

Write a Classifier: Zero-Shot Learning Using Purely Textual Descriptions

Supplementary Materials

Mohamed Elhoseiny, Babak Saleh and Ahmed Elgammal
Department of Computer Science, Rutgers University
[\[m.elhoseiny,babaks,elgammal@cs.rutgers.edu\]](mailto:m.elhoseiny,babaks,elgammal@cs.rutgers.edu)

This document presents four main points.

1. How the hyper-parameters were set?
2. Experiment to show the role of the constraints in the Quadratic Program
3. More results on the Birds and Flower Datasets
4. Sample textual descriptions for both the Flower and Birds datasets; we also attach two folders that contain the full textual description of all the classes for both datasets.

1. How the Hyper-parameters were set?

Our approach is based on learning two submodels. The first submodel is a regression function from the text features to the classifier space. The second submodel is a correlation function between the textual features and the visual features. Having learnt these two submodel, based on the information of the seen classes, Our approach predicts the classifier of the unseen class by solving a quadratic program that involves the regression and the correlation function. In this section we illustrate how the hyper parameters for each phase were selected.

1.1. Probabistic Regressor Hyper-parameters

GPR The hyper parameters of GPR ($\{\tau_i, \lambda_i\}$, $i = \{1, 2, \dots, D_T\}$) was learnt for each dimension i by maximizing the marginal likelihood of the data (i.e. the 80% of the classes in the dataset) for each dimension i indepenently, where k_i is the squared exponential kernel hyperparameter (i.e. $\tau_i(t_k, t_l) = \exp(-\tau_i \|t_k - t_l\|^2)$) and λ_i is the noise standard deviation for dimension i .

TGP Regression [1]. The hyper parameters of TGP are $\{\tau_{Ti}, \lambda_{ti}\}$, $\{\tau_{Ci}, \lambda_{ci}\}$ for textual space T and classifier space C respectively. Having contacted the authors of [1], we performed 5 fold cross validation and we selected the hyper-parameters by minimizing the sum of the optimized TGP cost function value over the validation set for each fold.

1.2. Correlation (Domain Transfer) Hyper-parameters

The optimization function that Learns W (Section 4.2 in the paper), involves l, u, λ as hyper parameters. l and u were set in our case to 2 and -2 respectively, as aforementioned in the paper. While, λ was selected through 5 fold cross validation so that W maximize the recall on the validation set.

1.3. Quadratic Program Hyper Parameter

In this stage, the following hyper-parameters were learnt on a fold of seen-unseen classes. In other words, Given a fold of unseen classes (i.e. 20% of the classes in the dataset), the remaining 80% of the classes were used for training and validation. In 5 fold cross validation setting, these 80% of the classes are splitted into 5 folds, in which 4 fold were used for training and 1 fold is used for validation.

The hyper parameters were learnt using 5 fold cross validation on the training classes. We tuned the hyper parameters by searching the hyper parameters on the following grid for each variable. $\alpha = 0, 2, 10, 100, 1000$, $\beta = 0, 2, 10, 100, 1000$,

$\gamma = \frac{1}{N_{tr}}, \frac{10}{N_{tr}}, \frac{100}{N_{tr}}$. For flower Dataset, the learnt hyper parameters were $\alpha = 10, \beta = 0, \gamma = \frac{10}{N_{tr}}$, For Birds Dataset the learnt hyper parameters were $\alpha = 10, \beta = 1, \gamma = \frac{10}{N_{tr}}$, It's observed here that there is no role for the probabilistic regressor for Flower dataset due to underfitting problem. However, in the case of Birds dataset, the TGP plays a role (i.e. $\alpha \neq 0$). The intuition behind that is Birds dataset has 200 classes while Flower dataset has 102 classes. This leads to better prediction in case of Birds dataset compared to Flower dataset.

We performed some experiments to see how α, β and γ affect the performance of the model. Table 1 shows some of these experiments performed on the 5th fold of the Birds Dataset. It is shown from the results that changing β and α hyper-parameter slightly affect the performance (i.e. maximum change is $\approx 3\%$ of the ROC AUC). This is due that both of regression and the correlation function gives good initial submodels because there is more classes for regression in Birds dataset.

β	α	$\gamma \cdot N_{tr}$	Average AUC
1000	1	10	0.6219
100	1	10	0.5897
10	10	10	0.5993
10	1	10	0.5990
1	1000	10	0.6034
1	100	10	0.6121
1	10	2	0.5959
1	10	10	0.5937

Table 1: Hyper-parameters-AUC on Birds dataset (5th Fold)

2. Role of the constraints in the Quadratic Program

In the paper we showed the result of an experiment to evaluate the effect of the constraint $-(\mathbf{c}^T \mathbf{x}_i) \geq \zeta_i$. Here we show the result of a similar experiment to show the effect of the constraints $\mathbf{t}_*^T \mathbf{W} \mathbf{c} \geq l$. We evaluated the optimization in Eq [2] without and with this constraint. The result on the flower dataset was reduced to average AUC=0.58 compared to AUC=0.65 with the constraint.

3. More Figures for Birds and Flower Datasets

Fig 1 shows the ROC curves for our approach on best predicted unseen classes from the Flower dataset. Fig 2 shows the AUC for unseen classes over three different folds. Fig 3 shows the improvement over the tree baseline for each class, where the improvement is calculated as (our AUC- baseline AUC)/ baseline AUC

