Backyard Ponds

Guidelines for Creating & Managing Habitat for Dragonflies & Damselflies

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Migratory Dragonfly Partnership

Canada • Mexico • United States

www.migratorydragonflypartnership.org

MIGRATORY DRAGONFLY PARTNERSHIP

Working to Understand and Conserve North American Dragonfly Migration

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Ontario Ministry of Natural Resources; Peggy Notebaert Nature Museum; Pronatura Veracruz; Rutgers University; Slater Museum of Natural History, University of Puget Sound; Smithsonian Conservation Biology Institute; St. Edward's University; U. S. Forest Service International Programs; U. S. Geological Survey; Vermont Center for Ecostudies; and the Xerces Society for Invertebrate Conservation.

Acknowledgements
Funding for the Migratory Dragonfly Partnership's work is provided by the U.S. Forest Service International Programs Migratory Dragonfly Project.

We thank Kathy Biggs for her review and helpful comments. Thanks also go to the photographers who generously allowed use of their images. Copyright of all photographs remains with the photographers.

Design and layout: Michele Blackburn.

Recommended Citation
Mazzacano, C., D. Paulson, and J. Abbott. *Backyard Ponds: Guidelines for Creating and Managing Habitat for Dragonflies and Damselflies*. 22 pp. Portland, OR. Migratory Dragonfly Partnership.

Front Cover Photograph
Common Green Darner (*Anax junius*) female laying eggs.
Photograph © Walter Chadwick.

Photograph Facing Page
Common Green Darner (*Anax junius*) male holds female as she lays eggs.
Photograph © Celeste Mazzacano.

Founded in 2011, the Migratory Dragonfly Partnership uses research, citizen science, education, and outreach to understand North American dragonfly migration and promote conservation of dragonflies and their wetland habitats.

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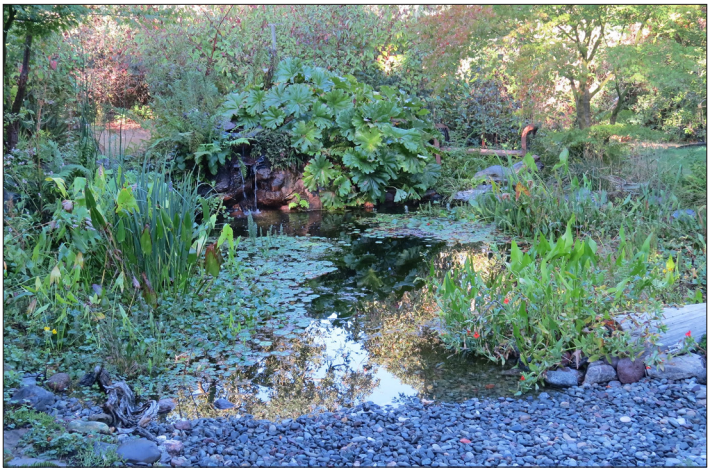
Water is the driving force of all nature. — Leonardo Da Vinci



A constructed backyard pond like this one in California can function as an urban oasis to a host of wildlife. Photo Celeste Mazzacano.

Who is this guide for?

This guide is for homeowners and other landowners interested in creating and providing backyard pond habitat for both dragonflies and damselflies, and other wildlife.

With the continued loss of many aquatic systems, digging ponds for dragonflies and damselflies can create stepping stones of habitat and provide much-needed aquatic resources to help replace wetlands that have been lost and degraded in many urban landscapes.

How do I use this guide?

This guide contains information about the creation, management, and maintenance of backyard ponds to attract native wildlife, specifically dragonflies and damselflies. Information contained in this guide includes:

- Life history information about odonates provided on pages 4–7.
- Pond creation described on pages 10–14.
- Key aspects of pond management described on pages 15–17.
- Literature cited and additional resources available on pages 19–22.

What are backyard ponds?

Backyard ponds are wildlife oases. With increased urbanization, creating aquatic habitat in your backyard will not only create a haven for dragonflies and damselflies, but will afford refuge for a diverse community of wildlife.

What do dragonflies need?

All dragonflies and damselflies are tied to aquatic habitats.

Dragonflies and damselflies need:

- Fresh water (except for one species that breeds in saltwater), either flowing or standing depending on species.
- Emergent, submerged, and floating aquatic plants for perching, roosting, and oviposition.
- Shallow water margins.
- Upland vegetation for adult refuge and shelter.
- Ideally, ponds will provide shelter from the wind and sunny areas for perching.

Facing page: Common Green Darner (*Anax junius*) female lays eggs. Photo Walter Chadwick.

Dragonflies and Damselflies:

Creating Habitat in Your Own Backyard

Introduction

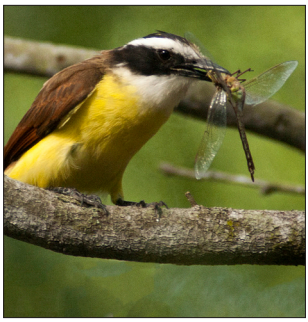
With their brilliant colors and bold flight, dragonflies and damselflies (Odonata; collectively termed odonates) are the most conspicuous, appealing, and easily recognized residents of almost any freshwater habitat. The immature stages (called nymphs, larvae, or naiads) are completely aquatic, while adults are dashing aerial acrobats. All North American species breed in fresh water, except one, the Seaside Dragonlet (*Erythrodiplax berenice*), which breeds in salt marshes and tidal estuaries.

