/ INTRODUCTION /

How do wild plants and animals in the city find mates? To explore this question, I invite you to join me on a stroll around downtown Philadelphia.

Our walk starts along a block of rowhouses. We chance upon a clump of annual bluegrass (*Poa annua*) in a sidewalk crack. The plant is ankle high and about as wide as my shoe. Intermingled with its deep green blades are minute greenish-white flowers. This species inhabits almost all major cities worldwide. It occurs in more cities than does any other flowering plant.[1] This particular clump faces a common urban problem: scarcity of nearby prospective mates.

Pavement and buildings in cities fragment populations of wild plants and animals. Denied mates, solitary individuals may fail to reproduce. Small, isolated urban populations may inbreed and lose genetic diversity. They may weaken and go locally extinct.[2]

Annual bluegrass can self-fertilize and cross-fertilize. Wind pollinates it.[3] Self-fertilization ensures that our clump of annual bluegrass will produce seed regardless of its ability to secure a mate. On the other hand, cross-fertilization would potentially produce offspring with more genetic diversity and more vigor, and it would avoid inbreeding.[4]

Sidewalk Cracks

As our stroll continues, we find other solitary clumps of annual bluegrass growing in cracks in this sidewalk. The smooth, flat surface of the sidewalk eases dispersal of grass seed by wind and water. The cracks trap the seeds along with organic debris. They act as soil composters and plant nurseries. They protect seedlings from trampling.

Farther down the block, clumps of blooming annual bluegrass in sidewalk cracks coalesce into linear arrays consisting of many plants. Our sidewalk brings clumps of annual bluegrass together even though it also disperses them. We suspect that this sidewalk helps flowering annual bluegrass mix and mate, increasing chances for cross-pollination.

Walking along the sidewalk, we contemplate our roles as seed dispersers. The botanist Henry Clifford recovered viable seeds from footwear of students returning to England from a trip to Ireland. From these seeds he grew 42 species, including annual bluegrass.[5] As our shoes tread the pavement, we disperse seed of annual bluegrass.

We track these seeds onto the street, where cars pick them up. The botanist Wolfgang Schmidt collected seeds from wheels and mud guards of one car driven for one season in the surroundings of Göttingen, Germany. From these seeds he grew almost 4,000 seedlings and over 100 species, including annual bluegrass. He concluded that vehicular dispersal of seed is the source of most roadside flora.[6] Applying these findings to our stroll in the city, we suspect that our foot traffic, combined with vehicular traffic, promotes genetic mixing over a wide area. In the city, annual bluegrass has incorporated us into its mating system.

Courtyard Gardens

Now we contemplate a courtyard garden behind a rowhouse. A brick wall and the rear of the house completely enclose the courtyard. The soil organisms within this garden are trapped within the courtyard. Their potential for outbreeding would appear at first glance precariously low. But think of our own gardens. Their soil contains abundant organisms: earthworms, snails, slugs, millipedes, centipedes, pill bugs, spiders, springtails, proturans, and diverse insects.[7] Every time we plant a shrub or tree with a root ball, we incidentally introduce into the soil new invertebrates.[8] For soil animals in isolated courtyard gardens, people like us facilitate outcrossing.

Door Lamps, Glass Façades, and Highways

A few doors down from this courtyard garden a common looper moth (*Autographa precationis*) rests on a wall beside a door lamp. Here, we consider another barrier to mating in the city: light pollution. Nocturnal light from the door lamp may interrupt mating and pollination by this moth. Nocturnal light pollution compounds polarized light pollution, which occurs during the day. Polarization of light reflected off shiny surfaces like glass façades confuses flying aquatic insects that normally orient using polarization of light reflected off water. These insects mature in water but mate out of water.

Highway traffic generates acoustic noise pollution. Acoustic noise masks songs of birds, frogs, and insects. Water pollution disturbs sexual differentiation in fish. It causes intersexes—fish with male gonads containing oocytes (cells capable of forming eggs). Sexual effects of pollution are not always negative. Door lamps promote mating of spiders that feed on insects attracted to light.

Urban Canyons

Our stroll about the city reaches blocks lined with the tallest buildings. For most of the day these urban canyons shroud streets and walkways in shadows. They shut out most visible forms of life other than people and ornamental plantings. Here we find no plants colonizing pavement cracks. These blocks demonstrate how pavement and buildings act as barriers in ways that are not specific to sex. For most wild plants and animals, they block basic functions required to sustain life.

While these barriers are formidable, organisms do meet and mate here, both indoors and outdoors. They include the oriental cockroach and bedbug. Jason Munshi-South, an urban evolutionary biologist at Fordham University in New York City, and colleagues, have used molecular genetics to track dispersal of populations of wild animals in Manhattan and other parts of New York City. They discovered that several species of mammals disperse within the city. They include coyotes, Norway rats, and white-footed mice.[9] By contrast, they found that populations of the urban dusky salamander in Manhattan were genetically isolated; they were confined within two tiny aquatic seeps in a degraded urban forest.[10]

Ports, Railroads, and Interstates

We enter a skyscraper (One Liberty Place) to visit its observation deck overlooking the city. Looking out from the 57th floor, we see bridges spanning rivers; barges and freighters; ports linked to networks of interstates and railroads; and air traffic. As hubs of commerce and transportation, cities historically have catalyzed genetic mixing. In recent centuries they have done so on an industrial global scale. In the nineteenth century, sailing ships arriving with empty holds dumped ballast mixed with plant material in port cities. By 1880, ballast plants around New York City encompassed over 350 species.[11] Here genetic varieties from foreign ports around the world could meet and mate.

