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Greenspace Restorations

WoonyBird Restoration Plant Selector Manual

Office of Research and Development
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Front Cover Bird photos (top to bottom): Eastern Towhee; Northern Mockingbird; Downy Woodpecker.
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WoonyBird restoration plant selector manual

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Notice

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Abstract

Modifying greenspaces to enhance habitat value has been proposed as a means towards protecting or restoring biodiversity in urban landscapes. As part of a framework for developing low-cost, low-impact enhancements that can be incorporated during the restoration of greenspaces to enhance their wildlife habitat value, we developed the WoonyBird Restoration Plant Selector, a spreadsheet-based tool to aid in the restoration of a land parcel by suggesting plants which are appropriate for light and soil conditions at the restoration site to attract bird species specified by the user. This manual provides some background information on enhancing bird habitat in urban greenspaces, describes the operation of the tool, suggests strategies for identifying target bird species, and provides some additional design considerations for habitat enhancement. Information provided by application of the tool will help to enhance habitat value of a restored greenspace, and may therefore be of use to regional resource managers and stakeholders including urban planning departments and local resource conservation organizations involved in planning and carrying out restoration of urban greenspaces.

Key words: greenspace; habitat value; urban biodiversity; New England; bird-plant associations.

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I. Introduction

Urban greenspaces include remnant natural lands, areas of ruderal vegetation, parks, nature trails, and vegetated areas created for stormwater management or water quality enhancement. Most cities support the restoration, enhancement, or creation of greenspaces under community development initiatives that promote the integration of built and natural environments. In many areas, urban planners are working to implement stormwater management plans that encourage best management practices such as vegetated buffers, stormwater wetlands, bioretention facilities, and vegetated swales. Urban greenspaces are recognized as having many benefits over built environments, but their potential as wildlife habitat is often not realized. This is in part because scientific knowledge about the potential wildlife habitat value of greenspaces is not developed to the point where it can consistently inform planning and restoration efforts. As a result, management practices that could enhance wildlife habitat of greenspaces are often discounted in the restoration process (Harrison and Davies 2002). The WoonyBird Restoration Plant Selector was developed as part of a project geared towards providing information that will facilitate the recognition of the potential habitat value of urban greenspaces, and provide a means by which low-cost, low-impact enhancements can be incorporated during the restoration of greenspaces to enhance their wildlife habitat value. We focus on birds as an indicator species for wildlife habitat value because of their high visibility and positive impacts on the attitudes of urban residents (Bjerke and Ostdahl 2004, Luck et al. 2011), as well as the ready availability of field techniques and modeling approaches to describe their use of urban habitats.

Ruderal vegetation in a city park. Photo: R. McKinney

Eastern Towhee, *Pipilo erythrophthalmus*. Photo: US FWS National Digital Library

The project featured a two-phased approach: the first phase developed a regional bird pool from which a target list of bird species appropriate to a given restoration project can be identified, as well as a candidate list of native woody plants derived from the habitat requirements of species in the regional bird pool. This phase also included empirical studies to assess the habitat value of existing greenspaces for breeding birds (McKinney and Nightengale 2013). The second phase of the project used the models developed in phase one to guide the development of the WoonyBird

Restoration Plant Selector, a spreadsheet-based tool that can be used by planners and restoration managers to optimize an urban greenspace restoration site for bird habitat value. The tool uses habitat requirements of site-specific target bird species to derive a list of appropriate plant species and a landscape plan that, when incorporated into the site design, can help enhance bird habitat value.