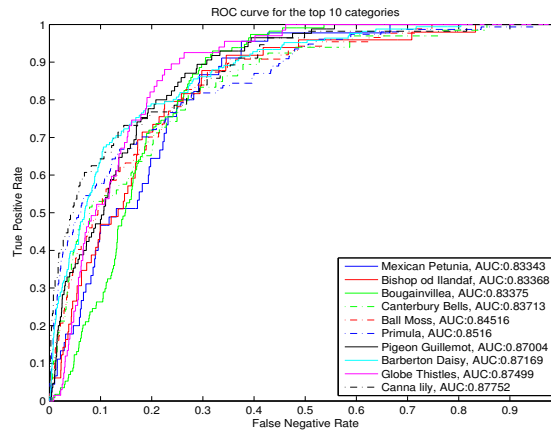


Figure 1: ROC curves for best predicted classes – Flower

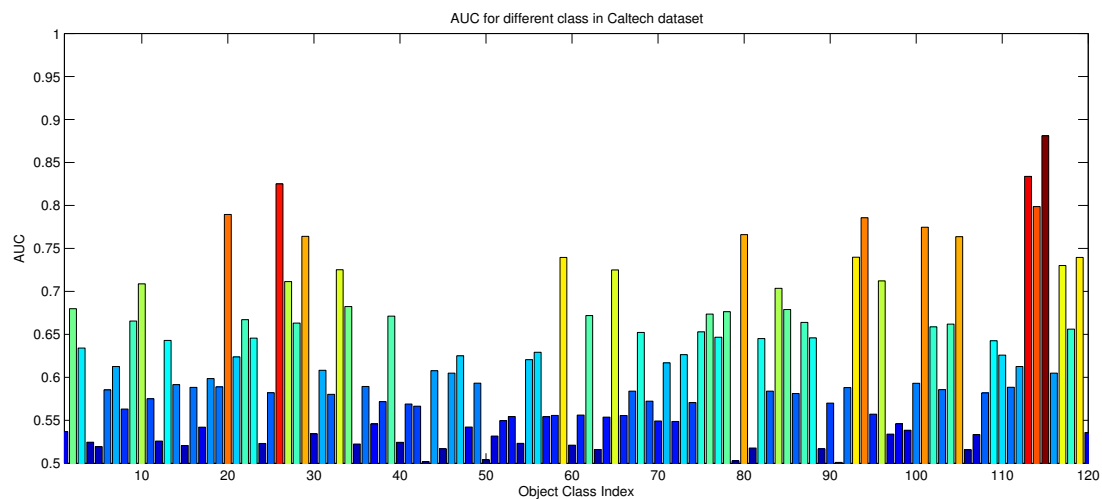


Figure 2: AUC – Birds

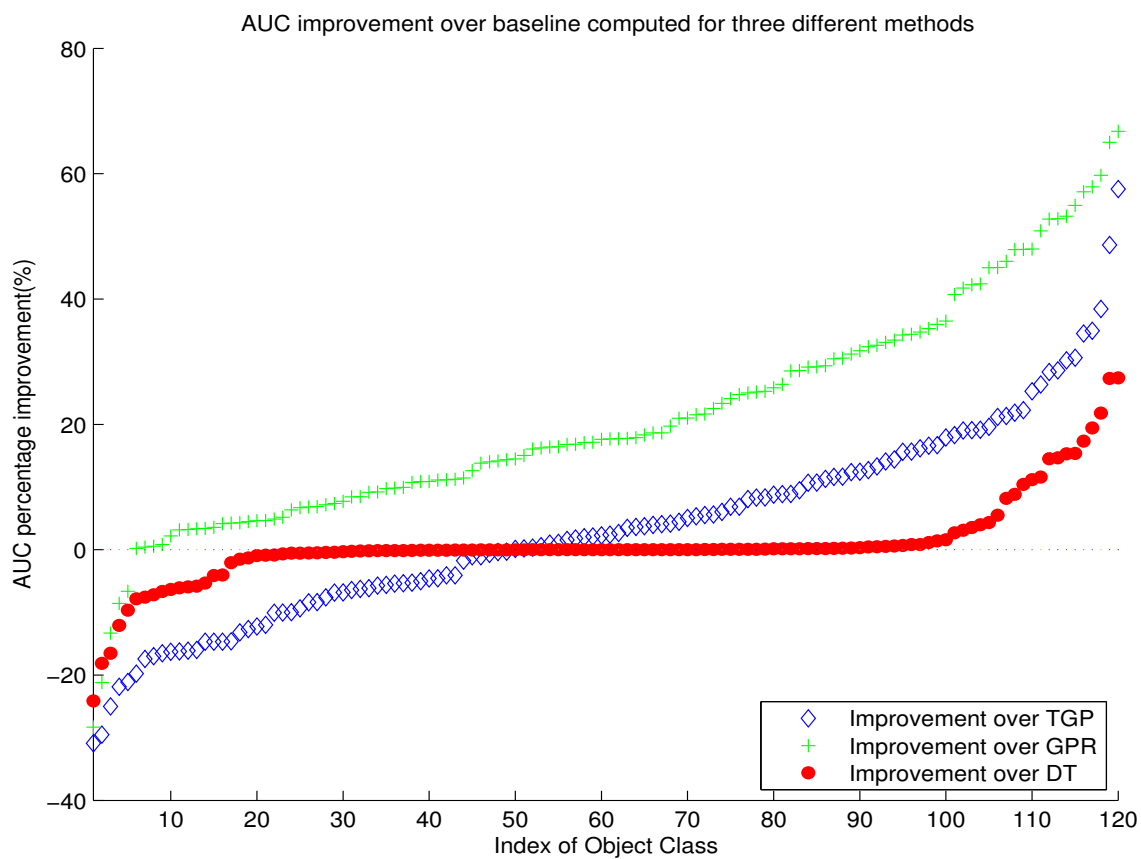


Figure 3: AUC Improvement – Birds

4. Sample Textual Descriptions

Here we show five samples of the textual descriptions used for prediction for each of the data sets used. ; we also attach two folders that contain the full textual description of all the classes for both datasets (FlowerText and BirdsText folders).

4.1. Flower Dataset

Canna lily

Canna (or Canna lily, although not a true lily) is a genus of nineteen species of flowering plants. The closest living relations to cannas are the other plant families of the order Zingiberales, that is the ginger family, bananas, marantas, heliconias, streptocarpus, etc. Canna is the only genus in the family Cannaceae. Such a family has almost universally been recognized by taxonomists. The APG II system of 2003 (unchanged from the APG system, 1998) also recognizes the family, and assigns it to the order Zingiberales in the clade commelinids, in the monocots. The species have large, attractive foliage and horticulturists have turned it into a large-flowered and bright garden plant. In addition, it is one of the world's richest starch sources, and is an agricultural plant. Although a plant of the tropics, most cultivars have been developed in temperate climates and are easy to grow in most countries of the world as long as they can enjoy at least 68 hours average sunlight during the summer. See the Canna cultivar gallery for photographs of Canna cultivars. The name Canna originates from the Celtic word for a cane or reed.