Hulls and cargo of ships have also unintentionally transported organisms.[12] In contrast to sailing ships, modern ships discharge ballast in the form of water. They introduce marine, brackish, and freshwater organisms around port cities.[13] The steady influx of introduced species worldwide testifies to the power of trade and shipping to disperse organisms that then mix and mate. Introductions are often intentional, such as those involving ornamental plants and fish.

Lawns and Vacant Lots

Back on the sidewalk, we walk out of the urban canyons and view municipal open space covered with turf. When not treated with herbicide, lawns support outcrossing in wild plants, as in the case of white clover. Vacant lots are scarce in this prosperous neighborhood compared to neighborhoods remote from downtown. Vacant lots function as refuges for herbaceous plants too big and unsightly for turf and sidewalk cracks. Loss of vacant lots downtown reduces genetic stock available for outcrossing of wild plants.

Green Verges and a River

We follow the sidewalk to a river trail. It runs between railroad tracks and the Schuylkill riverbank. Along this trail and tracks are green verges that connect semiwild urban green spaces. Similar verges along roads link urban forests to naturalized settings in parks and cemeteries. The river itself acts as an aquatic corridor connecting wetland plants and animals for miles upstream and downstream. A fish ladder helps migrating American shad surmount a dam.[14]

The City

The city exposes mating systems to a patchwork of habitats, each with opportunities and challenges. We have viewed a wide range of habitats, from pavement cracks to urban canyons. Most are integral to cityscapes globally. They provide places for reproductive diversity in cities around the world.

This book focuses on reproductive diversity in one city. While some of the species it presents may not occur in your region, the basic kinds of mating systems that the species represent occur worldwide and are taxonomically widespread. This book may serve as a reference for reproductive diversity in cities generally. I hope it encourages you to explore urban reproductive diversity close to home, wherever you may live. We conclude our journey with a photographic look at cities around the world.

Urban canyon, Seventh Avenue, New York City. Suppression of wild plants and animals here is not limited to sexual reproduction but is general to most functions essential for life. (See page xvi.)

Times Square 2, by Casper Moller (CC BY 2.0). Image exposure adjusted. URLs on page 162.

Pavement crack, Monfalcone, Italy. Pavement cracks constitute the predominant reproductive habitat of plants growing wild in habitats covered with asphalt and concrete.

A Very Simple Image of Some Pansies…, by Alex Brollo (CC BY-SA 3.0). URLs on page 162.

Annual bluegrass (*Poa annua*) in bloom, Philadelphia. The downspout has watered the plant and will soon disperse its seeds. Pavement cracks will trap many of these seeds. The cracks will protect and nurture seedlings. (See page xv.)

Screenshot

Vacant lot, Nazareth, Israel. Vacant lots in cities are refuges for birds and bees.[15] They are also repositories for genetic stock of wild urban plants.
(See pages 17 and 26.)

Vacant Lot with Wildflowers—Nazareth—Israel, by Adam Jones (CC BY 2.0). Image cropped. URLs on page 162.

Mission Dolores Park, San Francisco. In the absence of herbicides, lawns support reproduction of wild plants, as illustrated by the carpet of tiny white flowers in the foreground. Lawns provide long-lasting, expansive habitat, encouraging cross-pollination. (See page 27.)

Memorial Day 2020––San Francisco Under Quarantine, by Christopher Michel (CC BY 2.0). Image cropped. URLs on page 162.

Powązki Cemetery, Warsaw, Poland. Cemeteries and churchyards provide stable, long-term habitat for breeding populations of wild urban plants and animals, but intensive management can degrade their biodiversity.[16] (See pages 61 and 119.)

Muslim Cemetery (Tatar) Powązki, by Jolanta Dyr (CC BY-SA 3.0). Image cropped. URLs on page 162.

Valley Parkway, Mill Stream Run Reservation, Cleveland Metroparks, Ohio. Roads disperse seeds and spores, supporting genetic mixing;[17] but they also divide and degrade habitat.[18] (See pages 86 and 90.)

Low Water Ford of Valley Parkway…, by Chris Light (CC BY-SA 4.0). Image cropped and exposure adjusted. URLs on page 162.

Railroad, Plymouth, England. Plants along railroad tracks may function as green corridors connecting habitats.[19] (See pages 18 and 29.)

Towards Laira Rail Depot, by Graham Richardson (CC BY 2.0). Image cropped and exposure adjusted. URLs on page 162.

Shinjuku, Tokyo, at night. Artificial lighting at night disrupts mating and pollination by nocturnal insects. In cities it coexists with other severely disruptive disturbances.[20] (See page 21.)

Kabukicho Red Gate…, by Basile Morin (CC BY-SA 4.0). Image cropped. URLs on page 162.

"Moth night" at Bartram's Garden, Philadelphia. This wooded, naturalized urban site is 4 kilometers (2.5 miles) from downtown. Visitors are focused on the striking diversity of insects attracted to an illuminated sheet. The lamp emits ultraviolet and visible light. (See page 67.)

Treptowers, Berlin. Polarization of daylight reflected off glass façades disorients diurnal flying aquatic insects. These insects navigate ordinarily using polarization of daylight reflected off the surface of water. They mate out of water. (See page 61.)

Treptowers, Berlin, by Ansgar Koreng (CC BY-SA 4.0) Imaged cropped and exposure adjusted. URLs on page 162.

Jackhammer, Washington, D.C. Acoustic noise masks mating calls emitted by birds, frogs, and insects. (See page 111.)

Photo by Erik Calonius

The Seine, Paris. Pollution and damming of urban rivers interfere with migration of fish to spawning grounds. On the Seine these reproductive barriers have recently moderated, and populations of migratory fish have partly rebounded.[21] (See page 91.)

Seine @ Paris, by Guilhem Vellut (CC BY 2.0). Image cropped. URLs on page 162.