This manual describes the use of the WoonyBird Restoration Plant Selector tool, and includes 1) an overview of the tool including a brief description of its operation; 2) some strategies for developing of a target list of bird species for a given restoration site; and 3) some additional design considerations that may aid in enhancing bird habitat value of a restored greenspace. The overall goal of the study is to provide input to support greenspace restoration strategies that include the enhancement of bird habitat value through low-cost, low-impact design practices. We anticipate this information will be helpful to regional resource managers and stakeholders including urban planning departments, property owners, developers, engineers, consultants, contractors, municipal staff, and local resource conservation organizations involved in planning and carrying out restoration of urban greenspaces. The target bird species and planting recommendations in this tool are specific to the Woonasquatucket watershed in Rhode Island because the regional bird pool used as a basis of the tool reflects the mix of habitats present in the watershed. The tool could potentially be applied to other watersheds in northern Rhode Island or central / southern Massachusetts that have a similar habitat mix, but would have to be modified to reflect bird species utilizing habitats in other regions. However, the general principles underlying the development of the various components of the tool could be useful in developing similar recommendations in other urban watersheds.

II. Overview of the WoonyBird Restoration Plant Selector

The WoonyBird Restoration Plant Selector (hereafter Plant Selector) is a spreadsheet-based tool developed to aid in the restoration of a land parcel by suggesting plants which are appropriate for light and soil conditions at the restoration site, and which will attract bird species specified by the user. The user can then designate bird species for which habitat value is to be optimized and soil and light conditions of the greenspace, and the tool output will consist of a list of plant species that will enhance habitat value for the designated bird species. The user will also be able to obtain information about individual plant species including light and soil requirements, growth rate, maximum height, wetland indicator status (whether the plant can tolerate moist soils), and additional information such as its suitability for particular landscapes, or specific maintenance requirements. The tool also lists nurseries in southern New England from which the plant species can be purchased.

There are a number of reference guides that describe bird species known to associate with specific plant species (e.g., Martin et al. 1951, DeGraaf 2002); these resources provide a listing of all bird species supported by a particular plant species. For example, DeGraaf (2002) reports

that that Red Osier dogwood (*Cornus sericea*) potentially provides food for a number of songbirds, and is a preferred nest site for American Goldfinch (*Spinus tristis*). Similarly, there are handbooks available to guide creation of habitats to use specific plantings to attract birds to an area (e.g., Roth 1998, Kress 2006), however these are geared to attracting a variety of birds rather than specific species. The Plant Selector fills a gap in that it can be used to derive a list of all woody plants species that will support a specified bird species. This information can then be used to develop a site plan of specific plantings to attract and support desired bird species.

Plant Selector development

The Plant Selector was developed from a candidate list of thirty six native woody plant species identified as potential species for inclusion in greenspace restoration efforts in the Woonasquatucket watershed (Appendix 1; McKinney and Nightengale 2013). These plants were included based on the extent to which they support bird species identified as part of a regional bird species pool for the Woonasquatucket watershed. The regional bird pool species were included based on knowledge of the type and arrangement of natural habitats present in the watershed, along with their setting the surrounding human-dominated landscape, and are species that could potentially utilize appropriate habitats within the watershed and hence could be included as target species for greenspace restorations. As a whole, plant species included in the Plant Selector represented greater than 50% of the habitat value to birds of all woody plants (native, non-native, ornamental) that were originally considered, and are therefore a good representation of plants with relatively high bird habitat value.

Step-by-step instructions for using the Plant Selector are presented in Appendix 2.

III. Target List of Bird Species

One of the keys to application of the WoonyBird Restoration Plant Selector is to identify an appropriate target list of bird species to be supported in a restored greenspace. A regional bird pool of species known or with the potential to use habitats in the Woonasquatucket watershed has been identified (Table 1); a target list of species should be selected from this pool. In order to minimize the cost of proposed habitat enhancements, the target list should be small (on the order of 10 or fewer species) and specific to a site. Depending on the location of the site in the watershed, the target list of bird species may vary; for example, a target list for a site near a river or stream should include birds that inhabit riparian areas, whereas an inland restoration site list should consist of birds that primarily utilize upland habitats such as shrubland or urban forest.