The plants are large tropical and subtropical perennial herbs with a rhizomatous rootstock. The broad, flat, alternate leaves, that are such a feature of this plant, grow out of a stem in a long narrow roll and then unfurl. The leaves are typically solid green but some cultivars have glaucous, brownish, maroon, or even variegated leaves. The flowers are composed of three sepals and three petals that are seldom noticed by people, they are small and hidden under extravagant stamens. What appear to be petals are the highly modified stamens or staminodes. The staminodes number (1) 3 (4) (with at least one staminodal member called the labellum, always being present. A specialized staminode, the stamen, bears pollen from a half-anther. A somewhat narrower, 'petal' is the pistil which is connected down to a three-chambered ovary. The flowers are typically red, orange, or yellow or any combination of those colours, and are aggregated in inflorescences that are spikes or panicles (thyrses). Although gardeners enjoy these odd flowers, nature really intended them to attract pollinators collecting nectar and pollen, such as bees, hummingbirds and bats. The pollination mechanism is conspicuously specialized. Pollen is shed on the style while still in the bud, and in the species and early hybrids some is also found on the stigma because of the high position of the anther, which means that they are self-pollinating. Later cultivars have a lower anther, and rely on pollinators alighting on the labellum and touching first the terminal stigma, and then the pollen. The wild species often grow to at least 23 m (6.69.8 ft) in height but there is a wide variation in size among cultivated plants; numerous cultivars have been selected for smaller stature. Canna grow from swollen underground stems, correctly known as rhizomes, which store starch, and this is the main attraction of the plant to agriculture, having the largest starch particles of all plant life. Canna is the only member of the Liliopsida Class (monocot group) in which hibernation of seed is known to occur, due to its hard, impenetrable seed covering.

The genus is native to tropical and subtropical regions of the New World, from the southern United States (southern South Carolina west to southern Texas) and south to northern Argentina. Although all cannas are native to the New World, they have followed mankind's journeys of discovery and some species are cultivated and naturalized in most tropical and sub-tropical regions. Canna cultivars are grown in most countries, even those with territory above the Arctic Circle, which have short summers but long days, and the rapid growth rate of Cannas makes them a feasible gardening plant, as long as they receive 68 hours of sunlight each day during the growing season and are protected from the cold of winter.

The first Cannas introduced to Europe were *C. indica* L., which was imported from the East Indies, though the species originated from the Americas. Charles de l'Ecluse, who first described and sketched *C. indica* indicates this origin, and states that it was given the name of indica, not because the plant is from India, in Asia, but because this species was originally transported from America: "Quia ex America primum delata sit"; and at that time, one described the tropical areas of that part of the globe as the Western Indies. Much later, in 1658, Pison made reference to another species which he documented under the vulgar or common name of 'Albara' and 'Pacivira', which resided, he said, in the shaded and damp places, between the tropics; this species is *Canna angustifolia* L., (later reclassified as *C. glauca* L. by taxonomists). Without exception, all Canna species that have been introduced into Europe can be traced back to the Americas, and it can be asserted with confidence that Canna is solely an American genus. If Asia and Africa provided some of the early introductions, they were only varieties resulting from *C. indica* and *C. glauca* cultivars that have been grown for a long time in India and Africa, with both species imported from Central and South America. Canna is an American genus, as pointed out by Lamarck where he argues that "Cannas were unknown to the ancients, and that it is only after the discovery of the New World, that they made

their appearance in Europe; Since Canna have very hard and durable seed coverings, it is likely that seed remains would have survived in the right conditions and found by archaeologists in the Old World. If the soils of India or Africa had produced some of them, they would have been imported before the 1860s into European gardens.

Some species and many cultivars are widely grown in the garden in temperate and sub-tropical regions. Sometimes, they are also grown as potted plants. A large number of ornamental cultivars have been developed. They can be used in herbaceous borders, tropical plantings, and as a patio or decking plant. Internationally, cannas are one of the most popular garden plants and a large horticultural industry depends on the plant. The canna rhizome is rich in starch, and it has many uses in agriculture. All of the plant has commercial value, rhizomes for starch (consumption by humans and livestock), stems and foliage for animal fodder, young shoots as a vegetable and young seeds as an addition to tortillas. The seeds are used as beads in jewelry. The seeds are used as the mobile elements of the kayamb, a musical instrument from Reunion, as well as the hosho, a gourd rattle from Zimbabwe, where the seeds are known as "hota" seeds. In more remote regions of India, cannas are fermented to produce alcohol. The plant yields a fibre from the stem it is used as a jute substitute. A fibre obtained from the leaves is used for making paper. The leaves are harvested in late summer after the plant has flowered, they are scraped to remove the outer skin and are then soaked in water for 2 hours prior to cooking. The fibres are cooked for 24 hours with lye and then beaten in a blender. They make a light tan brown paper. A purple dye is obtained from the seed. Smoke from the burning leaves is said to be insecticidal. Cannas are used to extract many undesirable pollutants in a wetland environment as they have a high tolerance to contaminants. In Thailand, Cannas are a traditional gift for Father's Day. In Vietnam, canna is called dong ri?ng and its starch is used to make cellophane noodles known as mi?n dong.

Species Although most Cannas these days are cultivars (see below), there are approximately 20 known species of the wild form, and in the last three decades of the 20th century, Canna species have been categorized by two different taxonomists, Paul Maas, from the Netherlands and Nobuyuki Tanaka from Japan. Both reduced the number of species from the 50-100 accepted previously assigning most as synonyms. This reduction in species is also confirmed by work done by Kress and Prince at the Smithsonian Institution, however, this only covers a subset of the species range. See List of Canna species for full species information and descriptions. Horticultural varieties (cultivars)

