UCSC Arboretum California Native Plant Conservation Garden

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Report prepared by Josephine Lesage with feedback from Gage Dayton, Brett Hall, Karen Holl, Kathleen Kay, and Martin Quigley. Funding for report preparation was provided by the Ray Collett Trust.

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Brief History of the California Native Plant Conservation Garden

The University of California, Santa Cruz (UCSC) Arboretum is home to several thematic gardens which display plants native to the Mediterranean climate regions of Australia, New Zealand, South Africa, and California. Since the Arboretum's inception, California native plants have been an important focus of the collections. The California Native Plant Conservation Garden (CNCG), located to the northwest of the other Arboretum collections between Moore Creek and the Great Meadow, is home to over 55 acres of planted and naturally occurring California plant species. This garden includes an impressive collection of maritime chaparral shrubs, native conifer species, and native coastal prairie wildflowers and bulbs. The mission of the CNCG is to provide ex-situ conservation of native California plant species and serve as an educational and research resource to the campus and community.

The 55 acres of land have been home to the CNCG since the 1960s, although the garden's management has changed slightly over time. Since the late 1970s, the land on which the CNCG resides has been recognized as being jointly managed by the UC Campus Natural Reserves and the UCSC Arboretum; however, the vast majority of the land, except the region in close proximity to Moore Creek, has been managed entirely by Arboretum staff. In 2015, Arboretum and UCSC Campus Natural Reserve Staff signed an MOU that specifies academic, research, and management objectives and responsibilities for the area (MOU 2015). The MOU acknowledges and supports the use of the land as the CNCG to house and display native California plants, in an effort to further both organizations' goals of research, conservation, and education.

In addition to changes in management, the CNCG's layout and structure have been modified over time. In the early 2000s, the Arboretum developed its first master plan for the CNCG based on the foundational work done in the previous decades that organized the garden by geographic regions and their habitats (Hall and Harder 2004). In 2012, the CNCG plan was revised to reflect achievements made and new goals after almost a decade of work (Hall 2012). In the scope of these master planning documents, the garden was to host collections from a diversity of habitat types from the North and Central coast of California, as well as some from the interior Klamath range (Hall and Harder 2004, Hall 2012). Collection decisions were based on the guiding themes of "conservation, restoration ecology, evolution and biogeography, education and training, research, natural history interpretation, and aesthetic garden design" (Hall 2012). Budget constraints and other challenges have prevented the CNCG from reaching the full scope of the original plan, but hard work has been put into developing regions in a focused manner. Currently, efforts have shifted to focus on conserving species, lineages and rare communities through ex-situ conservation, although many of the original planned habitat types and locations are the same.

The purpose of this document is to record specific recommendations for the future development of the CNCG, based on synthesized information from past documents and interviews with key individuals. Additionally, this document will provide a brief summary of a survey to UCSC faculty about their current and potential use of the CNCG (Appendix A), the results of data compiled regarding undergraduate engagement in the Arboretum's activities in the recent past (Appendix B), and a timeline of recommended objectives (Appendix C).

Information Gathering

To prepare the recommendations made in this document, graduate student Josephine Lesage interviewed key staff and volunteers at the Arboretum, faculty in the Ecology and

Evolutionary Biology and Environmental Studies departments, the UCSC Environmental Studies Internship Office, UCSC Campus Natural Reserves Staff, and members of the CNCG advisory committee. To understand faculty awareness of the CNCG and potential avenues of collaboration, Josephine surveyed ten UCSC faculty who were likely to work with native plants or teach about native plants. Recommendations regarding Arboretum and CNCG interns were made based on discussions with the Environmental Studies Internship Office and the UCSC Campus Natural Reserves Staff (who regularly supervise large volumes of interns). In addition to these interviews, she reviewed historical documents related to the CNCG, including prior master plans, grant applications, and MOUs. The recommendations presented in this document are based on recurrent themes that appeared throughout her conversations.

A draft of this plan was reviewed and discussed by the CNCG advisory committee including Gage Dayton, Brett Hall, Karen Holl, Kathleen Kay, and Martin Quigley in February 2016. Based on this and other individual discussions with committee members, Josephine revised the report and it was again reviewed and the recommendations endorsed by the CNCG advisory committee in March 2016. The report uses “we” when making recommendations, as the recommendations have been reviewed and endorsed by the CNCG advisory committee.