Table 1. Territory size and Partners In Flight Population Trend classification of regional bird pool species for the Woonasquatucket River watershed, Rhode Island, USA

Scientific name	Common name	Territory size (ha)[1]	Reference	PIF PT-c[5]
Buteo jamaicensis	red-tailed hawk	425	p	1
Meleagris gallopavo	wild turkey	IN	h	1
Zenaida macroura	mourning dove	IN	l	2
Bubo virginianus	great horned owl	212	p	2
Chaetura pelagica	chimney swift	NT	g	5
Archilochus colubris	ruby-throated hummingbird	IN[2]	o	1
Dryocopus pileatus	pileated woodpecker	< 3.14	e	1
Melanerpes carolinus	red-bellied woodpecker	8.80	s	2
Picoides villosus	hairy woodpecker	1.05	a	1
Picoides pubescens	downy woodpecker	5.10	v	3
Myiarchus crinitus	great crested flycatcher	2.40	t	2
Sayornis phoebe	eastern phoebe	1.77	i	2
Empidonax traillii	willow flycatcher	1.09	r	4
Empidonax minimus	least flycatcher	0.18	p	4
Hirundo rustica	barn swallow	NN	d	4
Petrochelidon pyrrhonota	cliff swallow	NN	c	2
Progne subis	purple martin	NN	u	2
Cyanocitta cristata	blue jay	NT	k	4
Corvus brachyrhynchos	American crow	1.25	f	2
Corvus ossifragus	fish crow	IN[3]	b	2
Poecile atricapillus	black-capped chickadee	3.30	k	1
Baeolophus bicolor	tufted titmouse	4.20	n	2
Sitta carolinensis	white-breasted nuthatch	20.0	k	1
Thryothorus ludovicianus	Carolina wren	0.12	p	1
Troglodytes aedon	house wren	0.40	p	2
Mimus polyglottos	northern mockingbird	0.40	p	4
Dumetella carolinensis	gray catbird	0.11	p	2
Turdus migratorius	American robin	0.12	p	2
Sialia sialis	eastern bluebird	1.01	p	1
Vireo olivaceus	red-eyed vireo	0.73	p	1
Setophaga petechia	yellow warbler	0.04	k	2
Passer domesticus	house sparrow	NT	k	5
Agelaius phoeniceus	red-winged blackbird	0.29	q	4
Quiscalus quiscula	common grackle	NN	m	4
Cardinalis cardinalis	northern cardinal	0.15	p	2
Carpodacus mexicanus	house finch	NT	k	2
Spinus tristis	American goldfinch	IN[4]	j	2
Pipilo erythrophthalmus	eastern towhee	1.90	k	4
Spizella passerina	chipping sparrow	0.60	p	3
Melospiza melodia	song sparrow	0.16	p	4

[1] NT = non-territorial; NN = only territorial in immediate area around the nest; IN = indeterminate
[2] Depending on food resources available can range from 0.07 - 3000 ha
[3] Nests colonially or semi-colonially
[4] varies with type of nesting habitat and nest location
[5] Partners in Flight Population Trend descriptions Panjabi et al. 2012):

Table 1 Continued

Scientific name	Common name	Territory size (ha)[1]	Reference	PIF PT-c[5]

[a] Allison 1947
[b] Bent 1946
[c] Brown & Brown 1995
[d] Brown & Brown 1999
[e] Bull & Jackson 2011
[f] Caffrey 1992
[g] Cink & Collins 2002
[h] Eaton 1992
[i] Hill & Gates 1988
[j] McGraw & Middleton 2009
[k] McKernan & Hartvigsen 2001
[l] Otis et al. 2008
[m] Peer & Bollinger 1997
[n] Pielou 1957
[o] Robinson et al. 1996
[p] Schoener 1968
[q] Searcy & Yakusawa 1995
[r] Sedgewick 2000
[s] Shackleford et al. 2000
[t] Stewart & Robbins 1958
[u] Tarof & Brown 2013
[v] Twomey 1945