Adults can be found in fields and forests, but must return to the water to mate and lay eggs. Some species require the running water of rivers and streams, but others prefer the slow still waters in ponds, marshes, and lakes, and many will visit or colonize artificial or constructed ponds and wetlands. As aquatic ecosystems worldwide are lost and degraded, the continued survival of odonates can't be taken for granted. For some wetland-dependent species, constructed ponds provide a much-needed oasis within a landscape of disappearing habitat.

In this book you will find...

- **Information on the importance of odonates**
- **Natural history of odonates**
- **Information on the benefits of ponds to odonates and other wildlife**
- **Steps to create pond habitat in your own backyard to attract odonates**
- **Pond maintenance**
- **Additional resources**

Importance of Odonates

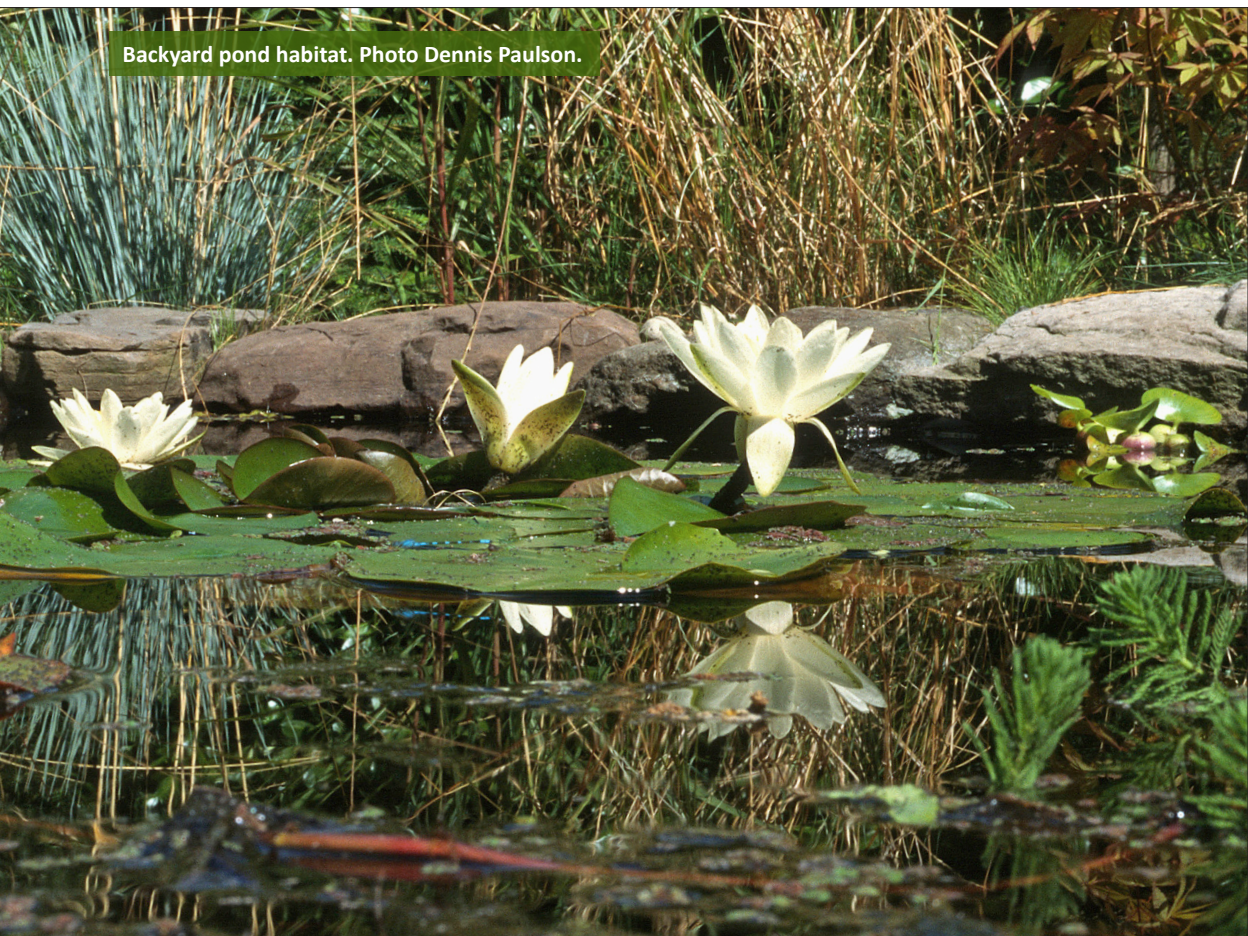


Great Kiskadee making a meal of a Common Green Darner (*Anax junius*). Photo Dennis Paulson.

Dragonflies and damselflies play important roles in aquatic and terrestrial habitats. Nymphs eat a variety of aquatic invertebrates, including mosquito and midge larvae, as well as small fish and tadpoles, and can be top predators in fishless ponds. Odonate nymphs are food for fish and amphibians, and adults are eaten by upland predators such as birds, bats, lizards, and spiders. Odonates can serve as indicators of different types of aquatic habitats and provide information about the biological health and diversity of a habitat.