Recommendations

The CNCG has the potential to become a well-integrated and engaging part of the UCSC Arboretum for both the academic community and general public. However, a number of concrete steps must be taken to document the plants currently on display in the garden, to increase visitor access and awareness, and to make improvements to garden infrastructure. The recommendations listed below are the highest priority objectives for the coming 1-2 years based on discussions with Arboretum staff and others during interviews. A suggested timeline for completing specific objectives is listed in appendix C and detailed in an associated spreadsheet that can be reviewed and updated quarterly by Arboretum staff.

Documentation and Record-Keeping

Specimen accession and collections inventory

For the CNCG to be a valued conservation tool for rare species and to be of use to research scientists who may be interested in working with the garden, the specimens within the garden must be inventoried, collections information must be digitized, and this information should be made accessible online to interested parties. A 2015 report by consultant Tony Morosco goes into great depth regarding the current status of Arboretum collections records, and should be referred to for additional specific recommendations (Morosco 2015).

Brett Hall, with the help of Arboretum staff, interns, and consultant Tony Morosco, has begun the digitization and inventorying process within the CNCG. Based on recommendations made in the 2015 collections report, efforts are underway to enter specimen information, for both seeds and inventoried plants, into a user-friendly database (Plant Information Records System; PIRS). The CNCG database team is in the process of entering many handwritten records of collections, plantings, and seeds that were not in the database yet, and garden beds which have not been inventoried in the recent past are being checked. This process will allow Arboretum staff to develop accurate maps of plant beds for interested researchers and Arboretum guests. When the CNCG accessions database update and inventorying process is complete, we recommend that the Arboretum make information about collections available online. Surveyed faculty indicated that online plant/seed lists that include relevant information (such as source

location, number of specimens available, etc.) would increase their interest in working with the CNCG on future research projects. We recommend that the plant database be made accessible online by September 2016, or as soon as feasibly possible following the database update.

In addition to the digital information-tracking, physical accession tags and identification labels on plants in the field will improve future inventorying efforts. Tony Morosco is hopeful that tagging all specimens in the Arboretum can be completed in the coming two years, though the efforts for specific priority garden areas and beds in the CNCG could be completed in the next six months. We recommend that the Arboretum focus on inventorying and tagging plants and communities that would be of the greatest interest to faculty and researchers first (for list of plants of interest, see appendix B). Furthermore, the complete labelling and mapping of a focal area of the CNCG would serve as an exemplar for Arboretum visitors and potential funders.

Goal-keeping and budgeting

There have been several broad prior plans for the CNCG. Initial plans in the late 70s through the early 1990s laid the groundwork for the garden, but it wasn't until 2004 that a master plan was written based on these foundational pieces (Hayes 1990, Hall and Harder 2004). This master plan was last revised in 2012 (Hall 2012).

In the last 20 years, extensive work has been done by students and Arboretum staff to improve and manage the CNCG. However, these efforts have not been entirely documented, resulting a poor record of what goals have been achieved. Setting specific short-term objectives and completing them within a specific time frame will keep a directional focus in place as the garden develops. Furthermore, keeping records of progress towards objectives will improve the Arboretum's ability to show concrete improvements in the CNCG when requesting funding, bolstering support for future projects. We recommend that the CNCG director make regular, quarterly records of goals and progress made towards objectives in the garden (see appendix C). In addition to recording progress towards goals, it is important for the CNCG director to keep track of acquisitions, maintenance, and other costs in a budget spreadsheet on a regular basis to fairly and equitably distribute funds within the CNCG and Arboretum as a whole. This will also help with developing budgets when fundraising and writing project proposals.

In addition to short-term goal-keeping, we recommend that a broader, structural plan for the future development of the garden be written. In some past instances, living plant specimens have died or become overgrown in the greenhouse because there was no planned space for them in the CNCG. Therefore, additions to the garden should be planned and thought should be given to where in the garden specimens will eventually be placed, though there should also be some space and funds available for important opportunistic conservation work when it arises. We recommend that the CNCG director write a plan for additions over the next five years by March 2017.

