URBAN MONARCH CONSERVATION
GUIDEBOOK

The Field Museum

LANDSCAPE CONSERVATION
COOPERATIVE NETWORK

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Executive Summary

The monarch butterfly is one of the most recognizable species in North America. From childhood to adulthood, many people relate to the transformation of the caterpillar to butterfly; we see monarchs raised in the classroom, we watch with excitement when they visit our gardens, and we are inspired as we witness hundreds if not thousands gather in a field during migration. Unfortunately, experiences with this iconic butterfly are occurring less often as the population declines.

A main reason for the 80% decline in the Eastern monarch migrating population is loss of habitat; this includes milkweed, which is the host plant for monarch caterpillars and the only plant on which females can lay their eggs, and nectar flowers the adult monarchs need for food.

How can we work together to secure the future of this ecologically and socially significant species? No one sector or organization can do it by themselves. All land use types, including agricultural communities, utility and transportation rights-of-way, and urban spaces, have to play a role in the effort to protect the monarch butterfly.

Urban spaces are often overlooked during traditional conservation planning processes and offer great potential to connect 8 out of 10 U.S. residents to nature in their own backyards. The monarch butterfly's ability to thrive in small patches of habitat, make it especially suitable as a flagship species in cities and towns. The role cities can play in monarch conservation--and in providing habitat for pollinators and other wildlife--is more important than previously recognized. In fact, a large metropolitan region such as Chicago has over 16 million stems of milkweed already on the ground, and through strategic outreach with different land users, that number could jump to over 35 million stems. While the prospects for adding milkweed stems will vary from city to city, there is clearly potential for cities to make a difference in monarch conservation- both through engaging millions of people on the topic and by putting functional habitat on the ground to support the monarch population.

Opportunities abound in urban areas to put milkweed and nectar plants on the ground, from schoolyards, churchyards and parkways to cultural institutions, corporate campuses and vacant lots. There are clear co-benefits of working with urban communities to plant monarch habitat on the ground, ranging from helping to absorb stormwater to increasing social cohesion.

This Guidebook describes why urban areas matter for monarchs and other pollinators, and provides tools and guidance to gain a deeper understanding of where are the best places and what are the best ways to put habitat on the ground at the local scale. Let's start planning, and planting, for a brighter future.

1 Why look at *urban* monarch conservation?

Each year, people across North America bear witness to one of nature's most dramatic events: the twice annual monarch butterfly migration. In March, adult monarchs leave their wintering grounds, a small area of coniferous forest in the mountains of Michoacán in central Mexico, to begin their northward journey. These butterflies stop to lay eggs in the southern United States, and their offspring continue the migration to the Upper Midwest and southern Canada. Each generation of monarchs must find milkweed plants to lay their eggs on because that is the only plant on which the caterpillars can feed. In late summer and early fall, adult monarchs that emerge in the north do not breed but instead prepare to migrate south. This generation of butterflies flies the entire 2000 to 3000 mile route, fueling the trip on nectar from flowers of a wide variety of plants. These adults will overwinter in Mexico and begin the cycle anew the following spring.

Today fewer and fewer monarchs are part of this migration: over the last two decades the monarch population has decreased by 80 percent (Jepson et al. 2015). A main threat to the species is the loss of its habitat, with fewer milkweed and nectar sources available (Flockhart et al. 2014).

The monarchs, in turn, bear witness to people throughout their migration path who are helping to make a landscape where monarchs—and many other pollinators—can thrive. That includes the people and landscapes of American cities. Four out of five Americans live in large metropolitan areas, and these urban lands teem with innovative and effective local-scale monarch recovery efforts. The role cities can play in monarch recovery—and in providing habitat for pollinators and other wildlife··is more important than previously recognized. In fact, a large metropolitan region such as Chicago has over 16 million stems of milkweed already on the ground, and through strategic outreach with different stakeholders, that number could jump to over 35 million stems. While the prospects for adding milkweed stems will vary from city to city, there is clearly potential for cities to make a difference in monarch conservation—both through engaging millions of people on the topic and by putting functional habitat on the ground to support the monarch population.

How can these efforts come together? After all, cities are large, diverse, complicated places that can be difficult to neatly summarize. And monarch recovery efforts vary in scale from backyards and schoolyards to large prairie restorations. This Urban Monarch Conservation Guidebook (Guidebook) maps the city from a monarch's point of view, in a way that ultimately stitches these pieces together into an overall strategy that helps cities to set priorities and goals for monarch recovery.

This Guidebook is intended to support the efforts of people like city planners and conservation practitioners who are interested in identifying the best places and methods to create habitat on the ground in urban areas that benefit both people and pollinators like the monarch. The Guidebook presumes only strong motivation to do something for monarchs, some familiarity with how city space is organized, and comfort with using maps. Guidebook users can select from a suite of tools and resources that provide help in developing new or expanding existing urban pollinator efforts at scales as small as backyards to as large as prairie restorations of multiple square miles.

To make the most of the resources offered in the Guidebook, we recommend creating a local "monarch conservation planning team." At a minimum, the team should include someone with mapping and/or geographic information systems (GIS) skills. The team should also include a person who knows best practices in community engagement, including, ideally, the ability to conduct social research through interviews or surveys. A field team, with local knowledge of native plantings, should be used in order

to collect on-the-ground milkweed densities that will later be used in the mapping tool. The team should take stock of existing local efforts and take advantage of resources and networks for monarch conservation that exist at the state and national levels.

The U.S. Fish & Wildlife Service, the federal agency primarily responsible for threatened and endangered species, is keenly aware of the important role of cities in conservation. The Service knows that building a meaningful framework for monarch conservation in cities needs a solid ecological underpinning paired with a good sense of how people in cities have approached the issue in a wide variety of ways. The Service partnered with the Keller Science Action Center at The Field Museum in Chicago to develop a specifically urban conservation design and guidebook for monarch recovery. The Museum's location in the city of Chicago, its interdisciplinary teams of ecologists, social scientists, and geospatial analysts, and its understanding of the important role of partnerships and networks positioned it to connect the ecological and cultural pieces to make monarch conservation succeed in urban areas. As the project developed, new networks between practitioners of urban monarch conservation in central North America were forged, and a close understanding of how the tools work in the landscape of Chicago was expanded to include other larger metro areas in the monarch flyway including Minneapolis-St. Paul, Kansas City, and Austin.

The resulting urban monarch conservation design contains both this Guidebook and a set of mapping and analytical tools that can be applied to most urban situations. This Guidebook invites the user to consider the city as a social and ecological whole. This overall approach points to the broad range of opportunities and partners for monarch conservation that exists in cities. Cities with a metropolitan planning agency (i.e., those with 50K people or greater) will find the mapping tools most helpful, but any town or city can benefit from the best practices and insights for engaging different stakeholder groups that are included. Next, the mapping tools are introduced. Specific real world scenarios show how and where the tools can be applied. Step-by-step instructions for map analysts using geographic information systems (GIS) are found in a separate companion Manual. This Guidebook concludes by suggesting programs and resources users can plug into, learn from, or adapt for use in their own city. A series of appendices includes more detailed discussion of how the tools were developed and applied.

