Chicago Botanic Garden

2016 Operating Plan

Plant Science and Conservation

The Garden's plant biology and conservation science programs will discover critically important knowledge and create practical land and water management tools and solutions to address environmental challenges facing society. These programs focus on appropriately managing plant populations and plant and soil communities, especially within human-impacted landscapes. Scientists will undertake rigorous research studies that address key biological questions that have plant conservation applications and advance the frontiers of basic science. The Garden will make a unique contribution to solving ecological problems by integrating theoretical research, applied solutions, and adaptive management to save individual species as well as communities of species at varying geographic scales.

Goal	Objectives	Deliverables
1. Discoveries resulting from research by Garden scientists and students, and enhanced conservation resources such as the Seed Bank, will demonstrably stem the loss of plant diversity and lay the foundation for healthy ecosystems. Garden scientists will be able to measure and articulate how their work has succeeded in addressing some of the most pressing threats to plants, including climate change, invasive species, habitat fragmentation, and pollution.	1.1 Conduct research to address the world's most pressing threats to biodiversity, including habitat loss, conversion, and fragmentation; climate change; invasive species; inappropriate plant harvest; and nutrient loading.	Identify species that would benefit from being included in restoration efforts, but that aren't currently used because seeds aren't available, and conduct research on one species (Cirsium hilliii) as a model species to assess approaches for producing appropriate seeds for restoration (White, Kramer, Fant).
		Identify and test the ability of "native winner" species to improve restoration outcomes in highly degraded landscapes, including species with greater competitive ability against invasive species like cheatgrass (Kramer, Foxx and Havens).
		Use data on past restoration activities and outcomes to inform future restoration efforts in the Colorado Plateau (Kramer, Still, Talkington).
		Investigate the role of living collections in plant conservation (Havens, Wood).
		Develop and disseminate software to enable researchers to manage, visualize, and analyze flowering phenology datasets for populations (Wagenius).
		Develop decision support tools to mitigate invasive species on USFWS refuges in Region 3. Invasive species being targeted include those in both native prairie and forested ecosystems (Jacobi and Hunt).
		Investigate reproductive decline in rare and vulnerable species: Use demographic, genetic, and pollinator data to guide restoration of vulnerable species. Includes mixed seed sourcing for Cirsium hillii (Kramer, Fant and White), hand pollination in Platanthera leucophaea (Ellwanger, Fant) and potential for population augmentation of Asclepias lanuginosa in NE Illinois (Fant) and Lepidospartum burgessii in New Mexico (Williams, Fant, Havens) to improve reproduction in, and viability of, native populations.
		Develop database to manage Integrated Crop Pollinator Project data (Jacobi).
		Identify how breeding systems and preferred pollinator influence the likelihood of inbreeding depression being expressed in different species of Onagraceae (Cisternas-Fuentes, Fant, Skogen).
		Landscapes of linalool: scent-mediated diversification of flowers and moths across western North America. This project integrates chemical ecology and comparative genomics to explore the impact of past selective pressures on current patterns of diversity in non-model organisms: evening primroses, hawkmoths, bees, and micromoths. (Skogen, Fant, Wickett, Overson and Jogesh).
		Investigate the role of pollinator foraging distance, gene flow, and floral traits in bee- and hawkmoth-pollinated Oenothera species (Onagraceae) (Lewis, Skogen, Fant).
		Investigate the role of pollinators in promoting floral diversity, including investigate fluctuating role of bumblebee and moth pollination in Castilleja sessiliflor, a locally rare species (Fant, Skogen); identify consequence and causes of flower color shift (red to yellow) in Castilleja coccinea (Fant, Skogen, Braum); and role of pollinators in speciation in coastal Californian Castilleja complex (Fant, Skogen, Widener).
		Continue demographic monitoring of Cirsium pitcheri in Wisconsin populations impacted by two biocontrol weevils (Havens, Vitt).
		Identify local plant communities that have potential to persist on green roofs, with aim of recreating these communities and the ecological services on green roofs (Ksiazek, Skogen, Fant).