1 = Significant large increase (population change > 50%; P < 0.1)
2 = Significant small increase or stable (population change 0% to 50%; P < 0.1)
3 = Uncertain population change, stable, or possible small decrease (P > 0.33; unreliable trend)
4 = Moderate decrease, possible large decrease (population change -15% to -50%; 0.1 < P < 0.33)
5 = Significant large decrease (population change < -50%; P < 0.1)

Factors to consider when developing a target list of bird species for a site

One overarching consideration that can guide development of a target list for a specific restoration site is the conservation status of species, whenever possible species with a higher conservation priority (i.e., rare or threatened species, or those of conservation concern) should be included. Table 3-1 lists Partners in Flight Population Trend descriptions; generally species with values 3, 4, or 5 are of greatest conservation concern and should be considered for inclusion in a target bird list, if possible. Another consideration is the aesthetic goal of the restoration: for example, some species such as Ruby-throated Hummingbird (*Archilochus colubris*) or American Goldfinch (*Spinus tristis*), while not of conservation concern, may be highly desired because of their aesthetic value. Birds to be included in the target list should also be determined in part by any existing conditions at the restoration site. Conditions include i) size of the site; ii) the type of restoration planned; iii) any restrictions on vegetation at the site; iv) land cover surrounding the site; and v) proximity of the site to existing natural habitats or known breeding habitat.

Size of the site

Site size is important in that many bird species have specific area requirements for breeding territories, or defended areas used for mating, nesting, and from which food is gathered to feed young. Territory size can range from less than a meter for some colonial-nesting species to ten, to several hundred hectares for birds of prey (Nice 1941). A recent review of territory size for forest-dwelling passerines listed territory sizes ranging from 0.5 to 6.5 ha (Whitaker and Warkentin 2010). This tool is optimized for use in urban environments; territory size may be smaller in birds utilizing urban habitats because of enhanced availability of food resources (Emlen 1974). In spite of this, there may be potential greenspace restoration sites that are too small for certain species. Where available, territory sizes of birds included in the regional bird pool are included in Table 1.

Type of restoration and restrictions on vegetation

The type of restoration and restrictions of vegetation types at a site may impact what bird species are feasible to include in the target list. For example, a common goal of greenspace restoration is to enhance stormwater retention in order to meet water quality criteria. Restoring areas as wet vegetated treatment systems, infiltration practices, filtering systems, green roofs, or open channel practices will help meet this goal (RIDEM 2010). Of these, wet vegetated systems (surface wet stormwater basins that provide water quality treatment primarily in a shallow vegetated permanent pool), green roofs, and open channels (vegetated swales) have specific vegetation requirements that may preclude targeting some bird species. Therefore, it may not be feasible to include plants identified using the WoonyBird selector for a given bird species in the plantings for these types of systems. Infiltration practices (areas that facilitate retention of surface water into underlying soils), depending on their design, may have more flexibility in the types of vegetation that can be included, or may simply consist of unvegetated areas. Filtering systems may consist of structural filters with no associated vegetation, but may also include bioretention ponds that may require specific vegetation types. Common among all these practices is the need to tailor the target list of bird species to the type and characteristics of the greenspace. That said, a majority of the regional bird species will readily utilize wet areas or wetlands, the limiting factor may be the ability of a given plant species to withstand the conditions at the site. This information can be found during the plant selection process in the “profile of a plant's features” section of the WoonyBird selector. Many other types of urban greenspaces are not specifically designed for stormwater retention or water quality enhancement, and these may be a target for greenspace restoration as well. Included are formal parks and gardens, remnant natural areas, green corridors, community gardens, and informal recreational areas. While having specific structural requirements (e.g., urban parks often consist primarily of mowed lawns and managed wooded areas), these areas may allow more flexibility with regard to specific species of plants that may be included.