Backyard Ponds as Habitat

Backyard habitats are part of the network that sustains biodiversity in urban and urbanizing landscapes by providing refuges and connectivity between green spaces. Backyard or constructed ponds create habitat for odonates and for other aquatic invertebrates such as water beetles and bugs. They create an oasis for birds and provide breeding sites for amphibians. Bees and butterflies are sustained by blooming emergent and upland vegetation, and butterflies can also use the pond as a "mineral lick". These ponds in turn provide us with many aesthetic and emotional benefits. Green space is important to the physical and mental health of people in urban areas, reducing stress and fatigue and increasing feelings of general health, well-being, and tranquility, and improving attitudes about neighborhood safety.



Backyard pond habitat. Photo Dennis Paulson.

Natural History

Development

Damselfly nymphs have 3 leaf-like gills at the end of the abdomen that also aid in swimming. Photo Celeste Mazzacano.

Odonate nymphs look nothing like the colorful aerial adults. Dragonfly nymphs are dull in color but come in a variety of shapes and sizes, such as sleek and streamlined, broad and flattened, and torpedo-shaped. These and other body shapes allow nymphs to lurk, burrow, or glide through vegetation, depending on the species. The abdomen is tipped with three short, stout spines surrounding a rectal gill chamber used to obtain oxygen from the water. Damselfly nymphs are minnow-like, with long, slender bodies tipped with three leaf-like gills that also help them swim. All are voracious predators, with a remarkable hinged, toothed lower lip that shoots out at high speed to snatch their prey.

Dragonfly nymphs have 3 stout spines at the tip of the abdomen, which houses an internal rectal gill chamber. Photo John Abbott.

Depending on the species, nymphal development takes a month to several years, and nymphs will molt (shed their skins) a dozen times as they grow. The adult develops within the final-stage nymph. When adult emergence is near, the nymph stops feeding and comes to the surface to breathe, then finally crawls up on the shore or a convenient stem, leaf, or rock. There, it splits its skin and within a few hours emerges as an adult, which looks quite rumpled until the wings expand and the body hardens.

This newly emerged adult, called a teneral, has shiny wings, weak flight, and hardly any pigment. The first flights of tenerals may take them a long distance from the water, where they quickly develop their definitive color pattern (though still not fully mature coloration). The adult may stay in a sexually immature stage for a few days to several months, remaining away from the water and concentrating on feeding as it matures.

Photo on left, a dragonfly splits its nymphal skin to emerge; wings still rumpled prior to unfurling. Photo Peg Serani. Photo on right, a newly emerged (teneral) Variegated Meadowhawk (*Sympetrum corruptum*) displays a distinct shine on its recently unfurled wings. Photo Dennis Paulson.

Variegated Meadowhawk (*S. corruptum*) in flight. Photo Dan Jackson.

Flight

Dragonflies and damselflies are accomplished fliers whose complex wings are perfectly structured for their intricate flight maneuvers. Not only does each pair of wings work independently of the others, but so does each wing. Dragonflies can fly at about the same speed as small songbirds (30 mph/48 kph), stop suddenly and hover, make instantaneous right-angle turns, shoot straight up in the air and even back up for a short distance.

Desert Firetail (*Telebasis salva*) male in flight. Photo John Abbott.

Vision

Odonate vision is the best in the insect world. The large eyes provide a wide visual field that allows the insect to see everywhere except directly behind its head. Each compound eye consists of up to 30,000 simple eyes (ommatidia) that give a mosaic view, and can detect movement, shape, and UV and polarized light. Excellent eyesight makes it relatively easy for an odonate to spot prey in the air or on vegetation.

Head of a Common Green Darner (*Anax junius*). Photo John Abbott.

Temperature Regulation

An odonate's body temperature is controlled by air temperature. On a cool morning, a dragonfly may rest perpendicular to the sun's rays to warm itself, often on a pale surface that reflects sunlight onto its body. Some whir their wings to warm their muscles enough to lift into flight. To avoid overheating, some odonates seek shade when their body temperature reaches a critical point, while others perch with their abdomen pointing up at the sun (obelisking) at midday or hanging down below them to reduce sun exposure.

A Blue Dasher (*Pachydiplax longipennis*) obelisking. Photo Walter Chadwick.

Eating and Being Eaten

Odonates capture their prey in the air. Some fly like a swallow and pick insects out of the air, while others watch from a perch like a flycatcher and take off after insects flying by. Many damselflies fly slowly through vegetation and pick tiny insects from leaves. They hold their spiny legs out like a basket to scoop up the insects they capture.

Despite being predators, adults and nymphs fall victim to a variety of animals, and are an important part of both aquatic and terrestrial food webs. Birds eat dragonflies in great numbers, especially during the breeding season when they feed their young on tender tenerals. Bats eat them at dusk, frogs and fish jump out of the water after adults, spiders catch them in webs or hunt them down, lizards and robber flies stalk them in the uplands, and they will also hunt and eat each other.

A Yellow-headed Blackbird catches two Pacific Forktails (*Ischnura cervula*). Photo Dennis Paulson.