2 A monarch's view of the city

Understanding the social landscape of monarchs

When monarchs encounter an urban area along their journey, they, like many migrants to cities, find themselves in large, densely populated, and diverse human settlements. Modern North American cities are very large, not only in population but also in land area. The historic core of most urban areas is surrounded by a vast suburban landscape, now home to roughly half of all Americans (Pacione 2009). "Metropolitan" America is understood to include both the historic cores and their suburbs, gathered for census purposes into metropolitan counties. From the monarch's point of view, the actual boundary between "urban" and "rural" land can be very ragged.

Cities are also densely populated. Intense pockets of development occur in historic cores, industrial districts, and suburban office and commercial locations. In many instances this density of built-up urban land requires a very close look to locate suitable monarch habitat. But density, too, can vary widely across the metropolitan area, with some surprising opportunities for habitat scattered throughout the region.

Cities are diverse, filled with many social groups, widely varying land uses, and differing interest groups. What motivates people to become engaged in monarch conservation can vary widely across the metropolitan area. Both the density and diversity of the city mean that land use turns over frequently and new opportunities for habitat creation may arise.

Monarchs have certain requirements, and their needs are met better in some places in the metropolitan area than others. Generally speaking, the success of monarch reproduction is dependent on the number of milkweed stems and a suitable range of other native plants. Some of these plants occur here and there without human intervention, but monarchs benefit greatly from neighbors purposefully creating more habitat. It's helpful to think of people and monarchs coming together in the urban area as part of a system or "supply chain" (see Figure 1).

If the current thinking about monarch conservation is "all hands on deck"—meaning that a variety of approaches and actors to sustain this species is needed—then seeing the social world of monarch conservation as a system brings our attention to what "all hands" really means in the city. There are many possible ways to try to affect the system for the benefit of monarchs. To begin understanding the shape of this system, The Field Museum and staff in partner city organizations studied the social world of monarch conservation: what motivates people to take action on behalf of the monarch, what challenges they face, what strategies are most effective, and so on. The Museum conducted a series of interviews and set up an online survey to try to answer these questions. The study was not limited to those working directly or explicitly on monarch recovery; individuals engaged in some kind of environmental practice that might benefit the monarchs, even if they did not refer to it that way, were also surveyed. This included, to give a few examples, active gardeners, elementary school teachers, and natural area managers.

In our research, we found it helpful to group these relevant environmental practices into four broad categories:

1. planting and managing land,
2. selling plants and designing landscapes,
3. educating the public and promoting environmentally friendly practices, and
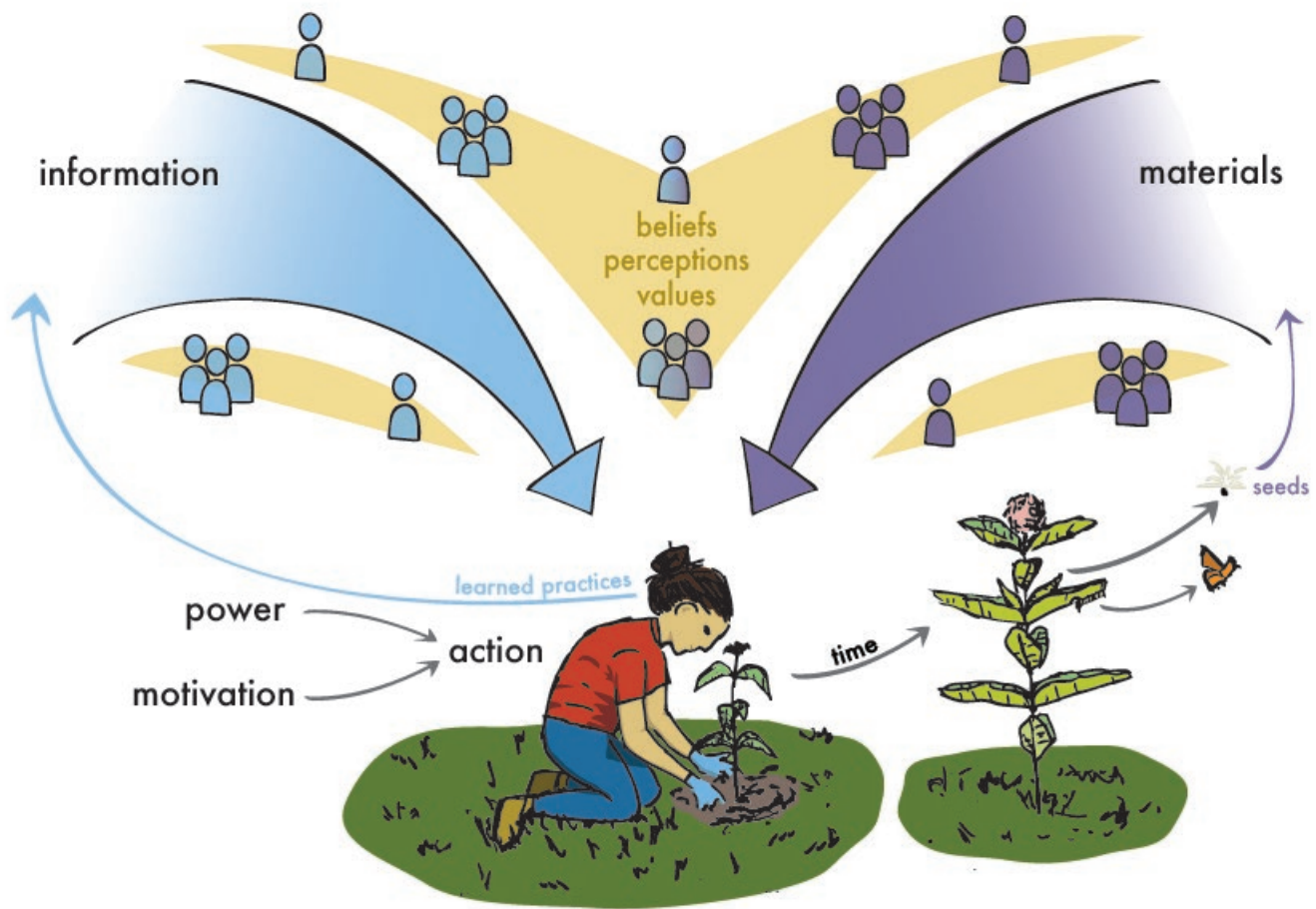4. studying and monitoring the natural environment.

Figure 1. A monarch butterfly "supply chain": What does it take to "produce" a monarch butterfly? Flows of **information** and **materials**, mediated by groups and individuals, make monarch conservation **actions** possible. These flows and exchanges are shaped by the individual and cultural **values**, **perceptions**, and **beliefs** that people bring to their participation in networks. Values, perceptions, and beliefs--which are particularly diverse in cities--motivate people to act on behalf of the monarch. People must also have the **power** to make decisions about a given piece of land in order to take action to make it more habitable for monarchs.

These categories were based on previous knowledge of Chicago's conservation scene and early discussions of potential research contacts. Dividing practices up in this way created a structure for the survey and interview guide that allowed survey respondents and interviewees to save time by skipping to their relevant area(s) of practice (see Figure 2). We structured the survey around practices rather than specific professions or roles because we knew of people who were engaged in this work in multiple ways, both formal and informal.