	Test the effects of phylogenetic diversity on restoration outcomes in tallgrass prairie, with collaborators from University of Minnesota, the Morton Arboretum, University of Wisconsin-Eau Claire, and University of Toronto-Scarborough (Williams and Jacobi).
	Enhance simulation model of migratory waterbirds and their intereactions with the landscape (Jacobi).
	Continue study on climate-change effects on native species germination (Havens, Kramer and Finch).
	Continue documenting and cataloging litter and soil mites, springtails, and spiders in an oak woodland restoration to further scientific knowledge concerning these important components of ecosystem services and function (Steffen and Palincsar).
	Continue long-term research projects on Echinacea angustifolia (Wagenius), Cirsium hillii (Fant), and Lespedeza leptostachya, and determine the effects of introduced bison on rare plant demography at the Nachusa Grasslands (Vitt and Havens).
	Develop ITS primers for Illumina sequencing of fungi sensu lato, and apply to multiyear analyses of decomposer fungal communities (Egerton-Warburton, Morgan, Ross).
	Investigate the effects of climate change in a tropical dry seasonal forest. Install rainfall intercept devices and catalog the effects of reduced rainfall on above and belowground systems (Egerton-Warburton).
	Investigate water acquisition and redistribution by evergreen trees in dry seasonal tropical forests (Egerton-Warburton).
	Document the consequences of buckthorn removal and restoration on the belowground biota in forests and savannas (Egerton-Warburton, Hevey, Umek).
1.2 Become a national center of excellence for plant conservation practice, including seed banking, DNA banking, plant documentation, and monitoring.	Continue national coordination of the Seeds of Success Program in partnership with the Bureau of Land Management (Haidet, Havens).
	Collaborate with Seeds of Success to bank the flora of the tallgrass prairie region. Continue collecting activities and add new collections for targeted species to increase genetic diversity (Vitt, Yates, Sollenberger, Rosenbaum).
	Undertake an analysis of the current collections of the Dixon National Tallgrass Prairie Seed Bank to determine their overall phylogenetic diversity (Vitt, Jacobi, Sollenberger and Yates).
	Contribute to ravine conservation and restoration through collaborative projects with the Alliance for the Great Lakes and Openlands, with focus on enhancing the resilience of these unique ecosystems to a changing climate (Goad).
	Maintain the spatially explicit Research Collections database for the DNA, Herbarium, and Seed Bank collections utilizing the Conservation GIS Laboratory (Vitt, Rosenbaum and Yates).
	Maintain and update field data forms for the Research Collections vouchers for use with Trimble Juno hand-held GPS devices utilizing the Conservation GIS Laboratory (Vitt and Yates).
	Continue and enhance the volunteer-assisted rare plant monitoring program, Plants of Concern. Incorporate external consultant review of monitoring protocols and data to effectively assess climate change; export POC program to other parts of the region. (Goad, Vitt).
	Maintain the Garden's collection of 500,000 aquatic plants along 4.5 miles of lakeshore gardens associated with U.S. EPA/Illinois EPA “Section 319” shorelines, Evening Island, Great Basin, Spider Island, the Elizabeth Hubert Malott Japanese Garden, and the North Lake (Nagle and Kirschner).
	Continue to expand the current DNA bank, and continue to add new accessions from living collections, seed bank and older collections of rare species (Rosenbaum, Fant).
	Add at least 500 sheets to the Nancy Poole Rich Herbarium collection (a 3 percent increase).