Eastern Pondhawk (*Erythemis simplicicollis*) eating an Eastern Amberwing (*Perithemis tenera*). Photo Dennis Paulson.

A Pacific Forktail (*Ischnura cervula*) falls victim to a carnivorous sundew plant (*Drosera* sp.). Photo Celeste Mazzacano.

A Western Fence Lizard catches a Common Whitetail (*Plathemis lydia*). Photo Dennis Paulson.

Reproduction

Dragonflies and damselflies return to the water to breed, and mature males spend long periods at the water searching for potential mates. Males of many species defend a territory against other males of the same species, thus giving them access to any female entering their territory without interference from other males. Males of non-territorial species cruise around lake shores or up and down rivers searching for females, and will give chase to other males of their species when they encounter them.

Odonate mating is a complex dance. Before encountering a female, a male dragonfly transfers sperm from a pore near the tip of his abdomen to an organ near the base of the abdomen, where it is stored for immediate use. Damselflies wait to do this until they have a female in tow. When a male encounters a female, he attempts to clasp her behind the eyes (dragonflies) or head (damselflies) with the appendages on the end of his abdomen. If the female is willing, she swings her abdomen up to the base of the male's, and they lock in copulation. The two now form a circle, often called the wheel position.

Yellow-sided Skimmer (*Libellula flavida*) pair in mating wheel. Photo John Abbott.

Copulation lasts from a few seconds in flight up to several hours at rest. Females of most species lay eggs immediately after mating. In some species, the wheel breaks but the male continues to hold the female, and they set off in tandem to lay eggs. In other species, the male releases the female but accompanies her to prevent others from mating with her. In still others, the female goes on her solitary way to lay eggs.

Springwater Dancer (*Argia plana*) pair in tandem. Photo John Abbott.

Dragonflies use a variety of techniques to deposit their eggs. Female damselflies and some dragonflies have a well-developed ovipositor that injects eggs into plant tissue, while other dragonflies simply drop their eggs in or near water. Females of some species tap their abdomens repeatedly on the water to lay eggs extruded in a ball at the tip, while those of other species lay eggs on dry land in seasonal wetlands that flood later. One female can lay thousands of eggs, scattering them over a wide area to increase the likelihood that eggs and nymphs will survive.

Benefits of Ponds to Odonates

Created and restored ponds increase local odonate species diversity, improve habitat connectivity and facilitate movement across the landscape. They also provide refuges where both common and locally rare species can thrive. Such ponds can achieve moderate to high levels of odonate diversity in as little as a year or two, with species diversity comparable to that at nearby natural wetlands. They are also excellent outdoor classrooms for environmental education.

Benefits of Backyard Ponds

- **Increase local species diversity**
- **Provide refuges for common as well as locally rare species**
- **Improve habitat connectivity**
- **Provide habitat features that may be missing from the local landscape**
- **Provide education opportunities**

Increased isolation of wetlands can decrease odonate species richness, and habitat specialists may be less likely to disperse over long distances to visit or colonize new habitat. Constructed ponds can help remediate the isolation resulting from wetland degradation and destruction, allowing increased movement and breeding of both common and rare species. Small ponds created to water livestock in the mountains of Italy provided important habitat in a region that lacks surface water, and odonate diversity increased in ponds protected from livestock grazing. A series of ponds created on the properties of major local industries in Japan enabled an endangered species found previously at only a single site to colonize and breed successfully at six of the study sites. Similarly, farm ponds and restored wetlands can provide habitat features missing from the local landscape in agricultural regions and sustain increased diversity and abundance of aquatic invertebrates, including vulnerable and rare odonate species.

A constructed backyard pond nine years after establishment. Photo Dennis Paulson.

Ponds are excellent outdoor classrooms for children and adults. Photo http://www.public-domain-image.com/.