Surrounding land use and land cover

Landscape setting, or the mix of surrounding land use and land cover, has been shown to play a role in determining use of a site by bird species (Marzluff et al. 2001, Chace and Walsh 2006, Bierwagen 2008). For example, a primary response noted in numerous studies is the absence of

human-intolerant species, or 'urban avoiders', at locations in urban areas (Chace and Walsh 2006, Shwartz et al. 2008). An urban bird guild classification system proposed by Shwartz et al. (2008) was used to eliminate those species from the regional bird pool, hence this factor should not have to be explicitly considered when developing a target bird list for a site. However, proximity to other natural and semi-natural areas may be worth considering; for example, close proximity of urban wetlands has been shown to influence bird communities in nearby areas (McKinney et al. 2011). Similarly, if a site is near an area known to support breeding birds of a particular species, it may be prudent to consider targeting these species and to include plantings that will provide habitat both for foraging and, if practical, nesting.

Examples of identifying an appropriate target list of bird species for two hypothetical greenspace restorations are provided in Appendix 3.

Nearby riparian areas can often provide enhanced resources to birds using restored greenspaces. Photo: Woonasquatucket River; R. McKinney

IV. Additional Design Considerations

Selecting plant species to support a target list of desired bird species for a greenspace is an important component leading to the enhancement of habitat value for the restoration. Another equally important component is the spatial orientation of the plantings in the greenspace, or the practice of landscape design. One strategy that may have merit is to strive to mimic the stratification, or spatial arrangement, of different vegetation growth forms found in natural environments such as a mature, mesic forest. The forest environment typically consists of distinct layers of vegetation characterized by height. These include the uppermost canopy layer provided by the tallest trees, an understory layer of intermediate height or low trees, a shrub layer, an herbaceous vegetation of grass layer, and a layer of leaf litter immediately above the soil surface. Stratification in forests allows multiple vegetation growth forms to coexist in the same space since each layer can successively take advantage of available light and resources as the seasons progress. In early spring, lower vegetative layers such as grasses and herbaceous plants green first and hence can utilize sunlight before they become shaded by taller plants.

Shrubs will then leaf out, followed by understory trees and finally the canopy. By the time of complete canopy formation, the lower growth form plants have already accomplished sufficient growth and acquired sufficient resources to survive and propagate. Stratification also provides significant benefits for bird species by providing a variety of food, nest, and shelter options in the different layers and growth forms. Several elements of the spatial arrangement of vegetation that may have application in greenspace restoration are discussed below.

Maximizing habitat heterogeneity

Wherever possible it would be beneficial to provide a variety of vegetative layers by planting different growth forms plants: ground cover, short and tall shrubs, and short and tall trees. This will in turn provide nest opportunities for bird species that utilize different vegetative layers including ground nesters, species that nest in shrubs, and cavity nesters. In addition, a variety of growth forms will increase the likelihood of having plants that fruit at different times of the year, hence providing more reliable foraging opportunities.

One way to maximize habitat heterogeneity at a site is to mimic the practice of agricultural windbreaks (Kress 2006). Windbreaks generally consist of anywhere from 3 to 6 rows of woody plants of different heights running lengthwise through a site. As an example, a six-row windbreak would be approximately 12 m or 40 feet wide, and if it were to run for 150 m or 500 feet would occupy a 0.2 ha or half-acre site. Ideally a six-row windbreak will consist of two central rows of tall conifers, surrounded on either side by a row of small to medium sized deciduous trees, and finally bordered on either side by a row of shrubs. To enhance habitat value, each outer edge can be bordered by a row of herbaceous vegetation. In this arrangement the latitudinal or width-wise space between the rows of conifers would be about 3 m or 10 feet, between the conifers and deciduous trees about 2.5 m or 8 feet, and between the deciduous trees and shrubs about 2 m or 6 feet (Kress 2006). A best practice is to plant conifers in a weaving or meandering row, and if possible to mix fast- and slow-growing trees and shrubs. This is just one possible means to achieve habitat heterogeneity, depending on the size and characteristics of the site, and any restrictions of sight lines, there are many other possible orientations that would result in a variety of vegetative layers.