Website

While the Arboretum boasts a beautiful and well-developed website, pages dedicated to the CNCG and research access are lacking. We recommend that the Arboretum develop web pages that provide information about the CNCG for both a lay audience and potential researchers, as well as a contact page for researchers. A page for the lay audience should at minimum include a map of the CNCG, a brief description of the habitats represented in the garden, and highlight specific plants of interest. A webpage describing CNCG as it relates to available research space and a brief list of seed and plant materials available can be published in

concert with the online database of specimens described above. Faculty have indicated that there is no clear mechanism for inquiring about potential research projects and resources, not only within the CNCG, but throughout the Arboretum. Therefore, we recommend a separate webpage dedicated to a description of research resources at the Arboretum, expectation of research conducted at the Arboretum, and contact information for research requests. We recommend these webpages be published by the end of June 2016.

Tracking student internships

Student internships are a critical part of the Arboretum's volunteer workforce. There are often more than ten student interns working at the Arboretum during any given academic quarter, including within the CNCG. Despite the large volume of interns who work with the Arboretum and CNCG, there has been little documentation of intern data. Past student intern data and internship projects based on records kept by the Environmental Studies Department Internship Office are described in appendix B. Without information about interns and how they value their time at the Arboretum, it is difficult to quantify the degree to which the Arboretum is successful in increasing environmental stewardship, sparking student interest in horticulture, and/or properly training students in propagation and care techniques. We recommend that the Arboretum keep track of intern statistics and opinions using pre- and post-internship surveys. Pre-internship surveys should capture information about student majors, college affiliation, whether they are returning interns, etc. Post-internship surveys should be anonymous, and ask about student satisfaction with their internship and what new skills they learned. In addition to surveys of interns, we recommend that the Arboretum ask Environmental Studies interns to anonymously submit their internship reflection papers. Environmental Studies interns are required to write these brief reflections to get credit for their internship, and anonymously submitted reflections could inform staff about potential ways to improve the internship program.

We recommend that the Arboretum develop and implement surveys, as well as begin requesting internship reflections from interns by June 2016. We also recommend that the CNCG director write a short annual report each September detailing the number of internships, results of the anonymous surveys, and senior theses that were produced that year. This document can then be used as a basis for making funding requests to further support the internship program. In addition to keeping records of interns and their experiences, we suggest that the CNCG director develop a list of potential projects for senior thesis and motivated internship students. An initial list of potential projects is included in appendix B.

In addition to tracking intern information, the Arboretum should attempt to increase the diversity of their intern community. Interviews with the advisory committee and the internship office suggested that most interns in the past have been Environmental Studies students, and that the advertisement of Arboretum internships does not reach a diverse pool of students. We recommend that the Arboretum increase efforts to develop a diverse intern community by advertising around campus, and targeting advertisements in colleges that cater to traditionally under-represented student demographics or are centered on themes of diversity, social justice, and inclusion (such as Oakes College, Merrill College, College Nine, and College Ten).

Finally, we recommend that CNCG Director Brett Hall work with multiple interns in two to four 3-4 hour shifts each week to minimize his time supervising while maximizing the number of interns working in the CNCG. Large volumes of interns can be difficult to supervise, as the majority of student interns are initially untrained in Arboretum practices, and must be trained over their ten-week internship. Training and supervising interns in groups is a more efficient way

to coordinate work so that supervisors can spend more time on other tasks.

CNCG Infrastructure

Signage

The creation of specimen tags and directional signage are both near-term goals for the CNCG. As described above, efforts are underway to accession and label all plants in the field. Directional signage is being produced using the Arboretum's newly acquired laser engraver. Ideally, directional signage will be in place to guide visitors through the Laurasian forest and towards the maritime chaparral section of the CNCG by September 2016 as permanent pathways and/or trails are developed.

Interpretive signage should also be developed and placed in the focal area of the CNCG by September 2016, if funding permits. Already, two UCSC 'Collective Museum' interpretive signs have been installed in the CNCG, describing the relationship between the plants in the garden and the Amah-Mutsun Tribal Band, and a sign commemorating Ken Norris is in place at his memorial bench. Additional interpretive displays are desirable to educate visitors and spark interest in the garden.