Canna (Crozy Group) 'Theresa Blakey' See the List of Canna cultivars for photographs of Canna cultivars. Cannas became very popular in Victorian times as a garden plant and were grown widely in France, Germany, Hungary, India, Italy, the United Kingdom, and the USA. As tender perennials in northern climates, they suffered severe setbacks when two world wars sent the young gardening staff off to war. It took many years for the frugalities of war and its rationing subsequences to change to the more prosperous times of the late 20th century. The Canna genus has recently experienced a renewed interest and revival in popularity. There were once hundreds of cultivars but many of these are now extinct. In 1910, rpd Mhle, from Hungary, published his Canna book, written in higher German. It contained descriptions of over 500 cultivars. In recent years many new cultivars have been created, but the genus suffers severely from having many synonyms for many popular ones. Most of the synonyms were created by old varieties re-surfacing without viable names, with the increase in popularity from the 1960s onwards. Research has accumulated over 2,800 Canna cultivar names, however, many of these are simply synonyms. See List of Canna hybridists for details of the people and firms that created the current Canna legacy. In the early 20th century, Professor Liberty Hyde Bailey defined, in detail, two garden species (*C. L. generalis* and *C. L. orchoides*) to categorise the floriferous Cannas being grown at that time, namely the Crozy hybrids and the orchid-like hybrids introduced by Carl Ludwig Sprenger in Italy and Luther Burbank in the USA, at about the same time (1894). The definition was based on the genotype, rather than the phenotype, of the two cultivar groups. Inevitably, over time those two floriferous groups were interbred, the distinctions became blurred and overlapped, and the Bailey species names became redundant. Pseudo-species names are now deprecated by the International Code of Nomenclature for Cultivated Plants which, instead, provides Cultivar Groups for categorising cultivars (see groups at List of Canna cultivars). Agricultural varieties

Canna (Agriculture Group) 'Edulis Dark' The Canna Agriculture Group contains all of the varieties of Canna grown in agriculture. Canna achira is a generic term used in South America to describe the cannas that have been selectively bred for agricultural purposes, normally derived from *C. discolor*. It is grown especially for its edible rootstock from which starch is obtained, but the leaves and young seed are also edible, and achira was once a staple foodcrop in Peru and Ecuador. Trials in Ecuador using a wide range of varieties have shown that achira can yield on average 56 tons of rhizomes and 7.8 of extractable starch per hectare. However the crop needs 9-12 months to mature to full productivity. Many more traditional varieties exist worldwide, they have all involved human selection and so are classified as agricultural cultivars. Traditionally, Canna 'edulis' has been reputed to be the variety grown for food in South America, but there is no scientific evidence to substantiate the name. It is probable that edulis is simply a synonym of *C. discolor*, which is also grown for agricultural purposes throughout Asia.;

Cannas grow best in full sun with moderate water in well-drained rich or sandy soil. Cannas grow from perennial rhizomes

but are frequently grown as annuals in temperate zones for an exotic or tropical look in the garden. In arid regions, cannas are often grown in the water garden, with the lower inch of pot submerged. In all areas, high winds tear the leaves so shelter is advised. The rhizomes are frost tender and will rot if left unprotected in freezing conditions. In areas which go below about -10 C (14 F) in the winter (USDA Zone 8), the rhizomes can be dug up before freezing and stored in a protected area (above 7 C / 45 F) for replanting in the spring. Otherwise, it is recommended that Cannas are protected by a thick layer of mulch overwinter. Pests Cannas are largely free of pests but in the USA plants sometimes fall victim to the Canna Leaf Roller and the resultant leaf damage, while not fatal to the plant, can be most distressing to a keen gardener. Slugs and snails are fond of cannas and can leave large holes in the leaves, preferring the tender young leaves that have not yet unfurled. red spider mite can also be a problem for cannas grown indoors or during a very hot, long summer outdoors. Japanese beetles can also ravage the leaves if left uncontrolled. Disease Canna are remarkably free of disease, compared to many genera. However, they may fall victim to canna rust, a fungus resulting in orange spots on the plant's leaves, caused by over moist soil. Cannas are also susceptible to certain plant viruses, some of which are Canna specific viruses, which may result in spotted or streaked leaves, in a mild form, but can finally result in stunted growth and twisted and distorted blooms and foliage. The flowers are sometimes affected by a grey, fuzzy mold called Botrytis. Under humid conditions it is often found growing on the older flowers. Treatment is to simply remove the old flowers, so the mold does not spread to the new flowers.

Sexual propagation

Canna fruit (green) and ripe seed pods

Canna fruits Seeds are produced from sexual reproduction, involving the transfer of pollen from the stamen of the pollen parent onto the stigma of the seed parent. In the case of Canna, the same plant can usually play the roles of both pollen and seed parents, technically referred to as a hermaphrodite. However, the cultivars of the Italian Group and triploids are almost always seed sterile, and their pollen has a low fertility level. Mutations are almost always totally sterile. Canna seeds have a very hard seed coat, which contributes to their dormancy. Germination is facilitated by scarification of the seed coat, which can be accomplished by several techniques. Pollination The species are capable of self-pollination, but most cultivars require an outside pollinator. All cannas produce nectar and therefore attract nectar consuming insects, bats and hummingbirds that act as the transfer agent, spreading pollen between stamens and stigmas, on the same or different inflorescence. Genetic changes Since genetic recombination has occurred a cultivar grown from seed will have different characteristics from its parent(s) and thus should never be given a parents name. The wild species have evolved in the absence of other Canna genes and are deemed to be true to type when the parents are of the same species. In the latter case there is still a degree of variance, producing various varieties or minor forms (forma). In particular, the species *C. indica* is an aggregate species, having many different and extreme varieties and forma ranging from the giant to miniature, from large foliage to small foliage, both green and dark foliage and many different coloured blooms, red, orange, pink, and yellow and combinations of those colours. Asexual propagation

In vitro culture of plants in a controlled, sterile environment Division of plant parts Outside of a laboratory, the only asexual propagation method that is effective is rhizome division. This is done by using material from a single parent, and as there is no exchange of genetic material such vegetative propagation methods almost always produce plants that are identical to the parent. After a summers growth the horticultural Canna can be separated into typically four or five separate smaller rhizomes, each with a growing nodal point (growing eye). Without the growing point, which is composed of meristem material, the rhizome will not grow. Micropropagation Micropropagation, or tissue culture as it is also known, is the practice of rapidly multiplying stock plant material to produce a large number of progeny plants. Micropropagation using in vitro methods that produce plants by taking small sections of plants and moving them into a sterile environment, where they first produce proliferations that are then separated from each other and then rooted or allowed to grow new stem tissue. The process of plant growth is regulated by different ratios of plant growth regulators or PGRs, that promote cell growth. Many commercial organizations have attempted to produce Canna this way, and specifically the Island Series of Cannas was introduced by means of mass produced plants using this technique. However, Cannas have a reputation of being difficult micropropagation specimens. Micropropagation techniques can be employed on specimens infected with Canna virus and used to dis-infest plants of the virus, it is possible to use a growing shoot tip as the explant, the growing tip is induced into rapid growth, which results in rapid cell division that has not had time to be infected with the virus. The rapidly growing region of meristem cells producing the shoot tip is cut off and placed in vitro, with a very high probability of being uncontaminated by virus, since it has not yet had contact with the sap of the plant which moves the virus within the plant. In this way, healthy stock can be reclaimed from virus contaminated plants.