Changes in slope

A number of species, including towhees, sparrows, and wrens, are attracted to abrupt changes in slope as foraging habitat. These species will take advantage of naturally-occurring steeply-sloped areas along stream banks, rock outcroppings, and tree roots in order to prey on the insects which in turn use the numerous micro-habitats found in these areas. An artificial change in slope can be incorporated in a greenspace restoration by creating a gently-sloping soil mound, one side of which should end in an abrupt, south-facing rock face (Kress 2006). For added habitat value, low shrubs or groundcover plants could be incorporated.

Brush piles

If feasible, downed branches and other woody debris from a site can be collected in a small brush pile, located either in the center or one corner of the site. This will provide shelter for birds and a labyrinth of escape tunnels for avoiding predators, as well as micro-habitats for potential insect prey (Kress 2006). There may however be objections to including brush piles at a site because of aesthetic considerations; these can be mitigated to some extent if the piles are constructed in an orderly arrangement using a base of interwoven logs.

Summary

A greenspace restoration that will include plantings as part of the landscape design can be enhanced by specific plantings chosen to increase its bird habitat value. The WoonyBird Restoration Plant Selector will facilitate this process by suggesting plants which are appropriate for light and soil conditions at the restoration site, and which will attract bird species specified by the user. Target bird species for a given restoration site can be selected based on their conservation status, but site characteristics including size, type of restoration and any restrictions on vegetation type, and surrounding landuse and land cover should be considered. The landscape design of the site should try to maximize habitat heterogeneity by including different plant growth forms in an orientation that will result in a variety of vegetative layers. Incorporating changes in slope and brush piles at a site may help increase habitat value for some bird species. Overall the design of a site will have to balance enhancing habitat value with site-specific practical, aesthetic, and economic considerations.

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V. Literature Cited

Allison DG. 1947. Bird populations of forest and forest edge in central Illinois. Master's Thesis. Univ. of Illinois, Urbana, IL.

Bent AC. 1946. Life histories of North American jays, crows and titmice. U.S. National Museum Bulletin 191.

Bierwagen BG. 2008. Connectivity in urbanizing landscapes: The importance of habitat configuration, urban area size, and dispersal. Urban Ecosystems 10, 29–42.

Bjerke T, Ostdahl T. 2004. Animal-related attitudes and activities in an urban population. Anthrozoos 17:109–129.

Brown CR, Brown MB. 1995. Cliff Swallow (*Petrochelidon pyrrhonota*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/149.

Brown CR, Brown MB. 1999. Barn Swallow (*Hirundo rustica*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/452 (Accessed June 2013).

Bull EL, Jackson JA. 2011. Pileated Woodpecker (*Dryocopus pileatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/148 (Accessed June 2013).

Caffrey C. 1992. Female-biased delayed dispersal and helping in American Crows. Auk 109:609–619.

Cink CL, Collins CT. 2002. Chimney Swift (*Chaetura pelagica*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/646 (Accessed June 2013).

Chace JF, Walsh JJ. 2006. Urban effects on native avifauna: a review. Landscape and Urban Planning 74:46–69.

DeGraff RM. 2002. Trees, shrubs, and vines for attracting birds. Hanover, N.H: University Press of New England.

Eaton SW. 1992. Wild Turkey (*Meleagris gallopavo*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/022 (Accessed June 2013).

Emlen JT. 1974. An urban bird community in Tucson, Arizona: derivation, structure, regulation. Condor 76:184–197.

Harrison G, Davies C. 2002. Conserving biodiversity that matters: Practitioners' perspectives on brownfield development and urban nature conservation in London. Journal of Environmental Management 65:95–108.

Hill SR, Gates JE. 1988. Nesting ecology and microhabitat of the Eastern Phoebe in the central Appalachians. American Midlands Naturalist 120:313–324.

Kress SW. 2006. The Audubon Society guide to attracting birds, 2nd edition. Cornell University Press, Ithaca, New York.