Another benefit of the survey's design is that it is modular and thus can easily be adapted for a narrower focus if needed, according to your locality's needs: for example, in your project you might like to focus only on the areas of practice that help you with mapping opportunities and estimating the impact of taking conservation steps. In this case, you could remove the monarch conservation, educating/promoting, and studying/monitoring survey sections. (See Appendices 1 and 2 for the full text of the survey and interview guide, respectively.)

To better connect these findings with estimates developed in the parallel mapping component of the urban conservation design, we also asked participants the land use type(s) with which their work is associated (we consolidated land use data into 16 land use types, which are defined in Appendix D and
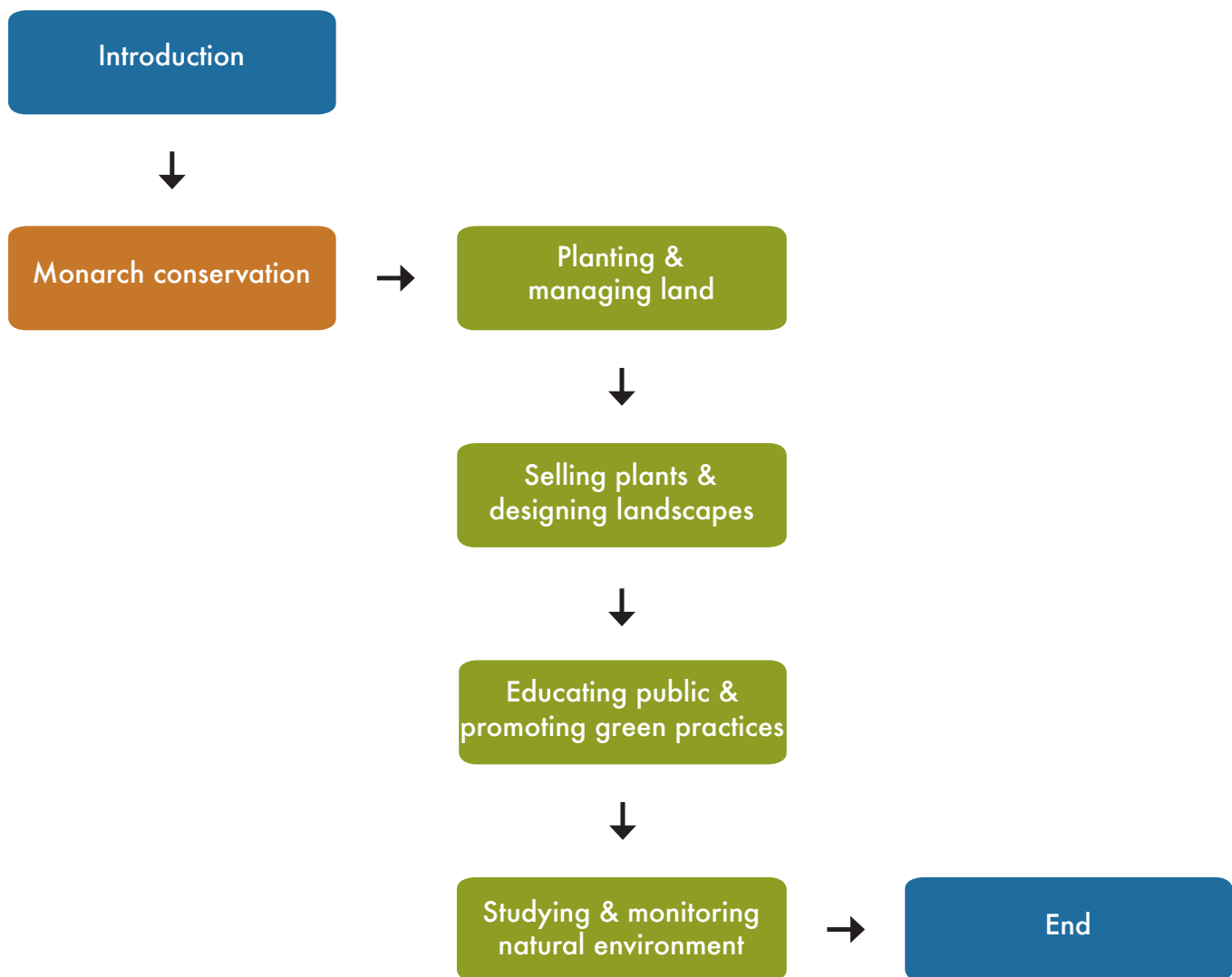
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                            │natural environment│       └──────────┘
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Figure 2. The structure of the online survey and corresponding interview guide.

discussed in greater length in the following section). This approach allows for a greater learning about a range of projects and strategies and how they apply in various land use types across the metropolitan area. Some findings appear to be true throughout the geography, while others apply only to certain land use types (see Table 1). The insights and best practices found to promote monarch conservation in urban areas that are summarized in Table 1 can be used as a starting point to assess which strategies may be most effective when working with stakeholders who own or manage different land use types. Specific examples of these approaches are described in Section 5: Plugging in: Monarch Efforts Underway.

Participants were also asked to give estimates of the amount of monarch-friendly plantings (specifically: native plants, nectar flowers, and milkweed) they have on land that they manage or design, and to say whether they would be willing to plant more in the next five years. These quantities helped inform the future scenario amounts in the mapping tool described in the following section.

Best practices and engagement insights

Column headers (land use types): Open space: conservation | Open space: non-conservation | Vacant lots | Agricultural | Residential (single & common space) | Corporate & medical | Commercial | Community & cultural | Industrial | Rights of way/ roads, utilities

Example/demonstration habitat spaces go far in educating others and encouraging them to create monarch habitat.

Home gardens and adjacent green space often function as informal **environmental education** spaces. Native plants spark conversation among neighbors and may inspire others to create monarch habitat. These conversations may build local **social cohesion**.

Creating habitat for monarchs or pollinators may seem less daunting and more concrete than other, broader ecosystem services goals where the results are less immediately visible or tangible (e.g., **conserving water**).

However, focus on a particular species may deter those concerned about restrictions that official "threatened" or "endangered" designations could bring. In these cases, it may be more effective to frame a project in terms of **overall ecological health** and/or connect it to practical concerns like **occupational safety** and **decreased mowing costs**.

One-on-one in-person communication is a highly effective method of education/promotion of monarch-friendly practices.

Hands-on, up-close encounters with monarchs and their host plants are most compelling when educating people about monarchs and creating habitat. The next best option is compelling video and/or photos.

To create a landscape that will be received well by its occupants and neighbors, be flexible and willing to balance native plants with more manicured plantings that signal awareness of mainstream aesthetic conventions.

Learning about monarchs promotes **observational skills** and **knowledge of geography** in youth. Children end up learning about more ecology and conservation more broadly, and that they can have a positive impact on their environment.

Plants used for **stormwater management** efforts such as bioswales and rain gardens may also provide monarch habitat; thus stormwater related grants and resources may be

Table 1. Best practices and engagement insights by land use type. Darker shading indicates that this finding applies more strongly in this land use context, and/or that this was the land use type where we most frequently encountered this approach. Lighter shading indicates that the finding applies but may not be as widespread or as much of a "rule." **Co-benefits** of various monarch conservation actions are called out in gold text. Land use categories are defined and explained further in Appendix D.