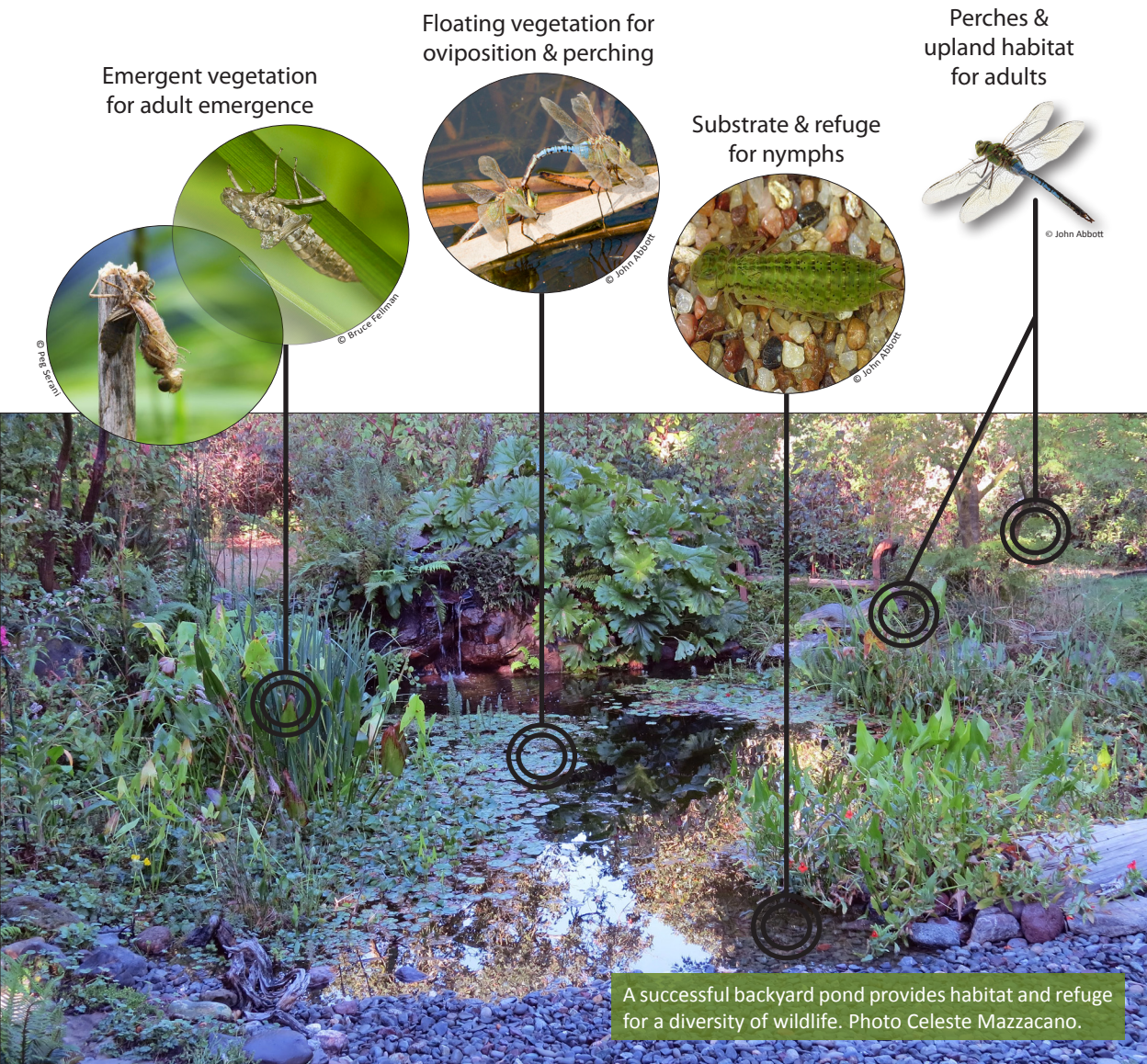
Urbanization has been suggested to lead to odonate communities composed of common generalist species. However, in a landscape where wetlands are degraded or destroyed, even common species can decline, and pond habitats designed with the needs of dragonflies in mind, including a variety of water depths and aquatic and edge vegetation, can increase occurrence of regionally rare species as well as generalists. In Yokohama, Japan, where urbanization and industrialization destroyed much wetland habitat, re-design of a concrete-lined ornamental fish pond that was previously inhabited only by three common species of odonates allowed it to be used by a total of 27 species. The success of this project spurred restoration of many other similarly degraded ponds in the area and these created ponds are now used as outdoor classrooms for children to learn about dragonfly ecology and conservation.

Creating Pond Habitat

Basic Needs

Dragonflies and damselflies have the same basic needs as any animal: clean water, abundant food, and places to find refuge, mate, and reproduce. In constructed and restored ponds, water persistence and the amount and structure of aquatic vegetation has a major influence in determining species assemblages, while pond age and surface area are less important. Because some species complete development from egg to adult within a few months to a year, while others may take two to five years to become adults, the permanence of water in a pond determines which species survive.

A diversity of aquatic vegetation is vital for a good dragonfly pond; plants take up nutrients, oxygenate and cool the water, create shelter and habitat for nymphs and their prey, and provide a stable surface for adult emergence. For adults, vegetation provides perches to use when seeking mates or guarding territory, and oviposition substrate for species that lay their eggs in or on plant tissue. Upland vegetation gives perches for nighttime roosting, territory patrol, hunting, mating, and a refuge from bad weather, wind, heat, and predators. Individual plant species matter less than the structure and diversity of vegetation in and around the habitat, along with patches of open water.



A successful backyard pond provides habitat and refuge for a diversity of wildlife. Photo Celeste Mazzacano.

Pond Construction

A pond does not have to be large and complex to have the elements needed for odonate colonization and breeding. The minimum viable area for a dragonfly pond has been estimated at around 43 ft² (4 m²). Odonates visit smaller ponds and some, such as damselflies, may even breed successfully, but a larger pond makes it easier to incorporate the range of water depths and plant types odonates need, and will develop better as a stable ecosystem that requires less maintenance. The shape of the pond is up to the individual, as it won't affect the likelihood of usage by odonates, and will be influenced by the site where the pond is being installed as well as the liner material used. Sinuous or irregular outlines make a more natural-appearing, pleasing shape for the human observer compared to a round or rectangular pond, while a more regular shape will result if a pre-formed pond is used.