Arboretum GIS, pathways, and updating the arboretum map

In 2002, the Arboretum began a Geographic Information System (GIS) project to map all paths, plant beds, pipes, roads, and buildings throughout the gardens. This GIS mapping effort has been continued to the current day, resulting in a robust GIS for both the CNCG and Arboretum as a whole. Currently, the CNCG is working to develop a GIS of collections sources throughout California, which will allow interested persons to create maps that reflect the vast geographic diversity of species represented by the CNCG.

Because visitor awareness and access to the CNCG is of crucial importance, an updated map of the Arboretum is also a high priority. We recommend that the Arboretum work with the Center for Integrated Spatial Research (CISR) on the UCSC campus to continue their mapping efforts. CISR owns a highly accurate Trimble GPS unit and the proprietary software required to download and convert the data for use in a Geographic Information System. A temporary map should be developed by June 2016, but this map will need to be updated as more permanent paths are put in place. We recommend a finalized map of the CNCG be developed and distributed as soon as paths are finalized, ideally by March 2017.

There is currently no well-labeled, visitor-friendly pathway that leads from the main visitor hub of the Arboretum (the Horticulture II building) to the CNCG. A pathway along the reservoir and out to the CNCG is a long-term goal, but a temporary pathway along the main access road will suffice in the interim for visitors who wish to see the CNCG. This path will lead visitors by the trash bins and storage/staging areas at the back of the parking lot. To increase the aesthetic value and accessibility of this temporary path, the Arboretum should focus on improving the appearance of this storage area by September 2016. Furthermore, we recommend that wayfinding signage be placed by September 2016 to guide visitors to the CNCG.

Irrigation

In June 2015, an Arboretum-wide irrigation plan was developed, including a well-developed GIS component which mapped current and future faucets and pipes. As noted in this plan, a large portion of the CNCG does not have permanent irrigation, and some of the irrigation system in other parts of the CNCG needs maintenance. Several Arboretum staff have identified

the lack of an irrigation network into the far reaches of the garden to be problematic and faculty member Ingrid Parker identified irrigated plots as an important resource for conducting future experiment research projects in the CNCG. There are plans to expand and improve the permanent irrigation in the CNCG, and we recommend that the CNCG director draft a CNCG-specific irrigation plan based on the currently existing Arboretum-wide plan by June 2016.

Fencing

A deer fence should be established around the entire CNCG in order to ensure the exclosure of deer which threaten the survival of plants within the garden. In the past, efforts have been made to fence the CNCG, but the fences have not been permanent or attractive for garden visitors. Future fencing efforts should follow CEQA procedures and the expectations laid out in the campus long-range development plan. In interviews, the primary concerns about the deer fence were the impediment of wildlife movement, potential viewshed impacts, and the cost of implementation and maintenance.

To answer the problem of wildlife movement, we recommend that the Arboretum work with Environmental Studies faculty Chris Wilmers' Lab to continue to determine wildlife movement and the potential impacts of the desired fencing on non-nuisance species (such as coyotes, foxes, pumas, and small mammals). Brett Hall has worked in the past two years to track wildlife movement using trail cameras, and an analysis of the data provided by these cameras could provide an interesting senior thesis topic for an interested student.

We recommend that a draft plan and budget for the fencing be completed by June 2016.

Research space

Several of the interviewed faculty requested space for small scale field experiments with irrigation at the Arboretum. Such an area could be especially useful for undergraduate senior thesis projects. We recommend that the Arboretum set aside a small region of the 55 acre CNCG for potential manipulative field studies.

Future objectives

The focus of this assessment was the near-term (1-2 year) priorities and recommendations discussed above. A number of additional goals for the CNCG have been suggested in prior planning reports by the CNCG advisory committee and require further discussion and prioritization. Some of these are listed briefly below.

A long-stated priority of the CNCG is to increase conservation efforts through seed-banking and specimen collection in a well-planned manner. Future additions to the garden should be carefully selected with consideration given to the current direction, plan and layout of the garden, which species are in need of ex-situ conservation, and what species are most desirable for teaching and research purposes. The CNCG should continue to be involved in the efforts of the California Plant Rescue (CaPR) Network by aiding with CaPR's seed banking efforts, particularly if funding for these efforts is provided through the CaPR network.

The Arboretum and CNCG should also continue to work with the Amah-Mutsun Tribal Band to develop areas of culturally significant plants to aid in their ethnobotanical relearning. These efforts should be coordinated with the rest of the CNCG program.