3 Mapping a monarch's view

The best tool to understand current and potential monarch habitat is a good set of maps. This Guidebook uses maps to estimate the amount of milkweed present in metropolitan areas. It also uses maps to estimate the potential increase in number of milkweed stems under different conditions (see Section 4). The use of maps permits users to visually assess the impact of particular conservation practices, which in turn can inform how conservation priorities can be set.

The maps are used to estimate the amount of grassland an area has, because the conditions that support grasslands favor the growth of milkweeds. The more detailed the maps, the more "grassland" can be found in urban areas, including at very fine scale areas such as backyards, vacant lots, parkways, and school yards. Once an estimated amount of grassland can be known and coupled with an idea of how the land is used, it is possible to make estimates of existing and potential milkweed. Different **land uses** will have different potentials and using the tools in this Guidebook the process of making these estimates can become refined as time and resources are available.

The Field Museum refined this process quite a bit, using the best possible data sources and methods. Generally speaking, it will be important to have available the best possible maps of local land use and **land cover**.

Land use maps are usually available as part of local planning processes and are required for transportation planning purposes in metropolitan areas of greater than 50,000 people. Some metropolitan areas use highly detailed land use classifications, but we recommend paring this down to the 16 consolidated land use classes identified in Appendix D for ease of use, comparison between cities, and clustering of similar stakeholder engagement practices. Highly detailed land cover maps permit the greatest accuracy.

The National Land Cover Dataset (NLCD) shows specific land cover classes (e.g., grassland, forest, "urban", etc.) down to 30 meters (about the size of a football field), but we strongly recommend higher resolution than that. In this section, we assume the use of high resolution land cover data (sub-meter

KEY TERMS

Adoption rate: This is expressed as the percentage of all landowners in a land use category that are likely to create monarch supporting habitat on some portion of their land. These values may be estimated separately by sub-regions based on urban population densities (e.g. using census tracts). Values may further adjusted geographically by the "localized momentum" to help account for the social and organic spread of monarch friendly habitats.

Baseline: The estimated natural/ background estimate of monarch habitat by land-use category. This estimate may be derived by 1) direct estimate of known monarch habitat areas (for example, mapped prairies, grasslands, wetlands, etc.), and 2) from field sampling and image analysis along transect lines bisecting aggregated land use categories.

Census block: The smallest geographic boundary used by the US Census Bureau to tabulate socioeconomic and other data about the US population. We use these boundaries to summarize spatial data and results.

Consolidated land use: The 16 land use categories represented in the urban monarch conservation tool. The methodology for that consolidation can be found in Appendix D.

Density: The number of milkweed stems per unit area. Units used in this study and national model are acres.

resolution) as a way of introducing the tools and the concepts, and then make suggestions as to how it can be adapted when not all of the resources are at hand.

What are the tools?

There are two mapping tools for setting goals and priorities for monarch conservation in a metropolitan area. The first is the *Urban Milkweed Baseline Tool*, which provides an estimate of existing milkweed **density** and stem count for a metropolitan area. The second is the *Urban Scenario Planning Tool*, which allows users to interactively model anticipated increases in milkweed density and total stem count for any sub-geography based on user scenarios across land use types. Since these tools use small geographic units (census blocks) as their basis, they can be combined with other data layers (e.g. public parks, vacant lots, utility corridors, planning project areas, etc.) by staff trained to use Geographic Information Systems (GIS) to give area and project-specific estimates. These tools are available online and can be accessed via The Field Museum's Urban Monarch page.

Enhanced sites: Sites that have converted a relatively high proportion of their plantable space to native habitat. These help determine what the maximum habitat conversion and milkweed densities are likely to be in each land use class.

Land cover: Vegetation, built structures, and other physical surfaces and features of the landscape.

Land use: The land use as defined by each governmental unit--will vary by locality. In most instances of the term in this Guidebook, we are referring to consolidated land use types, not raw data.

Metro transect: These are lines that are placed in urban areas that radiate out across the urban to rural gradient. These transect lines helped to establish random sampling areas. Field data is compared with land-use categories to estimate the density of milkweed and monarch habitat across land-use categories for extrapolating to other areas across the region.

NLCD: National Land Cover Database. U.S. region wide land cover provided by the USGS. This dataset could be used in place of high resolution land cover.

Plantable space: The total area in acres classified as "grass/shrub" or the equivalent land cover classification by land use category (or aggregated land-use category). These data are critical for estimating which land-use categories have the most acres of land that may be available for conversion to monarch supporting habitat.

How do the tools work?

Figure 3 describe the conceptual basis of the tools. In the first chart showing the *Urban Milkweed Baseline Tool*, land use data and high-resolution land cover data are combined to create plantable space, which represents existing and potential pollinator habitat areas. Land cover is important since any "grassland/shrub" space could be seen as an area that could be converted to pollinator habitat or that already contains monarch habitat. Effectively this removes buildings, roads, and forested areas from habitat conversion consideration. Land use is important since "grassland/shrub" land cover data also includes land uses like sports fields and play lots that cannot be converted to pollinator habitat. They, too, need to be removed from consideration. So every set of land uses should have a percentage of "plantable space" land cover. From there, field sampling (described in Appendix E) determines the amount of milkweed actually present in each of these land use/land cover combinations. The user can conduct a local field study or can use The Field Museum's estimates for milkweed stem density by land use type.