Selecting the Site

Avoid situating the pond directly beneath overhanging trees, as they can shade and cool the shallows too much and foul the water with decomposing leaves. If proximity to trees is unavoidable, try to place the pond so that no more than one-third of its area is overhung. Even if trees don't directly overhang the pond, their shade can reduce plant productivity and attractiveness to sun-loving odonates, so in general trees and woody vegetation are advised at no more than one side of a pond. However, trees or large shrubs at the west side of the pond can provide shade during the hottest part of the day. Consider also your desired ease of access for cleaning and tending the pond; you may prefer to dig a pond small enough so that all parts of it can be reached using a long-handled skimmer net (15 x 20 ft [4.5 x 6 m]), whereas you may have to wade into a larger pond to conduct maintenance.

Avoid areas that get a lot of runoff, as this may lead to flooding and wash in contaminants such as pesticides, herbicides, fertilizer, and oil. If run-off is unavoidable, consider surrounding the pond with a protective berm, which can be landscaped and planted to give it a more natural look. Be sure to create a topography that allows a range of water depths and

Pond Construction: Elements to Consider Before Digging Your Pond

- **Select an area with few overhanging trees**
- **Designate a minimum viable area of 43 ft² (smaller may also be feasible)**
- **Consider sinuous, natural-appearing outlines**
- **Provide habitat with a variety of water depths**
- **CALL BEFORE YOU DIG. Call local utilities to avoid buried lines**
- **Deepest depth to consider (2.5–6.5 ft [0.8–2 m]) will depend on pond size and should avoid freezing in deeper parts in winter**
- **Use a pond liner in well-drained soils**
- **Install a diversity of plant species and a variety of vegetation types (submerged, floating, emergent, plus shrubs and other upland plants)**

Pond creation should incorporate a variety of water depths to provide maximum habitat benefits. Photo Dennis Paulson.

ensures plant diversity both in and around the pond. Your pond may also need an outlet to direct any overflow that could result during periods of heavy rain. An overflow outlet can be artificial, i.e., a piece of pipe placed at the top of one edge of the pond to direct overflow to a desired area of the yard, or it can look more natural, i.e. a shallow rock-lined channel that directs overflow away from the pond.

Deciding on Your Pond Depth

The pond must provide a variety of water depths, from gently sloping shallows, where floating and emergent plants can grow and dragonfly and damselfly nymphs can warm themselves, to deeper areas that provide safety from predators and a cool refuge on a hot afternoon (this area will also be the warmest in winter). The deepest parts of the pond should not freeze solid in winter; a depth of 2.5 feet (0.8 m) in smaller ponds (up to 20 m^2/215 ft^2) and of 4 ft (1.2 m) in larger ponds should accomplish this. In larger ponds in colder parts of the continent, a maximum depth of 3.2–6.5 ft (1–2 m) may be needed.

Digging Your Pond

Consult your local utilities before digging to avoid buried gas, power, or water lines. Experiment with different pond shapes by laying out string or a hose on the ground. Once a desired shape is determined, make an outline using spray paint. Additional outlines can be marked off and labeled with the desired depth. Note that you will want to dig an additional one to two inches below the desired depth to accommodate the thickness of the pond liner and protective under layer. Remove all the grass or sod in the outlined shape; try to dig so the edges are at the same height all the way around (it is recommended to level the area first). Strips of sod can be laid aside and used later to build a protective berm, if needed. Next, dig down from the edges to create a gentle slope that extends to a shallow planting shelf about 1 ft (0.3 m) wide and 9–18 in. (0.2–0.5 m) deep; this edge depth may also help keep raccoons out once the pond is filled. Continue to dig additional slopes and shelves until you reach your desired maximum depth. One edge of the pond may also be dug with steeper, more vertical edges, as this can maintain an open water area that will be slower to fill in with aquatic plants.

The soil removed during digging can be set aside, sifted to remove rocks and twigs, and used later as either a protective layer beneath the pond liner, or to provide soil for landscap-

Most constructed ponds will require a water-tight liner to retain water. Photo Dennis Paulson.

ing and planting. If you anticipate entering the pond to perform maintenance, you may want to create steps leading into it at one edge, as an algae-coated pond liner can be very slippery. Steps can be created by stacking sandbags under the liner.

Once the pond is dug, the area must be covered with a thin protective layer before being lined to prevent the liner from being punctured. Some pond supply companies sell a pond liner underlay, but sifted soil, damp sand, newspaper, or even old carpeting can be used. After the underlay is in place, spread the pond liner out over the excavated area, and gently pat or press it into place, removing as many wrinkles as possible. The British Dragonfly Society recommends the following formulas to calculate the amount of lining needed (note: the added 1.8 in [50 cm] leaves a rim that extends beyond the pond edges and can be anchored with rock):

- liner length = pond length (X) + twice the maximum pond depth (Z) + 1.8 in (50 cm)
- liner width = pond width (Y) + twice the maximum pond depth (Z) + 1.8 in (50 cm)

To Line or Not to Line Your Pond

If your soil has extremely high clay content, you may not need a pond liner, especially if you can compact the area beneath the pond after digging by pounding it with a 2 x 4 or a baseball bat. In most areas, however, some type of liner will be needed to retain water. Hardware, garden supply, and specialty pond stores offer stiff pre-formed ponds, but these lack the necessary variations in depth and come in a limited variety of shapes and sizes. A pond can be dug to the shape and size of your choosing and then lined with 45 mil PVC, polyethylene, butyl rubber, or EPDM rubber pond liner.