globe-thistle

Echinops is a genus of about 120 species of thistles in the daisy family Asteraceae, commonly known as globe thistles. They are native to Europe east to central Asia and south to the mountains of tropical Africa. Globe thistle is one of the most elegantly colored plants around. It has fantastical large blue balls of steel-blue flowers in midsummer, which would be enough. But making it even more lovely is its large coarse, grayish green leaves, which sets off the flower beautifully. If you can bear to separate them from the foliage, globe thistle makes a great cut flower, lasting for weeks in the vase. It also dries well. It's bothered by few pests or diseases. If it likes its conditions, it will reseed fairly readily. If you want to prevent this, deadhead flowers shortly after they fade.

Sun Sun Zones 310 Perennial Plant Height 24 feet tall Plant Width 12 feet wide Landscape Uses Containers, Beds & Borders Special Features Flowers, Cut Flowers, Dried Flowers, Attracts Butterflies, Drought Tolerant, Deer Resistant, Easy to Grow

Echinops adenocaulos Echinops bannaticus Echinops chantavicus Echinops exaltatus Echinops giganteus Echinops gmelinii Echinops graecus Echinops humilis Echinops latifolius Echinops nivens Echinops niveus Echinops orientalis Echinops ritro Echinops ruthenicus Echinops sphaerocephalus Echinops spinosissimus Echinops setifer Iljin Echinops tournefortii Echinops tschimganicus

Barberton Daisy

Gerbera is a genus of ornamental plants from the sunflower family (Asteraceae). It was named in honour of the German botanist and naturalist Traugott Gerber (1743) who travelled extensively in Russia and was a friend of Carolus Linnaeus.

It has approximately 30 species in the wild, extending to South America, Africa and tropical Asia. The first scientific description of a Gerbera was made by J.D. Hooker in Curtis's Botanical Magazine in 1889 when he described Gerbera jamesonii, a South African species also known as Transvaal daisy or Barberton Daisy. Gerbera is also commonly known as the African Daisy.

Gerbera species bear a large capitulum with striking, two-lipped ray florets in yellow, orange, white, pink or red colours. The capitulum, which has the appearance of a single flower, is actually composed of hundreds of individual flowers. The morphology of the flowers varies depending on their position in the capitulum. The flower heads can be as small as 7 cm (Gerbera mini 'Harley') in diameter or up to 12 cm (Gerbera Golden Serena).

Gerbera is very popular and widely used as a decorative garden plant or as cut flowers. The domesticated cultivars are mostly a result of a cross between Gerbera jamesonii and another South African species Gerbera viridifolia. The cross is known as Gerbera hybrida. Thousands of cultivars exist. They vary greatly in shape and size. Colours include white, yellow, orange, red, and pink. The centre of the flower is sometimes black. Often the same flower can have petals of several different colours.

Gerbera is also important commercially. It is the fifth most used cut flower in the world (after rose, carnation, chrysanthemum, and tulip). [citation needed] It is also used as a model organism in studying flower formation. Gerbera contains naturally occurring coumarin derivatives. Gerbera is a tender perennial plant. It is attractive to bees, butterflies and/or birds, but resistant to deer.

Mexican Petunia

Britton's wild petunia or Mexican Bluebell (syn. Arrhoxylum microphyllum, Blechnum angustifolium (Sw.) R.Br.), Cryphiacanthus angustifolius Nees, Ruellia brittoniana Leonard, Ruellia ignorantiae Herter, Ruellia microphylla Lindau, Ruellia spectabilis Britton, Ruellia tweediana Griseb.) is an ornamental plant native of Argentina, Cerrado and Pantanal vegetation of Brazil, Mexico and Paraguay.

Ruellia brittoniana is a tough, drought-resistant plant with a long bloom period. It is a smooth-textured herbaceous perennial (evergreen), and is often arranged in garden borders or in the middle and back of garden beds. Native to Mexico, it is naturalized in some areas of the Gulf South and in Texas. It grows in nearly any soil, clay or sand, and tolerates wet or dry conditions. "Mexican petunia" has attractive dark-green foliage on fleshy stems. Petunia-like flowers appear throughout the growing season, although the plant is not related to the common garden Petunia. The species will grow as tall as three feet (1 m), while dwarf varieties can be kept at 8-10 inches tall. Leaves of brittoniana are narrower than those of R. malacosperma. Another species, R. nudiflora or wild petunia, is not as tall or aggressive as brittoniana.

R. brittoniana is best planted in early spring, providing time to increase foliage and bloom in its first season after which it blooms repeatedly through late Spring to early Fall. Pruning applies to the woody stalks as the plant ages.

Propagation is by seeds, cuttings or division. Plants can be divided after the first frost. Due to reseeding, it can become invasive in good soils if not controlled.

The plant is attractive to bees, butterflies and birds and is resistant to deer.

Bougainvillea

Bougainvillea is a genus of flowering plants native to South America from Brazil west to Peru and south to southern Argentina (Chubut Province). Different authors accept between four and 18 species in the genus. The plant was classified by Europeans in Brazil in 1768, by Philibert Commeron, a French botanist accompanying French Navy admiral and explorer Louis Antoine de Bougainville during his voyage of circumnavigation.

They are thorny, woody vines growing anywhere from 1-12 meters tall, scrambling over other plants with their spiky thorns. The thorns are tipped with a black, waxy substance. They are evergreen where rainfall occurs all year, or deciduous if there is a dry season. The leaves are alternate, simple ovate-acuminate, 4-13 cm long and 2-6 cm broad. The actual flower of the plant is small and generally white, but each cluster of three flowers is surrounded by three or six bracts with the bright colours associated with the plant, including pink, magenta, purple, red, orange, white, or yellow. Bougainvillea glabra is sometimes referred to as "paper flower" because the bracts are thin and papery. The fruit is a narrow five-lobed achene.