Outputs from the *Urban Milkweed Baseline Tool* are combined with fieldwork information to estimate future milkweed abundance in the Urban Scenario Planning Tool. The key question here is what the **adoption rate** will be, that is, what is the likelihood that stakeholders in given land use classes will pick up on monarch conservation practices. Here it can be very helpful to make site visits to places where conservation practices
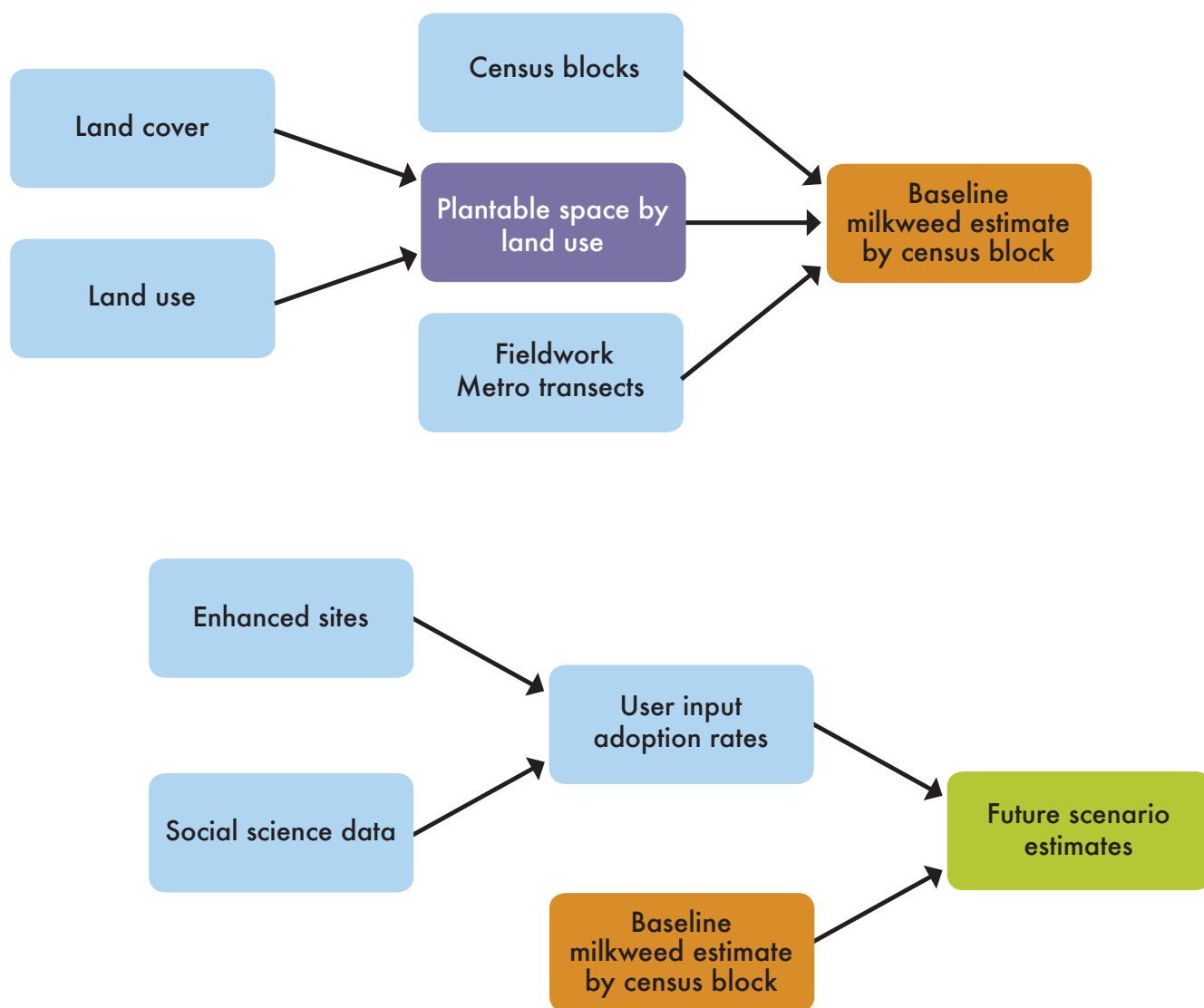
Figure 3. Flowcharts of input and output data in the monarch conservation tools. The datasets in the purple, orange, and green boxes above are illustrated in greater detail in Figure 4 on the following page.

are already in force ("**enhanced sites**"). The visits could be as few as needed to offer a picture of what the future could be, or they could be rigorously sampled. It might also be important in your locality to conduct interviews and/or a survey to get a feel for how the issue is gaining traction in the community ("social science data" in Figure 3).

From these site visits the team can assess the milkweed density across several example sites by land use sector. This density estimate or conversion ratio is the basis for scenario habitat modeling, where users estimate the proportion of landowners in a selected sub-geography anticipated to participate in habitat building land conversion.
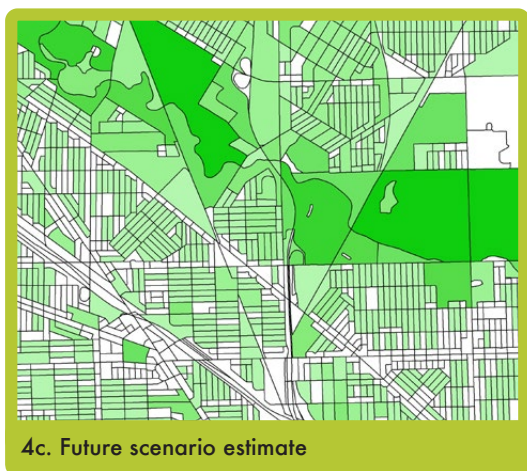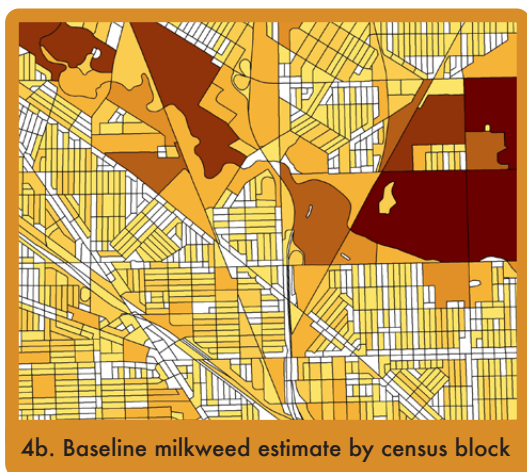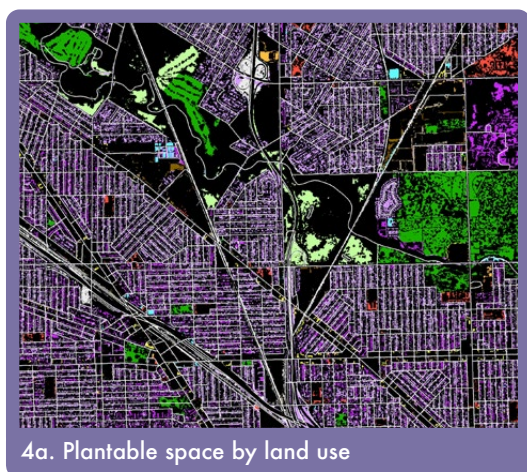
4a. Plantable space by land use

4b. Baseline milkweed estimate by census block

4c. Future scenario estimate

Figure 4. These figures illustrate the inputs and outputs for the Urban Monarch Conservation Tools. In Figure 4a, Plantable space by land use, the colors indicate grass/shrub areas coded by their land use type. These areas are combined with field data to output an estimate of the amount of milkweed present by census block (4b) using the *Urban Baseline Milkweed tool.* Output from the baseline tool is then used as input for the *Urban Scenario Planning Tool* that estimates the additional amount of milkweed that could be added under different user scenarios (4c).

Data issues and alternatives:

The variation and quality of spatial data can vary from one metropolitan area to another, and can affect both land use and land cover. Thus, rather than projecting data from one city to another, we recommend doing on-the-ground sampling for each city interested in employing these tools.

As noted above, we suggest aiming for a 16-class land use classification scheme, both for simplicity and for facilitating comparisons between metropolitan areas. Often, this will mean combining several classes. But some places might already use fewer than 16 classes, combining, say, open space conservation areas and recreational areas, or vacant lots and unclassified land. It may be possible to find a way to separate these categories, but it is important to keep the eyes on the prize: the reason to try to do so is because one category (open space conservation) may be very different for monarch conservation than the other (recreation). It may be possible to work with the combined category, but you should be aware of how land management practices can differ drastically between land use classes.

What should we do if ecological fieldwork is not an option?

If you are unable to complete field work to determine your own milkweed densities, you may use the milkweed densities that were obtained from field work conducted in Chicago. Users should be aware of the variation in milkweed densities in different regions of the U.S.; further, while you may use the Chicago milkweed densities, these may not accurately reflect the actual milkweed densities in your region.

What should we do if high resolution land cover data is not available?