Filling Your Pond

Fill the lined pond one-half to two-thirds full with water, smoothing or gently spreading out wrinkles in the liner as you go. If your water supply is heavily chlorinated, you may want to let the water sit for a day before planting to allow the chlorine to dissipate, although it's not unusual for dragonflies or damselflies to start investigating the pond as it is being filled. Staff at your local fish store is likely to know if the water is chlorinated, and may recommend products that can be added to dissipate the chlorine.

Planting Vegetation

A variety of aquatic vegetation can help control algae while providing areas for odonates to perch as well as lay their eggs. Photo Celeste Mazzacano.

The pond is now ready to be planted. A diversity of vegetation in and around the pond will offer a variety of food and cover for wildlife. Recommendations include total vegetation cover of 50–70%, consisting of 5% emergent, 10–25% floating, and 25–50% submerged plants, with areas of open water maintained. Plants can be set in mesh baskets or plant pots at the desired location and depth. Use soil with substantial clay content, as planting mixes will float. A layer of gravel on top of the pot will help prevent soil from floating out. The area at the pond margin and up to a few meters away should be planted with grasses, sedges, forbs, and shrubs, but leave one or more paths and small "beaches" for ease of observation and maintenance, and to facilitate pond access by small wildlife. Consult your local garden store or native plant society to find out what native species are appropriate and available in your area.

Additional Habitat Elements

A few large, light-colored rocks at the edge of the pond will provide places for adult dragonflies to perch and warm themselves. Logs or large tree branches laid at the pond edges and/or in the pond provide additional places for dragonflies to perch and in some species, lay eggs, and provide pathways into and out of the pond for a diversity of visiting wildlife such as birds, turtles, and frogs, as well as an escape route for any unwary, non-swimming wildlife that might otherwise become trapped.

If you enjoy gardening, installing nearby plantings that mimic a native meadow or a wildflower garden helps sustain insects that are eaten by adult dragonflies and damselflies, and provides places for additional wildlife to perch, shelter, or feed. Consult your local native plant society and local nurseries for native wildflower lists; regional wildflower lists for bees and other beneficial insects are also available from the Xerces Society for Invertebrate Conservation (http://www.xerces.org/plant-lists/).

It is not recommended to stock the pond with fish, as they prey on dragonfly and damselfly nymphs as well as other aquatic invertebrates that the nymphs rely on for food, and their wastes contribute additional nutrients to the water, which can decrease water quality and increase algal blooms. Ponds with fish can support stable odonate populations, but be aware that when fish are present production of adults may be decreased and the overall odonate community composition altered. If you want fish as a part of your pond community, consult your local natural resource experts to see what small native fish in your area might be good pond citizens.

Logs placed near pond edges provide perches and safe routes into and out of the pond for visiting wildlife like this Pacific Chorus Frog. Photo Celeste Mazzacano.

Pond Maintenance

True bugs like this water boatman (Corixidae) are beneficial inhabitants of ponds and other still waters. Photo John Abbott.

If you Build it, They will Come

Controlling Algae

It will take some time for the plants and animals in your pond to become fully established—be patient! A greater abundance of algae for the first six months is not unusual; this gives the water a green color but is not harmful. Algae problems clear up as the aquatic plants mature, as the growing plants cool the water and take up the excess nutrients that help algae thrive. Use of floating plants such as duckweed and azolla in the first year will help decrease the amount of light available for algae to grow.

Development and Reproduction

You may see dragonflies and damselflies investigating or even laying eggs in your pond as it is being planted, but be aware that development of nymphs to adults may not occur in the first year. If the nearest wetland is more than a few miles away, it will take longer for new colonists to find your pond. A bucket or two of water and mud taken from a nearby pond or wetland will seed your pond with naturally-occurring aquatic invertebrates and plants, but be sure not to venture too far afield to avoid introducing species that are either non-native or not adapted to your local conditions.

Black Saddlebags (*Tramea lacerata*) in tandem linkage, cruising over a pond. Photo Dan Jackson.

Plants

While the plants are maturing, a few stakes and branches should be placed at the pond margins to provide surfaces for nymphs to crawl up onto for adult emergence. Some plants may need to be thinned or removed if they begin to take over the pond. Herbicide use is not recommended, as this can impair water quality and harm wildlife. In addition, decomposition of dead plants decreases dissolved oxygen levels and creates improved conditions for mosquito breeding.

Over time, ponds fill in with sediment and plant growth may become excessive, so a regular cleaning schedule should be established. Cleaning can be done every two to three years as needed, and involves removing fallen leaves, excess algae or dominating floating plants, decaying plant material, excess sediment, unsightly debris, and any invasive species that may have colonized. Check with your state or local natural resource agency, native plant societies, nurseries, University Extension department, or Master Gardener group to learn which aquatic plants are considered invasive in your area.

Development of early life stages, like this Black Saddlebags (*T. lacerata*) nymph, may take an additional growing season following the first year of pond construction. Photo John Abbott.