The Arboretum and CNCG should continue to develop and strengthen its relationships with organizations like the California Native Plant Society, California Native Grasslands Association, and others by aiding with their projects when resources allow, and hosting

workshops. The CNCG advisory committee feels that current efforts should focus on the native plant and seed collections at the Arboretum before undertaking extensive off-site habitat monitoring efforts.

An important overarching recommendation for the CNCG is to continue acquiring its own funding. The CNCG covers nearly half of the area managed by the Arboretum, although much of it is still under-developed. As the CNCG becomes more visited and established, the Arboretum will need to find revenue sources to support these regions. Endowments specific to the CNCG and grants for specific projects would allow the CNCG to implement many of the costly improvements recommended (such as the deer fence, interpretive displays, and improvements to the irrigation system).

Appendices

Appendix A. Summary of faculty surveys

To investigate faculty awareness of the CNCG and potential avenues of future collaboration between faculty and the Arboretum, graduate student Josephine Lesage surveyed ten faculty who were likely to work with native communities at the Arboretum (Laurel Fox, Greg Gilbert, Karen Holl, Kathleen Kay, Michael Loik, Flora Lu, Bruce Lyon, Ingrid Parker, Jarmila Pitterman, and John Thompson). All ten faculty members responded to the survey.

Eight faculty had already worked with the Arboretum for either research or teaching purposes in the past, and all faculty surveyed indicated that they were aware of the existence of the CNCG, suggesting that awareness is not the primary block to collaboration between faculty and the CNCG.

Six of the faculty surveyed indicated that they worked with native California plants and/or communities. The faculty who work with native plants indicated the following communities and taxonomic groups as primary research interests: chaparral, including maritime (Fox, Holl); coastal grasslands and prairie (Fox, Holl, Parker), sand hill habitat (Fox), coastal scrub (Holl); Saxifragacaeae (Thompson); mixed evergreen forest (Gilbert, Parker); *Clarkia*, *Lasthenia*, and *Monardella* (Kay); and ferns (Pitterman). While only six faculty work with native species directly, nine indicated that their graduate students work with native species and communities. In addition to the communities listed above, graduate students work with the following species and communities: serpentine-adapted species, Brassicaeae, and Joshua trees. Nine out of ten faculty indicated that they teach about native plants and communities in their classes, though several indicated that California natives were not an extensive or important aspect of their classes. Despite the large number of faculty who work with and teach about native California plants, only three faculty members had worked directly with the CNCG, indicating that faculty engagement and interaction could be greatly increased.

In order to understand how the faculty might utilize the CNCG in the future, faculty were asked to identify ways in which the CNCG could facilitate their research and teaching, and how to improve their interaction with the CNCG. The most requested feature, an accessible map and species list of plants/seeds in the CNCG collection, has been included in the recommended objectives listed above. In addition to an accessible species list, faculty desired a web page outlining the spaces and services available to them, as well as the responsibilities of those interested in performing research at the Arboretum, also included in the recommendations above.

Appendix B. History of recent Arboretum internships

Only the interns who enroll for credit through the Environmental Studies Department are documented in this appendix. Interns who do not register with the Environmental Studies Department are not included in the information below.

The UCSC Arboretum has a history of providing internship and research opportunities to UCSC undergraduates. Internships train students in plant propagation and care techniques, and senior thesis students are offered space and materials to perform independent research projects. These activities fall directly under the Arboretum's mission to educate and inspire stewardship in undergraduates.

There are several ways through which undergraduate students can participate in Arboretum activities: 2-unit internships, 5-unit internships, paid internships, and by completing senior theses/projects. 2-unit and 5-unit interns typically work with garden curators to weed and maintain gardens, propagate plants, and plant them in the field. Paid positions are occasionally offered to experienced interns who show leadership qualities and are knowledgeable about the plants and techniques required in the garden.

In the last five years, there have been 140 total interns who have worked at the Arboretum and received credit through the Environmental Studies Department, with as many as 25 interns registered in a single quarter. Senior project students are students who typically work with a faculty member and the UCSC Arboretum over a minimum of two quarters on a focused project. In the past, these projects have included reports on the ethnobotany of native California plant species (Guiliano 2002, Vayssières 2010, Murdock Murrlogh 2008), an examination of lichens at the Arboretum (Murray 2009), and several projects about *Dudleya* species (Glenn-Hall 2004, Angelo 2004, Boehnke 2011). Students have also produced reports on plant propagation and cultivar selection (McCown 2008, Schmidt 2010) and specific regions of the garden (Hyman 2009, Lovinger 2010, Glascock 2015).