Luck GW, Davidson P, Boxall D, Smallbone L. 2011. Relations between urban bird and plant communities and human well-being and connection to nature. Conservation Biology 25:816–826.

Martin AC, Zim HS, Nelson AL. 1951. American wildlife and plants. New York: Dover Publications.

Marzluff JM, Bowman R, Donnelly R. 2001. A historical perspective on urban bird research: trends, terms, and approaches. Pgs 1–17 *In* J. M. Marzluff, R. Bowman, and R. Donnelly [EDS.], Avian ecology and conservation in an urbanizing world. Kluwer Academic, Norwell, MA.

McGraw KJ, Middleton AL. 2009. American Goldfinch (*Spinus tristis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/080 (Accessed June 2013).

McKernan P, Hartvigsen G. 2001. The territory distribution of breeding songbirds in the Roemer Arboretum, Geneseo, NY. SUNY Geneseo Journal of Science and Mathematics 2:7–15.

McKinney RA, Nightingale ME. 2013. A framework for enhancing bird habitat value of urban greenspaces in the Woonasquatucket watershed, Rhode Island USA. US EPA Office of Research and Development Technical Report EPA/600/R-13/163, October, 2013.

McKinney RA, Raposa KB, Cournoyer RM. 2011. Wetlands as habitat in urbanizing landscapes: patterns of bird abundance and occupancy. Landscape and Urban Planning 100:144–152.

Nice MM. 1941. The role of territory in bird life. American Midland Naturalist 26:441–447.

Otis DL, Schulz JH, Miller D, Mirarchi RE, Baskett TS. 2008. Mourning Dove (*Zenaida macroura*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/117 (Accessed June 2013).

Panjabi AO, Blancher PJ, Dettmers R, Rosenberg KV. 2012. The Partners in Flight handbook on species assessment. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory website: http://www.rmbo.org/pubs/downloads/Handbook2012.pdf (Accessed June 2013).

Peer BD, Bollinger EK. 1997. Common Grackle (*Quiscalus quiscula*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/271 (Accessed June 2013).

Pielou WP. 1957. A life-history study of the Tufted Titmouse, Parus bicolor Linneaus PhD. Michigan State University, East Lansing.

RIDEM. 2010. Rhode Island Stormwater Design and Installation Standards Manual. Rhode Island Department of Environmental Management and Coastal Resources Management Council, Providence, RI, 487 pgs.

Robinson TR, Sargent RR, Sargent MB. 1996. Ruby-throated Hummingbird (*Archilochus colubris*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/204

Roth S. 1998. Attracting birds to your backyard. Rodale Press Emmaus, Pennsylvania.

Schoener TW. 1968. Sizes of feeding territories among birds. Ecology 49:123–141.

Searcy WA, Yasukawa K. 1995. Polygyny and sexual selection in Red-winged Blackbirds. Princeton Univ. Press, Princeton, NJ.

Sedgwick JA. 2000. Willow Flycatcher (*Empidonax traillii*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/533 (Accessed June 2013).

Shackelford CE, Brown RE, Conner RN. 2000. Red-bellied Woodpecker (*Melanerpes carolinus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/500 (Accessed June 2013).

Shwartz A, Shirley S, Kark S. 2008. How do habitat variability and management regime shape the spatial heterogeneity of birds within a large Mediterranean urban park? Landscape and Urban Planning 84:219–229.

Stewart RE, Robbins CS. 1958. Birds of Maryland and the District of Columbia. Fish and Wildlife Service, North American Fauna No. 62.

Tarof S, Brown CR. 2013. Purple Martin (*Progne subis*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/287 (Accessed June 2013).

Twomey AC. 1945. The bird population of an elm-maple forest with special reference to aspection, territorialism and coactions. Ecological Monographs 15:173–205.

Whitaker DM, Warkentin IC. 2010. Spatial ecology of migratory passerines on temperate and boreal forest breeding grounds. Auk, 127:471–484.