Bougainvillea are relatively pest-free plants, but may suffer from worms, snails and aphids. The larvae of some Lepidoptera species also use them as food plants, for example the Giant Leopard Moth (*Hypercompe scribonia*).

Bougainvilleas are popular ornamental plants in most areas with warm climates, including Ethiopia, Indonesia, Aruba, the Philippines, Thailand, Pakistan, India, Sri Lanka, Taiwan, Vietnam, Malaysia, Australia, Greece, Spain, Turkey, Cyprus, Singapore, the Mediterranean region, the Caribbean, Central America, Mexico, South Africa, Kuwait, the United Arab Emirates and the United States in Arizona, California, Florida, Hawaii, Louisiana, South Carolina, and southern Texas. Locarno in Switzerland, with its mild Mediterranean climate, is famous for its bougainvilleas.

Although it is frost-sensitive and hardy in U.S. Hardiness Zones 9b and 10, bougainvillea can be used as a houseplant or hanging basket in cooler climates. In the landscape, it makes an excellent hot season plant, and its drought tolerance makes bougainvillea ideal for warm climates year-round. Bougainvillea has a high salt tolerance, which makes it a natural choice for color on coastal regions. As a woody clambering vine, bougainvillea will stand alone and can be pruned into a standard, but it is perfect along fence lines, on walls, in containers and hanging baskets, and as a hedge or an accent plant. Its long arching branches are thorny, and bear heart-shaped leaves and masses of papery bracts in white, pink, orange, purple, and burgundy. Many cultivars, including double flowered and variegated, are available.

Twenty years after Commeron's discovery, it was first published as 'Buginvillea' in *Genera Plantarum* by A.L. de Jussieu in 1789. The genus was subsequently split in several ways until it was finally corrected to 'Bougainvillea' in the *Index Kewensis* in the 1930s. Originally, *B. spectabilis* and *B. glabra* were hardly differentiated until the mid 1980s when botanists recognized them to be totally distinct species. In early 19th century, these two species were the first to be introduced into Europe, and soon, nurseries in France and England did a thriving trade providing specimens to Australia and other faraway countries. Meanwhile, Kew Gardens distributed plants it had propagated to British colonies throughout the world. Soon thereafter, an important event in the history of bougainvillea took place with the discovery of a crimson bougainvillea in Cartagena, a Spanish port in the Mediterranean, by Mrs. R.V. Butt. Originally thought to be a distinct species, it was named *B. buttiana* in her honour. However, it was later discovered to be a natural hybrid of a variety of *B. glabra* and possibly *B. peruviana* - a "local pink bougainvillea" from Peru. Natural hybrids were soon found to be common occurrences all over the world. For instance, around the 1930s, when the three species were grown together, many hybrid crosses were created almost spontaneously in East Africa, India, the Canary Islands, Australia, North America, and the Philippines.

Many of today's bougainvillea are the result of interbreeding among only three out of the eighteen South American species recognized by botanists. Currently, there are over 300 varieties of bougainvillea around the world. Because many of the hybrids have been crossed over several generations, it's difficult to identify their respective origins. Natural mutations seem to occur spontaneously throughout the world; wherever large numbers of plants are being produced, bud-sports will occur. This had led to multiple names for the same cultivar (or variety) and has added to the confusion over the names of bougainvillea cultivars.

The growth rate of Bougainvillea vary from slow-growing to rapid, depending on the particular variety. Bougainvillea tend to flower all year round in equatorial regions. Elsewhere, they are seasonal bloomers. They grow best in somewhat dry, fertile soil. Bloom cycles are typically four to six weeks. Bougainvillea grow best in very bright full sun and with frequent fertilization, but the plant requires little water once established. As indoor houseplants in temperate regions, they can be kept small by bonsai techniques. If overwatered, Bougainvillea will not flower and may lose leaves or wilt, or even die from root

decay. Bougainvillea can be easily propagated via tip cuttings.

Various species of Bougainvillea are the official flowers of the island of Grenada, Guam; Lienchiang and Pingtung Counties in Taiwan; Ipoh, Malaysia; the cities of Tagbilaran, Philippines; Camarillo, California; Laguna Niguel, California; San Clemente, California; the cities of Shenzhen, Huizhou, Zhuhai, and Jiangmen in Guangdong Province, China; and Naha, Okinawa.

The sap of the Bougainvillea can cause skin rashes similar to Toxicodendron species.

4.2. Birds Dataset

Bronzed Cowbird

The Bronzed Cowbird (once known as the Red-eyed Cowbird), *Molothrus aeneus*, is a small icterid.

It breeds from the southern U.S. states of California, Arizona, New Mexico, Texas, and Louisiana south through Central America to Panama. An isolated population on the Caribbean coast of Colombia is sometimes treated as a separate species, the Bronze-brown Cowbird (*M. armenti*).

The male Bronzed Cowbird is 20 cm long and weighs 68 g, with green-bronze glossed black plumage and red eyes. The female is 18.5 cm long and weighs 56 g. She is duller black above and browner below. Young birds are like the female but have grey feather fringes.

Like all cowbirds, this bird is a brood parasite: it lays its eggs in the nests of other birds. The young cowbird is fed by the host parents at the expense of their own young. Hosts include Prevost's Ground-Sparrow and Yellow-throated Brush Finch.

Black-throated Sparrow

The Black-throated Sparrow (*Amphispiza bilineata*) is a small sparrow primarily found in the southwestern United States and Mexico. It is sometimes referred to as the Desert Sparrow, due to its preferred habitat of arid desert hillsides and scrub. This name usually refers to the Desert Sparrow of Africa and Asia.

The Black-throated Sparrow reaches a length of about 4.5-5.5 inches, and is pale gray above, with a distinctive black and white head pattern. Immature are similar but lacks a black throat. Its call is high and bell-like, and its song is a fairly simple, mechanical tinkling. It feeds primarily on insects and seeds, and travels in small groups, though larger groups may accumulate around sources of water in the desert.

It has a loose nest of grass twigs and plant fibers carefully hidden in brush 6-18 inches above the ground. 3-4 white or pale blue eggs are laid.