		Add at least 500 new magnified images of seed collections in the seed vault to the Seed Bank image archive and process these images for inclusion in the web-based Research Collections Database (Yates, Sollenberger).
	1.3 Develop and apply appropriate restoration and maintenance activities to maintain the ecological, research, educational, and aesthetic values of the Garden's natural areas, including the Garden Lakes, McDonald Woods, Dixon Prairie, and the Skokie River Corridor.	Continue monitoring and assessment programs to assess the effectiveness of the Garden's suite of 50-plus shoreline restoration techniques; share results with professional colleagues via presentations and journal/newsletter manuscripts; initiate research into the use of biocontrols for several invasive species in the Garden's lakes, including Eurasian watermilfoil (Myriophyllum spicatum) and zebra mussels (Dreissena polymorpha); utilize the aquatic tanks in the new Production Nursery to rear the watermilfoil weevil (Euhrychiopsis lecontei) (Kirschner).
		Continue maintenance and management efforts to support recently planted shrubs, trees, lakeshore herbaceous plantings, and woodland/prairie areas that were previously seeded in the Barbara Brown Nature Reserve (Steffen).
		Expand control efforts of invasive native species in McDonald Woods focusing on choke cherry (Prunus virginiana), common dewberry (Rubus flagellaris), gray dogwood (Cornus racemosa), wild grape (Vitis riparia), sugar maple (Acer saccharum), and tall goldenrod (Solidago altissima) (Steffen).
		Work to restore lost and declining fern populations in McDonald Woods through spore propagation and transplantation of broad beech fern and maiden hair fern (Steffen).
		Evaluate the use of herbicides to control invasive shrubs that re-sprout following controlled burning (Steffen).
		Continue efforts to establish and maintain native grasses and expand diversity of plant species in the Dixon Prairie and along the Skokie River Corridor through mowing and burning, seeding, planting, adaptive management, and research projects (O'Shaughnessy).
		Continue and refine management activities, including prescribed burning, mowing, and invasive species control in the Dixon Prairie and the Skokie River Corridor with particular foci on crown vetch (Coronilla vicia), birdsfoot trefoil (Lotus corniculatus), purple loosestrife (Lythrum salicaria), reed canary grass (Phalaris arundinacea), seaside goldenrod (Solidago sempervirens, and new or expanding species including common reed (Phragmites australis), leafy spurge (Euphorbia esula), common St. Johnswort (Hupericum perofatum), lesser celadine (Ranunculus ficaria), European buckthorn (Rhamnus cathartica and other weedy tree and shrub species), and common tansy (Tanacetum vulgare). Expand efforts to control aggressive native species, including sawtooth sunflower (Helianthus grosseserratus), tall goldenrod (Solidago altissima), rosinweed (Silphium integrifolium), and compass plant (Silphium laciniatum). Submit to the New Invaders Watch Program locations of species in the river and prairie that are on the program's plant list (O'Shaughnessy).
		Continue development of an oak savanna on the west slope of the Skokie River Corridor by replacing dead oaks included as part of the Wall and Berm's original landscape plan, as well as planting in areas opened up through removal of dead ash trees (O'Shaughnessy).
		Continue efforts to establish lake-edge plant communities at the northern and western edges of the lower pools of the Skokie River through removal of invasive plants and experimental planting of native species (O'Shaughnessy).
		Continue to advance research objectives in the ongoing management of the prairie and Skokie River Corridor related to invasive species control, floodplain native plant community establishment, and soil ecology and their relationship to grassland community development (O'Shaughnessy).
		Continue efforts to document and study instream habitats in the Skokie River (O'Shaughnessy).
		Continue efforts to remove/manage dead and dying ash trees resulting from the emerald ash borer in the McDonald Woods, the Barbara Brown Nature Reserve, the Lake Cook Road woodlands, and the Plant Science Center woodland; work to protect south perimeter fencing and eliminate dead tree hazards near pedestrian trails and roads (Steffen).