Without high resolution land cover, GIS staff can develop the tool to instead incorporate the total area of the land use type in a given census block, rather than only the plantable space. It should be noted that this method will require baseline milkweed densities to be calculated on a total land use area and not by plantable space.

4 Applying the tools
How to set priorities and reach subsets of the landscape

In general, the approach and tools we have described can be used to provide a good characterization of the metropolitan landscape that is relevant, both ecologically and socially, to monarch conservation. However, the tools become most useful when applied to specific urban monarch conservation issues. We show three common situations that arise in urban monarch conversations as a method of teaching what the tools are and showing how they can be of use to you. Here are three example situations:

Example A: We've just signed the Mayors' Monarch pledge and are otherwise new to monarch conservation. We're a municipality with a lot of single-family homes. How can the tools help us to prioritize actions?

Example B: We'd like to integrate monarch conservation into other important regional planning discussions such as stormwater management. How do we make the case?

Example C: Our locality has a number of vacant lots. Where should we focus our efforts so that a monarch conservation program has a chance to succeed?

Before we turn to the tools, a few reminders. The *Urban Monarch Conservation Tools* are organized around 16 categories of consolidated land use. These are fairly common categories of urban land use (e.g. residential, industrial, etc.). These consolidated categories were designed to combine similar types of land use and land uses that share engagement strategies across the four pilot cities. If users have a specific stakeholder group, geographic areas of focus, or individual land use types of interest, the Urban Monarch Conservation Tools can target specific land use types.

In the application scenarios below, a map of the area of interest (for GIS users, a "shapefile") is overlaid and used to select the underlying census blocks for analysis. If the user is also interested in the land use that surrounds their selected blocks they can use the "select by location" or "buffer" commands built into the tool to highlight those blocks. Users should start with the output from the milkweed baseline tool and then run the future scenarios tool on selected blocks. Examples of this method are seen in the scenarios that follow.

Application example A

We've just signed the Mayors' Monarch pledge and are otherwise new to monarch conservation. We're a municipality with a lot of single-family homes. How can the tools help us to prioritize actions?

Issue: After signing the Mayors' Monarch Pledge, a municipality wants to know what's next: which lands to prioritize for Monarch habitat and how to set realistic goals for future monarch habitat.

Tools and/or data needed:
    Urban Monarch Conservation Tools   Municipal boundary
    Milkweed stem densities by land use type   Some enhanced sites where milkweed densities
                                                                          on converted land can be determined

Step 1   Determine total plantable space by land use.

Land use datasets can contain many classes and you may find it necessary to consolidate them into a more generalized class. If you are not able to use the methods that we followed for consolidating land use (Appendix D), the more generalized parent class should be used. For example if you have a land use dataset that has single family residential, multifamily residential, residential common space, consider combining them into a single class called "residential." Once you have your land use data you will need to determine the total plantable space in each of the land use types.

In the most ideal scenario your regional planning agency will also have available a high resolution land cover data set. These data are the digital representation of what is physically on the ground and are usually one meter or smaller in their resolution. Common to these data are classes such as: buildings, roads, tree canopy, and, most important here, grass/shrub. By isolating only the grass/shrub areas and then classifying the grass/shrub area based on the land use class, it will give a municipality the total plantable space by land use.

Taking the municipality of Glenview, Illinois as an example, we can sum the total acreage of plantable space to identify which land use type has the most plantable space. Unless working in a rural area, municipalities tend to have the most plantable space on residential land. Although the number of different landowners involved presents a challenge, and the plantable space per landowner is small relative to some other land use categories, the collective impact of many homeowners' converting plantable space can lead to a substantial increase in monarch habitat in a locality.

Step 2   Determine current baseline milkweed totals for your municipality by land use.

Once the total plantable space by land use has been determined, the next task will be to find the densities of milkweed in each of the land use types. To determine the baseline milkweed densities, ideally you would conduct your own survey of milkweed densities within your municipality (see Appendix E), as milkweed densities can vary greatly from region to region. If you are unable to determine your own milkweed densities, you may use the milkweed densities that were obtained from our research in Chicago, which are included in the tool. Users should be aware of the variation in milkweed densities in different regions of the U.S. and while you may use the Chicago milkweed densities as a rough estimate, these will not as accurately reflect the actual milkweed densities in your region.

Using the baseline milkweed calculator for Glenview, it's been determined that the existing milkweed total for the municipality of Glenview was approximately 8,100 milkweed stems, with the most milkweed in the following land use types: open space: non-conservation, minor rights-of-way and landfill, and residential (single-family).

Step 3   Identify which lands to prioritize for monarch conservation and analyze future monarch habitat under different scenario-plans.

In order to analyze future monarch habitat we will need to sample enhanced sites. These enhanced sites have, on average, higher milkweed densities when compared to the baseline milkweed densities and are used for estimating the maximum realistic amount of milkweed stems that could be added. For example in Glenview we found 1,373 acres of total plantable space in residential land use, with a baseline of 0.9 milkweed stem per acre. Multiplying these two numbers yields approximately 1,245 milkweed stems present in the residential land use type. If upon surveying enhanced residential sites we find that on average, these sites have 500 milkweed stems per acre, we can use that average density to project milkweed abundance under different conversion goals. Again, using the example above, if we set a goal of converting five percent of residential land, at a density of 500 milkweed stems per acre (the same densities as enhanced sites), we can effectively add an additional 34,000 milkweed stems to the residential space in Glenview.

Original baseline milkweed total	*Scenario planning*	*New milkweed total*
8,106 stems	Converting 5% of residential land at 500 milkweed stems/acre →	**42,500 stems**

Step 4 **Apply best practices and engagement insights for the residential land use type.**
Having determined that residential gardeners will be the focus of our effort, we could then refer to Table 1 in Section 2: A Monarch's View of the City for guidance in engaging these residents. For example, you might work with a few particularly active gardeners to create demonstration gardens in their neighborhoods, or create a residential habitat design template that takes local aesthetic conventions into account.

Application example B

We'd like to integrate monarch conservation into other important regional planning discussions such as stormwater management. How do we make the case?

Issue: Flooding is a major concern in parts of most metropolitan areas. Between 2007 and 2014, flooding in Illinois' urban areas caused over two billion dollars in documented damage (Winters et al. 2015). By combining stormwater/flooding issues with other green infrastructure goals such as habitat corridors for pollinators and other target species, these projects are more likely to be approved, to get public support, and to receive funding while addressing an important issue for residents.

Tools and/or data needed:

Urban Monarch Conservation Tools	Floodplain or flood problem areas data
Milkweed stem densities by land use type	Planned green infrastructure project areas (optional)

Step 1 **Select census blocks that intersect with problem areas.**
The Urban Monarch Conservation Tool may be run on a localized area (e.g. a problem area, community area, or small municipality). Using GIS floodplain data (or problem flooding data) a simple overlay can be done to select census blocks that overlap with these problem areas. Or, if a green infrastructure project is already planned to address known problem areas, you may want to manually select census blocks for the sites under consideration to then create project-specific estimates of the number of existing milkweed stems and, more importantly, to estimate the potential increase in milkweed stems based on various scenarios targeting property and population sectors.