In the recommended objectives above, we suggest that the CNCG director develop a list of potential senior thesis and internship projects that would benefit the CNCG. To begin, we have identified the following potential projects:

1. Cataloguing and creating a searchable database of all Arboretum and CNCG documents, including past senior theses, permits, and other relevant student documents.
2. Aiding in the creation of more detailed a searchable database and plant list for the CNCG than currently exists (including information about flower color, edibility, etc. See Morosco 2015 for the value of detailed databases).
3. Mapping the GPS coordinates of individual plant specimens so that it can be made available to visitors and researchers. This project would be a good fit for a student who is taking advanced GIS coursework.
4. Creating audio or pamphlet trail guides for the CNCG on a theme of interest
5. Investigating the movement of wildlife through the Arboretum to better understand how a deer fence would affect movement of wildlife locally, with the advice of Chris Wilmers' Lab.

Appendix C. Proposed timeline of objectives

Three Months (to be completed by end of June 2016)

1. Update the Arboretum website.
    a. Create a website page that includes information about available resources for interested researchers and faculty. The page should also include a contact form for interested researchers and faculty to fill and submit, as well as general contact information in case of questions.
    b. Create a website page for the CNCG explaining where the garden is located, how visitors can access it, and highlighting some of the plants in the collection.
2. Student internships
    a. Create google forms to track student intern information. 'Entry' forms should capture intern year, major, and how they learned about the internship program. 'Exit' forms should be anonymous, and should capture information about intern experiences over the course of a quarter.
3. Irrigation
    a. Draft a brief plan of incremental increases to irrigation network based on master plan that is already in place.
4. Fencing
    a. Draft a rough plan for the cost and requirements of fencing the CNCG.
5. Mapping
    a. Update the Arboretum GIS with new paths.
6. Fiscal and planning
    a. Write a budget plan for the 2017-2018 fiscal year of expected expenses.
    b. Generate a base list of plants that are expected to be collected and propagated in the coming year, as well as any planned collecting trips that are expected to be made. Include information about the gardens these collections will be geared for.
    c. Implement Arboretum-wide best practices for management of *Phytopthera* with the help of other Arboretum staff.

Six Months (to be completed by end of September 2016)

1. Faculty engagement
    a. Make plant lists/database information available online to faculty (preferably though Arboretum website).
    b. Email relevant faculty with information about database, website, and available resources to perform research with the Arboretum.
2. Visitor Experience
    a. Develop high quality interpretive signage for the CNCG with text and graphics a few of the most developed beds.
    b. If funding permits, purchase materials to print and place signage in the garden. This objective may need to be pushed back if funds are limited.
3. Internships
    a. Internship surveys are functional and fully implemented with incoming interns.
4. Pathways
    a. Clear pathways to maritime chaparral region
    b. Place wayfinding/directional signage to guide visitors in CNCG
    c. Clear or improve the appearance of brush and piles in the back gate area

5. Mapping
    a. Continue to update the Arboretum GIS with new paths and collections locations
    b. Update Arboretum map and prepare draft visitor-use map

One Year (to be completed by end of March 2017)

1. Planning documents
    a. Write a long-term planning document detailing focal points for coming year. Generate list of garden sections to be improved/developed, as well as species lists for potential collections trips.
2. Mapping
    a. Finalize the CNCG map, and distribute map to visitors alongside the current map.
3. Faculty engagement
    a. Designate space for experimental field research plots, and begin discussions with potentially interested faculty members to begin planning research.

Recurring objectives

1. Every three months: update the to-do list and narrative to reflect actions taken and new goals
2. Annually between June and September (at the discretion of the Arboretum director): write fiscal planning/budgeting document for the CNPG expected expenses for the following fiscal year which can inform the overall annual fiscal budgeting plan
3. Annually in September: write a report detailing internship program participation and achievements in the CNCG. Update the list of potential senior thesis and 5-unit intern projects which could be completed.

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