		Continue removal of buckthorn, privet, honeysuckle, and oriental bittersweet from last remaining eight acres of dense shrub-covered land in McDonald Woods and reseed with native species. Maintain the 60-plus acres of restored woodland habitat through exotic species removal and controlled burning (Steffen).
		Continue searching out new local genotype sources for new and existing woodland species for propagation of plants to amplify seed needed for restoration work in McDonald Woods (Steffen).
	1.4 Conduct research to address evolutionary history and relationships in plants and fungi.	Undertake analyses and publish 2-3 papers resulting from monographic work on Laccaria (Mueller, Wilson and collaborators).
		Continue and expand work on orchid mycorrhizas; publish data on vanilla associates and begin work on ghost orchid mycorrhizas (Mueller and Johnson).
		Compare mycorrhizal communities of pines in natural stands versus plantations (Mueller and Ning).
		Prepare a taxonomic revision of the breadfruit genus Artocarpus (Moraceae) (Zerega).
		Collaborate with international scientists to study the genetic diversity and origins of underutilized crops, including breadfruit (Artocarpus altilis), jackfruit (A. heterophyllus), cempedak (A. integer), and others (Zerega).
		Investigate pollination modes within Artocarpus,the breadfruit genus (Zerega, Gardner, international collaborators).
		Utilize genomic and transcriptomic tools to investigate the evolutionary history of the mulberry family (Moracea) (Zerega, Williams, Laricchia, Gardner).
		Investigate systematic relationships and biodiversity in the legume family Caesalpinioideae; collaborators at University of Montreal and Royal Botanic Gardens, Kew (Herendeen).
		Continue research on Mesozoic fossil plants, including Cretaceous age fossils from the eastern U.S. and Jurassic age fossils from England. Conduct exploratory fieldwork on other fossil localities; collaborators Yale University, Niigata University (Japan) (Herendeen).
		Study Early Cretaceous age fossil plants from Mongolia; collaborators Yale University, Niigata University (Japan) (Herendeen).
		Continue research on selected significant fossil legumes (Herendeen).
		Resolve the rapid radiation of pleurocarpous mosses using phylogenomic methods (Wickett and collaborators from University of Connecticut and Duke) and develop extensive resources for comparative genomics in early land plants.
		Evaluate the role of gene duplications and horizontal gene transfers from bacteria in the diversification (functional and species) of diatoms, and contrast these patterns with flowering plants (Wickett with collaborators from University of Arkansas).
		Continue research on genomic changes associated with parasitism in Orobanchaceae (Wickett and collaborators from Penn State, Virginia Tech, University of Virginia, and UC Davis).
		Use high throughput transcriptomics to resolve the backbone phylogeny of land plants (Wickett and collaborators from University of Georgia, University of Alberta, University of Arizona, University of Texas, and University of Florida).
		Reconstruct the phylogeny of early land plants using an expanded sampling of bryophyte chloroplast genomes (Wickett and collaborators from U of Conn).
		Resolve the diversity of ectomycorrhizal taxa in dry seasonal tropical forests using stable isotopes and sequencing (Egerton-Warburton).
2. The Garden will become the nation’s leading center for training the next generation of scientists, restoration ecologists, land managers, and policy makers focused on saving plants and plant communities. Its training programs will build national and international capacity in plant biology	2.1 Informal and continuing education	Offer, in partnership with BGCI and iDiv, a workshop on modern plant conservation methods. Target under-resourced countries in biodiverse regions (Havens).
		Increase outreach efforts on climate change by collaborating with the Garden's Education staff to analyze early data collection from Floral Report Card Gardens and modify programing if needed (Havens and Schwarz).

		Continue Project BudBurst, in collaboration with the National Ecological Observatory Network (NEON), as an outreach activity about climate change (Havens and Schwarz).
		Work with the Garden’s Education department as well as external partners to create new opportunities for sharing the Garden's knowledge on aquatic restoration and protection with school groups as well as adult audiences; aggressively seek out opportunities to publish and present on the Garden’s shoreline management experiences; add extensive plant labeling along the Garden’s restored lake shorelines (Kirschner).
		Teach at least five courses for the Joseph Regenstein, Jr. School of the Chicago Botanic Garden.
		Participate in outreach activities through World Environment Day.
		Inform and engage the public about research activities related to ecology and evolution in fragmented prairie habitat through social media through weekly blog posts and tweets during the academic year and more frequently during the summer (Wagenius).
		Collaborate with approximately 80 federal, state, and regional agencies and partners to offer the Plants of Concern training workshops and field mentoring to engage more than 200 citizen scientists in rare plant monitoring (Goad).
	2.2 Internships and undergraduate mentorship	Place 100-plus conservation interns on federal lands (funded by BLM, NPS, USFS, and USFWS); meet with federal and NGO organizations to assess interest in expansion of conservation internship program (Skogen, Havens).
		Offer 10 summer research internships in conservation science through the Research Experiences for Undergraduates (REU) in plant conservation and biology site program (Fant and Kramer).
		Offer summer field research internships to two undergraduate students, a high school student, and a high school biology teacher in west central Minnesota (Wagenius).
		Offer 3-week winter lab internships to two undergraduate students (Wagenius).
		Participate in the Associated Colleges of Illinois internship program, placing at least two interns with Garden scientists.
		Work with Education department to incorporate College and Science First, REU, ACI, CLM, and plant biology and conservation programs into an integrated Science Career Continuum for training in conservation science (Fant, Kramer, Skogen, Havens, Herendeen, et al.).
		Offer two internships in the Plants of Concern program (Goad).
		Provide scientific mentors for the College First and Science First Programs.
		Mentor research of current graduate students.
	2.3 Graduate student mentorship	Matriculate seven to eight new master's students and two Ph.D. students into plant biology and conservation program, and additional students as funding allows.
		Continue to offer new non-thesis track for master's degree program.
		Offer plant genomics course module as part of Biology 378 (Functional Genomics, Instructor: Wickett) at Northwestern University, with the opportunity for undergraduates to continue research as independent study.
		Work with an interdepartmental team to continue implementation of an invasive species policy for the Garden.