Step 2 **Decide on one or more conservation scenario solutions.**
As a planning agency or major land owner, you may be targeting particular land use types such as residential homeowners, vacant lots, waterway rights-of-way, schools, etc. (see Table 1, pg 6). These can be considered individually with multiple runs of the Urban Scenario Planning Tool, or you may want to compare categories simultaneously. As an example, a user might create a scenario where 40 percent of a right-of-way and 20 percent of an open space non-conservation area are targeted for creating co-beneficial stormwater retention and pollinator habitat.

Step 3 **Run the scenario-planning tool and compare results.**
The scenario-planning tool provides estimates of the number of existing milkweed stems, the number that would be added, and the estimated stem density for each census block in the analysis area. A variety of stakeholders such as project managers, planners, public land-owners, policy makers, etc. could take these values and leverage them when seeking funding opportunities (e.g., Section 319 -- Clean Water Act EPA funding, Great Lakes Restoration Initiative projects) by making the connection between green infrastructure improvements with benefits to pollinators.

Step 4   **Apply best practices and engagement insights for whichever land use types emerge as opportunity areas for stormwater conservation (see Table 1).**

For example, if rights of way and roadways seem to be a key focus area, you might focus primarily on co-benefits and ecosystem services in your messaging to these land managers, rather than on monarch conservation alone.

Application example C

Our locality has a number of vacant lots. Where should we focus our efforts so that a monarch conservation program with real impact has a chance to succeed?

Issue: Vacant lands pose a challenge for every modern city. They are often seen as blight to the surrounding community that hold little to no value. Recently cities have begun to implement policies that incentivize homeowners to purchase these vacant lands, for potential conversion urban green space. These policies not only may give the homeowners a deeper sense of investment in their landscape and community, they also may turn non-productive land into habitat for the many plant and animal species that live in urban environments. Similar policies have also given rise to a variety of programs, as well as many organizations that solely work on creating native habitat on urban vacant land.

For example, the Adjacent Neighbors Land Acquisition Program (ANLAP) allows homeowners within the city of Chicago to purchase vacant city-owned lots for less than market value if the parcel meets certain criteria established by law. Knowing these criteria, along with the milkweed calculator, cities can identify neighborhoods that contribute to increasing milkweed in urban environments, prioritizing those areas with the highest habitat potential.

Tools and/or data needed:

Urban Monarch Conservation Tools   City neighborhood boundaries
Milkweed stem densities by land use type   Some enhanced sites where milkweed densities
                                                                          on converted land can be determined

Step 1   **Identify census blocks that contain both residential and vacant lots.**
The ANLAP requires buyers of vacant land to have their home adjacent to the vacant lot; blocks that have both vacant land as well as residential land need to be prioritized over those blocks that do not. Since the mapping tool contains land use classes for both residential and vacant lots, users are able to select census blocks that meet the criteria.

Step 2   **Identify census blocks that contain the most amount of plantable space.**
Planners want to prioritize planting milkweed in census blocks that have the most potential to increase milkweed. In order to do so they must first determine which census blocks with residential single-families have the highest amount of plantable space in vacant lots. This can be accomplished by using the set of ANLAP criteria to select only those blocks with vacant land and residential and then sorting those blocks based on the highest amount of plantable space in vacant lots.

Step 3   **Survey homeowners to gauge knowledge of and interest in native habitat creation and to understand community concerns.**
Having narrowed down your locality to a set of census blocks that are particularly promising in terms of plantable space, you might then further refine your list by speaking with the homeowners in these census blocks. If possible, work through influential community organizations and leaders to convene

resident focus groups or obtain contact lists to survey (ask community leaders which method is appropriate for their neighborhood). Select a few key questions about planting/managing land from the research instruments (see Appendices 1 and 2) to ask residents, then compare the results in different census blocks so that you undertake your initiative in a neighborhood where it is welcome and has a higher chance of success. It would also be helpful to ask open-ended questions about residents' desires and visions for their neighborhood generally, in case there are other environmental benefits important to the community that could be leveraged. Finally, you might also take into account the proportion of renters to homeowners in the area, as a way of gauging the stability of potential green space stewards, but this shouldn't be the only factor considered.

Step 4 Determine potential milkweed contribution under different adoption scenarios.

Once the key census blocks have been selected, users can determine the current milkweed totals for the vacant lots by running the baseline milkweed calculator. If there are available resources to conduct site specific milkweed sampling on these vacant lots it would be strongly encouraged to do so as regional milkweed densities can vary from city to city. The densities in the milkweed calculator can be easily changed if sampling has been done in a specific land use type or geographic region. Once baseline milkweed has been determined, the user can then plan on how much of the plantable space in vacant lots would be needed in order to increase the current milkweed on these vacant lots to meet conservation planning goals.

Users of the tools should be aware that land use data between regional planning organizations can vary in accuracy as well as refinement of its land use type. For example, some datasets have combined vacant and undeveloped lands into the same class. This can make identifying these areas difficult depending on the city's land use type refinement. The datasets also have limited accuracy depending on when they were collected, so studies requiring greater accuracy or up-to-date data may need to plan for additional ground-truthing to be carried out. If this is the case, other aspects to consider would be whether your organization operates at the citywide level or at some sub-geography, and whether there are staff who have capacity to conduct the necessary studies for increased accuracy and refinement of the data.

Step 5 Apply best practices and engagement insights for residential and vacant land (see Table 1), taking into account what you learned by talking to residents in Step 3.

Consulting community leaders and/or residents that seemed particularly interested based on your initial survey, choose a few key engagement strategies to get the word out about the program. Is mail the best way to reach people? Do materials need to be distributed in multiple languages? With what other initiatives (existing or desired) in the neighborhood might your green space effort collaborate? The strategies in Table 1 represent good overall practices, but engagement practices should be tailored to the local context whenever possible.

5 Plugging in
Monarch efforts underway

In this section, we provide examples of programs and resources that illustrate the connections between the many complementary urban monarch efforts underway—and a way for you to plug in! It begins with general guidance for how to design a pollinator garden, then offers resources for options to certify pollinator gardens once they are planted, followed by information on how to get high-level decision makers involved through the Mayors' Monarch Pledge, and finally highlighting examples of education and citizen science programs that can help create a community of monarch conservation practitioners where you live.

With so much interest and enthusiasm around monarchs, there are a wide variety of efforts underway that complement and help support monarch conservation in urban areas. The Monarch Joint Venture website at www.monarchjointventure.org is an extensive clearinghouse of information on all aspects of monarch conservation across the country.

I. "Rules of Thumb" for Designing Pollinator Gardens

Adapted from Monarch Watch

Your butterfly garden can be any size, from a window box to a portion of your landscaped yard to a wild, untended area on your lot. You can include native plants, cultivated species, or both. But before you get started, read the hints here in our gardening section to make your garden as successful as possible.

Size. A suitable pollinator garden habitat can be easily integrated with an existing vegetable or flower garden. There is no minimum area requirement, however, a truly effective plot will be at least 100 square feet. The total area may be split among several sites at your location and there is no upper limit for the size. Small is OK! Small spaces with milkweed and nectar sources are thought to be beneficial because monarchs will find them, and the number of predators and parasites may be lower than larger sites.

Exposure. Butterflies and butterfly plants need lots of sun; therefore gardens should be located in an area that receives at least six hours of sun a day.