Winter is generally a good time for pond maintenance, as most creatures are dormant. Dragonfly and damselfly nymphs, as well as aquatic beetles, bugs, and snails lurk in the sediment and vegetation so as you skim, rake, scoop, or pull material from the pond, be careful not to permanently remove any clinging or buried pond denizens. Material removed from the pond can be piled near the edge for a day or two to allow trapped organisms to crawl back. It can also be placed in a bucket or tub with some pond water added, then stirred and swirled around as you pick through it with fingers or tweezers. Any pond residents found can be returned to their home—a great way for you to get to know who is living there!

Managing Mosquitoes

Mosquito production can be a concern to pond owners or their neighbors. Once the pond is established it may produce few or no mosquitoes, as populations are controlled by dragonfly and damselfly nymphs and other predatory aquatic invertebrates such as copepods, water bugs, and diving beetles. Your pond may also be home to vertebrate wildlife such as frogs and salamanders that feed on mosquito larvae. The first step is to determine whether mosquito production is actually occurring. Some species breed readily in stagnant water in untended gutters and wading pools, abandoned swimming pools, dog dishes, and water pooled under leaky faucets, so a perceived problem with mosquitoes in your neighborhood may not arise from your backyard pond. Sampling the pond edges using a mosquito dipper (basically, a white plastic cup attached to a pole) will tell you whether mosquito larvae are present or not. Be careful not to confuse them with larvae of non-biting midges (Chironomidae), which are an important food source for aquatic animals and can comprise a large proportion of the biomass in a pond or wetland (see photo at left for a side-by-side comparison).

Photo on left, mosquito larvae, photo James Gathany, Wikimedia Commons; photo on right, non-biting midge larva, photo Frank Fox (www.mikro-foto.de), Wikimedia Commons.

Predaceous beetles like this member of the Dysticidae family can help control mosquito reproduction in ponds. Photo John Aboott.

Mosquitoes breed in standing water, so installing a small waterfall can help increase water movement and discourage mosquitoes. Using open water pumps without screening is not recommended, as they can pull in and kill dragonfly and damselfly nymphs. Introduction of the mosquito fish (*Gambusia* spp.) is likewise not recommended to control mosquitoes; this fish is non-native throughout much of North America, is a voracious generalist predator that eats a wide array of aquatic invertebrates as well as tadpoles and developing salamanders, and has such a rapid reproductive rate that it can quickly take over a small space. In some cases *Gambusia* introduction can actually worsen a mosquito problem, as they eliminate the predatory bugs, beetles, and crustaceans that would otherwise prey on mosquito larvae.

If mosquitoes become an issue, the pond can be treated with "dunks" or briquettes of a biological control agent called *Bacillus thuringiensis israelensis*, or Bti. This bacterium produces a crystalline protein toxin that disrupts the guts of mosquito larvae that eat it, killing them before they can develop into adults. Bti is only toxic to members of the order Diptera (true flies), so be aware that other groups such as beneficial non-biting midges and crane flies can also be affected. Mosquito and midge larvae are an important food source for many pond-dwelling animals, so consider very carefully whether, when, and how frequently treatment is needed.

Watching the Water Level

In hot weather it will be necessary to top off the water level in your pond regularly. You can use collected rain water or a hose. If you are using municipal water and are concerned about chlorine content, set the water out in buckets for a few days to allow the chlorine to dissipate; be sure to cover the buckets with fine screening to prevent mosquitoes from finding them and laying their eggs.

A Pond for All Seasons

The benefits of backyard dragonfly ponds can't be overstated. They create habitat for a variety of local wildlife, provide relaxing and rejuvenating natural spaces for quiet contemplation,

nature-watching, and photography, and generate environmental education opportunities for children and adults. Each season brings a different aspect to your pond and something new to see among the plants and animals it sustains. These observations may be purely for your own enjoyment, but backyard ponds can serve another important purpose—advancing our knowledge about dragonflies and damselflies.

Odonates may seem like a well-studied group, but there is still a lot we don't know about their distribution, ecology, and behavior, especially when it comes to their spectacular annual migrations. The dragonfly species best known as regular migrants in North America are wetland-dependent, and you may find Common Green Darners (*Anax junius*), Black Saddlebags (*Tramea lacerata*), Wandering Gliders (*Pantala flavescens*), Spot-Winged Gliders (*Pantala hymenaea*), or Variegated Meadowhawks (*Sympetrum corruptum*) visiting your pond or its surroundings to rest, hunt, and possibly even mate and lay eggs, depending on the species. If so, consider submitting your observations to Pond Watch (www.PondWatch.org), a volunteer-based project of the Migratory Dragonfly Partnership (MDP; www.migratorydragonflypartnership.org/) which is investigating the annual movements and local life histories of migratory dragonfly species in North America. You may also be interested in submitting photographic vouchers of your odonate pond visitors to OdonataCentral (OC; www.odonatacentral.org), a volunteer-based project aimed at increasing our knowledge about the distribution and biodiversity of all dragonflies and damselflies in the New World.

No matter what your motive is for establishing a backyard pond—conservation, recreation, research, relaxation, or all of the above—you can be certain that both you and the local odonate populations will benefit!

Amanda's Pennant (*Celithemis amanda*) taking advantage of a pond-side perch. Photo John Abbott.

For More Information

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Northern Spreadwing (*Lestes disjunctus*). Photo John Abbott.

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PondHabMDP_Apr2014