced is from plants in the native range, such as Europe or North Africa. If the native range is vast, as is the case with Sahara mustard, we would expect to find subtle, yet distinct, genetic differences among the populations of Sahara mustard throughout its native range. This is to say that Sahara mustard found in Afghanistan, for example, would be the same species of plant as the Sahara mustard found in Tunisia; but we would be able to now genetically distinguish these two populations of the single Sahara mustard species. Depending upon the size of the native range and the number of plants sequenced, we could expect to see dozens of genetically distinct populations of plants that we would be able to map to specific geographic locations.

This leads us now to the power and specificity of modern DNA sequencing. *Armed with the results of the genetic sequencing of the invasive plant conducted in Phase I, we can now compare that genetic sequence to the specific DNA sequences of the populations in their natural habitat from Phase II. When we match the genetic sequence from the invasive plants with the genetic sequence from one or more of the native plant populations we will then be able to pinpoint the geographic origin of "our" type of Sahara mustard. Given that information, we will then know exactly where to look for biocontrol agents.* No more guessing, no more trial and error, no more botanical roulette.

Cost-effective DNA Sequencing

Twenty years ago the cost of a comprehensive botanical DNA investigation would have been prohibitive. However, the process of DNA sequencing that was once on the cutting edge of science has become automated, routine, and inexpensive. *The sequencing of one plant sample that once would have cost thousands of dollars and hours of a researcher's time can now be done for less than $10.*

Testing

Once biological agents that control Sahara mustard in its native habitat are identified, there is an elaborate protocol that has been used for decades to test an agent's effectiveness in the laboratory and in the field. An equally important aspect of this testing is to assure that the discovered biocontrol agents do not "misbehave" if released in a new environment such as the deserts of the Southwestern United States and arid northern Mexico. This latter aspect

of testing will be particularly important in the case of Sahara mustard because of its close genetic relationship to a number of commercial crops, notably kales, cabbages, Brussels sprouts, broccoli, and cauliflowers.

Action

We propose work in three phases over three years. This work will represent the first steps toward finding and implementing an effective biocontrol method to stop the aggressive spread of Sahara mustard and its consequent destruction of vulnerable, beautiful, and economically important native desert habitat.

Phase I (2014 June through 2015 May)

1. Perform DNA sequencing ("destructive sampling") of Sahara mustard already collected, and housed in herbaria, from the current geographic range of Sahara mustard across the desert Southwest of the United States.
2. Acquire and analyze new samples of recent mustard growth in the Anza Borrego Desert and surrounding areas, which have been the subject of recent study and selective hand removal.
3. Determine the genetic homogeneity / diversity of the invasive population(s), thereby revealing whether Sahara mustard in North America originates from one source location in the plant's native range, or several. We will also be able to determine what degree of hybridization among populations has occurred among this invasive mustard?

Work to be performed by: University of California, Irvine and affiliated laboratories under the direction of Travis E. Huxman, Ph.D., Director, Center for Environmental Biology, UC Irvine and Director or the Steele/Burnand Anza-Borrego Desert Research Center.

Results to be published in scientific literature and online in a format useful to land stewardship agencies (parkland managers), universities, botanical organizations and research institutions, including State/Federal academic agricultural extensions.

Estimated cost: $60,000

Phase II (2014 September through 2015 July)

1. Ascertain the locations and contacts for overseas herbaria with collections of Sahara mustard from its native range upon which DNA sequencing can be performed.
2. To the extent needed to fill probable gaps in existing overseas collections, acquire new samples (direct field collection) from native Sahara mustard populations in as many locations as possible.
3. Perform genetic analysis in alignment with analysis performed in Phase I, Steps 1 & 2.
4. Correlate results in Phase I, Step 3 with Phase II, Step 3 to determine geographic range and site(s) of origin for the invasive mustard populations found in the Southwest United States and northern Mexico.

Work to be performed by: USDA-ARS- European Biological Control Laboratory, Montpellier, France under the direction of Marie-Claude Bon, Ph.D.

Results to be published in scientific literature and online in a format useful to land stewardship agencies (parkland managers), universities, botanical organizations and research institutions, including State/ Federal academic agricultural extensions.

Estimated cost: $60,000

Phase III (2015 August – ~2018)

1. Create a biocontrol testing, introduction, and implementation plan based on results of Phases I and II.
2. Laboratory and sequestered field testing per an approved plan.
3. Introduction based on an approved plan and changes in the plan based on the results of testing and regulatory approvals.
4. Implementation based on above that will reduce Sahara mustard under field conditions.

Work to be performed in association with: USDA-ARS Exotic and Invasive Weeds Research, Albany, CA, and/or CA Department of Food and Agriculture Biological Control Program.

Land stewardship agencies: US Fish and Wildlife Service, US Bureau of Land Management, US Bureau of Reclamation, CA Department of Parks and Recreation, CA Department of Fish and Wildlife.

Appropriate regulatory bodies: CA Department of Food and Agriculture, US Fish and Wildlife Service, CA Department of Fish and Wildlife.

Costs and funding sources for Phase III will be estimated based on results of the two prior Phases.

Costs and parties affected by *not* taking action will be estimated based on observed progress of the Sahara mustard invasion and type conversion, associated environmental damages and adverse impacts on affected communities (including recreational parklands), and comparison with similar invasive species impacts in other ecosystems.

For further information, contact:

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