3. The Garden will provide rigorous, science-based information about plants and the natural world. Garden scientists will become the first choice of committees, institutions, and agencies worldwide, providing leadership in plant conservation and restoration policy and practice.	3.1 Serve on local, regional, national, and international boards and committees.	Serve on International Union for Conservation of Nature (IUCN) Species Survival Commission Steering Committee, Conservation Genetics Specialist Group, and chair the Mushroom, Bracket, and Puffball Specialist Groups; lead the global fungal red listing initiative; Plant Conservation Alliance; Botanic Gardens Conservation International-US; Chicago Wilderness' Executive Committee, Steering Committee, Science Team, Natural Resources Management Team, and task forces on aquatics, seeds and restoration, climate change, and invasive species; Mayor's Committee on Nature and Wildlife; Chicago Park District Advisory Committee for Nature Areas Management; FPCC Next Century Conservation Plan Nature Committee and Steering Committee; APGA Conservation Professional Section; Illinois TNC Science Advisory Committee; Council of International Fungal Conservation Society; Midewin Stakeholder's Alliance,\; Illinois Native Plant Society Governing Board, etc.
		Assist neighboring municipalities in their efforts to manage invasive species and promote the use of native plants; e.g., the Park District of Highland Park's ravine seed trial project and the Jens Jensen Park aquatic plantings as well as cooperation with the Friends of the Green Bay Trail (Steffen and Kirschner).
	3.2 Advocate for plants (and fungi) and their conservation at all levels of government.	Provide leadership for the Plant Conservation Alliance, participate in advocacy visits to elected officials and agencies.
		Serve on Natural Resources Commission of the City of Highland Park (Wagenius).
		Work to get more fungi included on the IUCN Global Red List and on various national red lists (Mueller and collaborators)
	3.3 Disseminate research results through publications and presentations.	Submit at least 30 manuscripts to professional journals or books, aiming for journals with high impact whenever possible.
		Publish at least 15 articles in the popular press.
		Present research results, organize symposia, participate in committee meetings, and/or moderate sessions at professional meetings.
4. The Garden's Department of Ornamental Plant Research will increase its ability to develop, evaluate, and release new horticultural plants. It will be known for its unique strength in improving the landscapes and gardens of the Midwestern United States and comparable climates; this includes expanding the planting options available for roof gardens and other emergent environmentally conscious gardens while respecting the ecological integrity of natural areas. The Garden will partner with nurseries around the world to introduce its plants, thereby generating significant earned income.	4.1 Advance the evaluation program's goal of assessing and recommending the best ornamental plants for Midwestern and comparable landscapes.	Promote the plant evaluation program and disseminate trial results in publications such as Plant Evaluation Notes and Fine Gardening, and through lectures, tours, and educational classes.
		Develop plans for new comparative trials in the full sun evaluation garden. Complete extensive removal of former evaluation plants from the south green roof and replace with new trial taxa. Plan new Evaluation/Collections collaborative trials of hardy gladiolas, perennial alliums, and tender salvias.
		Oversee the data collection and curation (inventory, planting, labeling, and image collection) of the 1,000 taxa in the evaluation program. Continue developing a master taxa list of previously untested plants for full sun and green roof trials, and compile the taxa list for inclusion in the new shade evaluation garden.
		Maintain agreements with national and international plant introduction programs to evaluate new and untested ornamental plants for the Midwest.
	4.2 Advance the plant breeding program's goal of developing new perennial plants for Midwestern gardens and comparable climates.	Oversee the horticultural maintenance, planting and propagation, and provide curation (labeling, inventory, data and image collection, data entry into database, etc.) of the current plant collection.
		Continue the breeding, propagation, and field evaluations of the current targeted genera, Aster, Phlox, Vernonia, and others.

		Enhance the germplasm base of the targeted genera, Aster, Phlox, Vernonia, and others.
		Initiate propagation or continue to propagate and distribute to the 125 licensed nurseries and four tissue culture labs any plants ready for nursery evaluation.
		Promote the 2016 introduction(s) and plan the promotion of the 2017 plant releases.
	4.3 Manage the Chicagoland Grows plant introduction program to increase its plant introductions and income.	Collect plant description data and develop cultivar names, then register new plants from the program with the appropriate trademark/plant patent/breeder's rights offices in the U.S., Canada, and Europe.
		Collect royalty payments and propagation and production data on the plants in the program from all the licensees.
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