Drainage and Soil Type. Milkweeds and nectar plants will do best in relatively light (low-clay) soils. Good drainage is needed to avoid root rot and provide good aeration of the roots. Pay attention to the soil types that the plants do best in, and try to select plants that correspond with the native soil. Because most city soil will be compacted and have too much clay or sand, it is important to amend the soil with compost before planting.

Shelter. To assure that the maximum number of monarchs survive in your habitat, the plants should be relatively close together. However, they should not be crowded – be sure to follow the planting guides specific to each plant. All monarch life stages need shelter from predators and the elements. Planting milkweeds and nectar plants close together contributes to this shelter for monarchs and other wildlife.

Milkweed Plants. To maximize the utilization of your habitat by monarchs, it is desirable to include a number of milkweed species. It is best to have at least 10 plants per 100 square feet, made up of two or more species; however, a large number of plants (more than 10) of one species is sufficient.

Milkweeds of different species mature and flower at different times during the season. By increasing the number of milkweed species in your habitat you will increase the likelihood that monarchs will utilize your property for a longer period during the breeding season. Remember monarch caterpillars eat milkweed so you may wake up to just a milkweed stalk, this is ok you have made a caterpillar very happy!

Nectar Plants. Monarchs, other butterflies, and numerous pollinators need nectar. By providing a diverse set of nectar sources that bloom sequentially or continuously throughout the season your pollinator garden can provide resources for monarchs throughout the breeding season and the migration in the fall. It is recommended that gardens contain at least 4-6 annual, biennial, or perennial plants that provide nectar for butterflies. Examples of important perennial plants that benefit pollinators in the midwest, for example, are Aster oblongifolius, Echinacea purpurea and Coreopsis lanceolata. Monarch Watch has a more extensive list of plant species for your garden that covers both host and nectar plants for monarchs and other pollinators. The list may be over the top for beginners and, if so, remember to keep it simple at the outset. To help you do this, the "must have" plants for basic gardens are in bold type.

Design. There are a variety of great "how to" guides available for natural landscaping, such as this Conservation@Home resource that helps to visualize design possibilities and provide native plants lists that benefit wildlife. In additional to these types of resources, here are some practical suggestions to help guide the design of a pollinator garden:

1. Provide distinct borders so yard crews are less likely to remove or mow over plants that are not easily distinguished from the lawn;
2. If a more traditional garden look is desired, try clumping several plants of the same species together throughout the garden and/or plant shorter species;
3. Place low-water plants together and high-moisture plants together;
4. Be sure to have a water source nearby. Gardens will need to be watered for the first few years until they are fully established.
5. Place milkweed on the garden periphery to allow casual observers to see monarchs and pollinators interacting;
6. Consider adding some native grasses or sedges for visual appeal. These also make great shelter for insects, and some butterflies utilize them as host plants. They won't have showy flowers, but still have value in the system; and
7. Consider certifying your garden and place the signs in public areas so the garden serves an educational purpose as well. This also might help protect your garden from rogue mowers.

Management. You should have a plan to sustain a pollinator garden. Specific actions you take will depend on the features of your habitat; however, some general examples include mulching (which helps retain moisture and prevent weeds), thinning, fertilizing, amending the soil, removing dead stalks, watering, eliminating insecticide use, removing invasive plant species, and incorporating additional features. You can also provide shelter for butterflies during the winter by leaving some leaf litter on the ground. Watering and weeding during the first several years is important to help the garden establish; but once they're established, native gardens require very little watering, weeding, or fertilizing compared to non-native gardens.

II. Habitat Certification

To show your support of monarch conservation, you can have your monarch habitat certified as an official Monarch Waystation by Monarch Watch. Your habitat will be included in the International Waystation Registry, and will receive a certificate with your habitat's Waystation ID number, and a weatherproof sign that identifies your habitat as an official Monarch Waystation. For more information on how to get the process started, see Monarch Joint Venture's Waystation brochure and list of additional habitat

certification programs. If you work for a city, consider creating your own certification program like Milkweeds for Monarchs in St. Louis.

III. Take the Mayor's Monarch Pledge

Through the National Wildlife Federation's Mayors' Monarch Pledge, cities and municipalities are committing to create habitat and educate citizens about how they can make a difference at home. There are four steps to taking and implementing the pledge: take the pledge, specify at least 3 actions, take action, report progress. It's easy to do, so encourage your Mayor or other local government chief executives to sign on today! More information and a link to the pledge are available here.

IV. Monarch Education

For those creating gardens for schools, remember gardening for butterflies and pollinators is both fun and educational. Butterflies and pollinators are easy to watch and easy to identify. Pocket cameras and smartphones can be used to take pictures of the visitors to your garden so you they may be identified using some of the large number of websites devoted to different groups of insects. Pollinator gardens are also a good way to introduce students to insect diversity. The attributes of the flowers that attract certain types of pollinators or conversely the attributes of the pollinators and the flowers they visit could be the subject of many student projects.

Further, the seasonal progression of bloom, or phenology, could also be tracked from year. The maintenance activities in the garden, the flower phenology and visitors, unusual sightings, etc., could all be logged on a website dedicated to the garden, a website that could be shared with other schools with similar gardens. Remember you are also gardening with another purpose – to attract specific butterflies to the host plants you have added to the garden. Some may show up soon while others may take some time before they discover the resource you've created. These arrivals can be quite gratifying. Resources like the "Monarchs and More" curriculum guide, created by the University of Minnesota Monarch Lab, can engage students grades kindergarten through middle school. To view the curriculum, visit Monarch Lab. Additional curriculum resources are available through NWF.

Besides traditional biology principles, monarch butterfly gardens can provide opportunities for every teacher to explore creative ways to teach math, literature, art, social studies; the applications are endless. To discuss with and learn from others, visit the Monarch Teacher Network on Facebook.

V. Citizen Science

There are excellent citizen science monarch programs to which anyone can contribute data. A number of them can be found on Monarch Joint Venture's site.

Whether for a school group project, a family activity, or an individual interest, joining a citizen science effort can help develop a strong sense of understanding, ownership, and excitement for monarch biology and conservation. A great example is Journey North, a program that focuses on migratory organisms, including gray whales, hummingbirds, American robins, whooping cranes, and monarchs. They have a variety of educational materials about monarch conservation and biology.

The North American network of monarch butterfly monitoring programs has a comprehensive list of monitoring programs.

Another citizen science tool is The Nature Conservancy and The Cornell Lab of Ornithology's Habitat Network. This tool is intended to help engage and create a community of practice· a network of users to communicate lessons learned and tips and tricks· and to collect data on how individuals manage their properties to quantify the cumulative impact of urban areas for wildlife and monarch butterflies, organized across the entire migratory path.

6 Let us know

Visit The Field Museum's Urban Monarch page for the latest news, and email us at monarchs@fieldmuseum.org.

An expanding chorus of urban residents, in places both large and small, have been at work to create habitat for monarchs. We hope that this Guidebook assists in your efforts. And we are interested in what you are finding works in your city. The tools presented here will be sharper and more useful the more that people use them, providing better estimates of milkweed densities, a better sense of the circumstances where the tools are helpful, and a wider range of activities and projects that work to engage city folks across the monarch flyway. So let us know what works for you, and how we can improve the tools. Meanwhile, have fun working on behalf of monarchs!

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