The Yellow-breasted Chat

The Yellow-breasted Chat (*Icteria virens*) is a large songbird, formerly considered the most atypical member of the New World warbler family, though the long-standing suspicion is that it does not actually belong there. Its placement is not definitely resolved. It is the only member of the genus *Icteria*. Found throughout North America, from southern-plains Canada to central Mexico during the summer, these birds mainly migrate to Mexico and Central America, although some of their number may overwinter in coastal areas.

Yellow-breasted Chats are noticeably larger than all other warblers, reaching a length of convert—7.5—in—cm—abbr=on and a wingspan of convert—9.75—in—cm—abbr=on. These birds have olive upperparts with white bellies and yellow throats and breasts; they also have long tails, thick heavy bills, large white eye-rings, and dark legs.

The breeding habitats of this species are dense, brushy areas and hedgerows. The nests of these birds are cup-shaped, and are placed in thick shrubs. These birds eat insects and berries, and will forage in dense vegetation, occasionally gripping food with their feet.

The song of this bird is an odd, variable mixture of cackles, clucks, whistles and hoots. Their calls are harsh chak's. Unlike most warblers, this species has been known to mimic the calls of other birds. This bird is somewhat secretive, but will usually sing from exposed locations.

Yellow-breasted Chats are declining in eastern North America due to habitat loss, which is caused primarily from deforestation and urban development. This species is particularly vulnerable to brood parasitism from Brown-headed Cowbirds that have taken advantage of the fragmentation of Eastern forests to expand their range in the last century.

White-breasted Nuthatch

The White-breasted Nuthatch (*Sitta carolinensis*) is a small songbird of the nuthatch family which breeds in old-growth woodland across much of temperate North America. It is a stocky bird, with a large head, short tail, powerful bill and strong feet. The upperparts are pale blue-gray, and the face and underparts are white. It has a black cap and a chestnut lower belly. The nine subspecies differ mainly in the color of the body plumage.

Like other nuthatches, the White-breasted Nuthatch forages for insects on trunks and branches, and is able to move head-first down trees. Seeds form a substantial part of its winter diet, as do acorns and hickory nuts that were stored by the bird in the fall. The nest is in a hole in a tree, and the breeding pair may smear insects around the entrance as a deterrent to squirrels. Adults and young may be killed by hawks, owls and snakes, and forest clearance may lead to local habitat loss, but this is a common species with no major conservation concerns over most of its range.

The nuthatches are a genus, *Sitta*, of small passerine birds which derive their English name from the propensity of some species to wedge large insects or seeds into cracks, and then hack at them with their strong bills. *Sitta* is derived from *sitt*, the Ancient Greek for nuthatch, and *carolinensis* means "of Carolina" in Latin. The White-breasted Nuthatch was first described by English ornithologist John Latham in his 1790 work, the *Index Ornithologicus*.

Nuthatch taxonomy is complex, with geographically separated species sometimes closely resembling each other. The White-breasted Nuthatch has a similar appearance and contact call to the White-cheeked Nuthatch, *Sitta leucopsis*, of the Himalayas and was formerly considered to be conspecific.

Like other members of its genus, the White-breasted Nuthatch has a large head, short tail, short wings, a powerful bill and strong feet; it is 1314 cm (56 in) long, with a wingspan of 2027 cm (811 in) and a weight of 1830 g (0.641.06 oz).

The adult male of the nominate subspecies, *S. c. carolinensis*, has pale blue-gray upperparts, a glossy black cap (crown of the head), and a black band on the upper back. The wing coverts and flight feathers are very dark gray with paler fringes, and the closed wing is pale gray and black, with a thin white wing bar. The face and the underparts are white. The outer tail feathers are black with broad diagonal white bands across the outer three feathers, a feature readily visible in flight.

The female has, on average, a narrower black back band, slightly duller upperparts and buffer underparts than the male. Her cap may be gray, but many females have black caps, and cannot be reliably distinguished from the male in the field. In the northeastern United States, at least 10

Like other nuthatches, this is a noisy species with a range of vocalizations. The male's mating song is a rapid nasal qui-qui-qui-qui-qui-qui. The contact call between members of a pair, given most frequently in the fall and winter is a thin squeaky nit, uttered up to 30 times a minute. A more distinctive sound is a shrill kri repeated rapidly with mounting anxiety or excitement kri-kri-kri-kri-kri-kri-kri-kri; the Rocky Mountains and Great Basin subspecies have a higher, faster yididititit call, and Pacific birds a more nasal beerf.

Three other, significantly smaller, nuthatches have ranges which overlap that of White-breasted, but none has white plumage completely surrounding the eye. Further distinctions are that the Red-breasted Nuthatch has a black eye line and reddish underparts, and the Brown-headed and Pygmy Nuthatches each have a brown cap, and a white patch on the nape of the neck.

The White-breasted Nuthatch has nine subspecies, although the differences are small and change gradually across the range. The subspecies are sometimes treated as three groups based on close similarities in morphology, habitat usage, and vocalizations. These groups cover eastern North America, the Great Basin and central Mexico, and the Pacific coastal regions. The subspecies of the western interior have the darkest upperparts, and eastern *S. c. carolinensis* has the palest back. The eastern form also has a thicker bill and broader dark cap stripe than the interior and Pacific races. The calls of the three groups differ, as described above. The Great Basin and Eastern forms have been observed in secondary contact on the Great Plains, where they do not seem to mix.

The breeding habitat of the White-breasted Nuthatch is woodland across North America, from southern Canada to northern Florida and southern Mexico. In the eastern part of its range, its preferred habitat is old-growth open deciduous or mixed forest, including orchards, parks, suburban gardens and cemeteries; it is found mainly in the lowlands, although it breeds at 1,675 m (5,500 ft) altitude in Tennessee. In the west and Mexico, this nuthatch is found in open montane pine-oak woodlands, and nesting occurs at up to 3,200 m (10,500 ft) altitude in Nevada, California and Mexico. Pinyon-juniper and riverside woodlands may be used locally where available. The White-breasted Nuthatch is the only North American nuthatch usually found in deciduous trees; Red-breasted, Pygmy and Brown-headed Nuthatches prefer pines.

The presence of mature or decaying trees with holes suitable for nesting is essential, and trees such as oak, beech and hickory are favored in the east since they provide edible seeds. Although suitable habitat is distributed continentally, it is discontinuous, and the separate populations of this non-migratory species have diverged to form distinct regional subspecies.

This nuthatch, like most of its genus, is non-migratory, and the adults normally stay in their territory year-round. There may be more noticeable dispersal due to seed failure or high reproductive success in some years, and this species has occurred as a vagrant to Vancouver Island, Santa Cruz Island, and Bermuda. One bird landed on the RMS Queen Mary six hours sailing east of New York in October 1963.

The White-breasted Nuthatch is monogamous, and pairs form following a courtship in which the male bows to the female, spreading his tail and drooping his wings while swaying back and forth; he also feeds her morsels of food. The pair establish a territory of 0.100.15 square kilometers (2538 acres) in woodland, and up to 0.2 square kilometers (50 acres) in semi-wooded habitats, and then remain together year-round until one partner dies or disappears. The nest cavity is usually a natural hole in a decaying tree, sometimes an old woodpecker nest, and occasionally an artificial nest box intended for the Eastern Bluebird.

The nest hole is usually 312 m (1040 ft) high in a tree and is lined with fur, fine grass, and shredded bark. The clutch is five to nine eggs which are creamy-white, speckled with reddish brown, and average 19 x 14 mm (0.75 x 0.55 in) in size. The eggs are incubated by the female for 13 to 14 days prior to hatching, and the altricial chicks fledge in a further 18 to 26 days. Both adults feed the chicks in the nest and for about two weeks after fledging, and the male also feeds the female while she is incubating. Once independent, juveniles leave the adults' territory and either establish their own territory or become "floaters", unpaired birds without territories. It is probably these floaters which are mainly involved in the irregular dispersals of this species. This species of nuthatch roosts in tree holes or behind loose bark when not breeding, and has the unusual habit of removing its faeces from the roost site in the morning. It usually roosts alone except in very cold weather, when up to 29 birds have been recorded together.

Predators of adult nuthatches include owls and diurnal birds of prey (such as Sharp-shinned and Cooper's Hawks), and nestlings and eggs are eaten by woodpeckers, small squirrels, and climbing snakes such as the Smooth Green Snake. The White-breasted Nuthatch responds to predators near the nest by flicking its wings while making hn-hn calls. When a bird leaves the nest hole, it wipes around the entrance with a piece of fur or vegetation; this makes it more difficult for a predator to find the nest using its sense of smell. The nuthatch may also smear blister beetles around the entrance to its nest, and it has been suggested that the unpleasant smell from the crushed insects deters squirrels, its chief competitor for natural tree cavities. The estimated average lifespan of this nuthatch is two years, but the record is twelve years and nine months.

This nuthatch's responses to predators may be linked to a reproductive strategy. A study compared the White-breasted Nuthatch with the Red-breasted Nuthatch in terms of the willingness of males to feed incubating females on the nest when presented with models of predators. The models were of a Sharp-shinned Hawk, which hunts adult nuthatches, and a House Wren, which destroys eggs. The White-breasted Nuthatch is shorter-lived than the Red-breasted Nuthatch, but has more young, and was found to respond more strongly to the egg predator, whereas the Red-breasted showed greater concern with the hawk. This supports the theory that longer-lived species benefit from adult survival and future breeding opportunities, while birds with shorter life spans place more value on the survival of their larger broods.

The White-breasted Nuthatch forages along tree trunks and branches in a similar way to woodpeckers and treecreepers, but does not use its tail for additional support, instead progressing in jerky hops using its strong legs and feet. All nuthatches are distinctive when seeking food because they are able to descend tree trunks head-first and can hang upside-down beneath twigs and branches.

This nuthatch is omnivorous, eating insects and seeds. It places large food items such as acorns or hickory nuts in crevices in tree trunks, and then hammers them open with its strong beak; surplus seeds are cached under loose bark or crevices of trees. The diet in winter may be nearly 70

The White-breasted Nuthatch often travels with small mixed flocks in winter. These flocks are led by titmice and chickadees, with nuthatches and Downy Woodpeckers as common attendant species. Participants in such flocks are thought to benefit in terms of foraging and predator avoidance. It is likely that the attendant species also access the information carried in the chickadees' calls and reduce their own level of vigilance accordingly.

The White-breasted Nuthatch is a common species with a large range, estimated at 8.6 million square kilometers (3.3 million square miles). Its total population is estimated at 10 million individuals, and there is evidence of an overall population increase, so it is not believed to approach either the size criterion (fewer than 10,000 mature individuals) or the population decline criterion (declining more than 30

The removal of dead trees from forests may cause problems locally for this species because it requires cavity sites for nesting; declines have been noted in Washington, Florida, and more widely in the southeastern U.S. west to Texas. In contrast, the breeding range is expanding in Alberta, and numbers are increasing in the northeast due to regrown forest. This nuthatch is protected under the Migratory Bird Treaty Act of 1918, to which the three countries in which it occurs (Canada, Mexico, and the United States) are all signatories.

Green Kingfisher

The Green Kingfisher, *Chloroceryle americana*, is a resident breeding bird which occurs from southern Texas in the USA south through Central and South America to central Argentina.

This small kingfisher breeds by streams in forests or mangroves. The nest is in a horizontal tunnel up to a metre long made in a river bank. The female lays three, sometimes four, eggs.

The Green Kingfisher is convert—19—cm—in long and weighs convert—27—g—oz. It has the typical kingfisher shape, with a short tail and long bill. It is oily green above, with white markings on the wings and tail, and a white collar around the neck.

Males have white underparts apart from a broad chestnut breast band and some green spotting on the flanks. Females have buff-white underparts with two green chest bands, the lower of which links to the green spotting along the sides of the belly.

Green Kingfishers are often seen perched on a low shaded branch close to water before plunging in head first after their fish prey. They also eat aquatic insects. These birds often give a pebbly rattling call.

Variation in this species is clinal. There are five subspecies:

Birds occurring on Trinidad and Tobago, usually included in *americana*, have a larger and heavier bill than the mainland forms, and are sometimes separated as subspecies *croteta*.

Kingfisher, Green

References

- [1] L. Bo and C. Sminchisescu. Twin gaussian processes for structured prediction. *Int. J. Comput. Vision*, 87(1-2):28–52, Mar. 2010. [1](#)