Appendix 1. Growth requirements and life history characteristics of woody plants either observed during 2012 at 17 study sites in the Woonasquatucket River watershed, Rhode Island, USA, or identified in the candidate plant species list.

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Acer negundo	Y	boxelder	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree	35–60	3–8	short	available	does best in riparian zones
Acer rubrum	Y	red maple	native	full sun, part shade	fine, medium, coarse	rapid	tree	35–68	3–9	short	available	does best in wet environments
Acer saccharinum	Y	silver maple	native	full sun, part shade	fine, medium, coarse	rapid	tree	45–95	3–9	moderate	available	looks un-kept if un-pruned; lifts sidewalks; good tree for away from homes
Acer saccharum	Y	sugar maple	native	full sun, part shade, full shade	medium, coarse	slow	tree, shrub	60–80	3–8	long	available	
Alnus incana	Y	gray alder	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree, shrub, thicket	15–25	2–6	short	available	nitrogen fixing
Alnus serrulata	Y	hazel alder	native	full sun, part shade	fine, medium, coarse	rapid	tree, shrub	12–30	3–8	moderate	available	nitrogen fixing
Amelanchier arborea	Y	common serviceberry	native	full sun, part shade	medium, coarse	slow	tree, shrub	25–36	5–8	moderate	available	used as a street plant-attractive
Amelanchier canadensis	Y	Canadian serviceberry, shadbush, juneberry		full sun, part shade, full shade	fine, medium, coarse	moderate	tree, shrub	20–23	4–10	long	available	found naturally in bogs
Amelanchier laevis	Y	allegheny serviceberry	native	full sun, part shade, full shade	medium, coarse	moderate	tree, shrub	30–35	4–8	short	available	sensitive to drought
Betula alleghaniensis	Y	yellow birch	native	full sun, part shade	fine, medium, coarse	slow	tree	25–75	3–7	moderate	field collections only	usually found in moist soils
Betula lenta	Y	cherry birch, sweet birch	native	full shade, part shade	medium, coarse	moderate	tree	15–60	4–9	moderate	field collections only	

Appendix 1 Cont'd

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Betula papyrifera	Y	paper birch	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree	40–70	2–7	moderate	available	
Betula populifolia	Y	gray birch	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree, thicket	25	3–6	short	available	
Carpinus caroliniana	N	American hornbeam	native	full sun, part shade, full shade	fine, medium, coarse	slow	tree	20	3–8	short	available	
Carya alba	Y	mockernut hickory	native	part shade, full shade	fine, medium, coarse	slow	tree	18–85	5–8	moderate	field collections only	prefers well drained soils, ridges, hillsides
Carya glabra	Y	pignut hickory	native	full sun, part shade	medium, coarse	slow	tree	30–80	5–9	moderate	contracting only	grows well in dry conditions; very drought tolerant
Carya ovata	Y	shagbark hickory	native	full sun, part shade, full shade	fine, medium, coarse	slow	tree	15–75	5–8	long	available	nuts can damage cars; do not put near streets
Celtis occidentalis	Y	common hackberry	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree, shrub	26–60	3–9	moderate	available	
Cornus alternifolia	Y	dogwood	native	full sun, part shade, full shade	medium	moderate	tree	25	3–8	moderate	no known source	
Cornus amomum	Y	silky dogwood	native	full sun, part shade, full shade	fine, medium, coarse	moderate	shrub	7–20	4–8	moderate	available	prefers moist soils
Cornus canadensis	Y	bunchberry dogwood	native	part shade, full shade	medium	slow	subshrub, shrub, herb	0.5	2–6	long	contracting only	prefers moist soils
Cornus racemosa	Y	gray dogwood	native	full sun, part shade, full shade	fine, medium	moderate	shrub	6–10	5–8	moderate	available	highly adaptable
Cornus sericea	Y	redosier dogwood	native	part shade	fine, medium, coarse	rapid	tree, shrub	7–10	2–7	moderate	available	naturally found near wetlands

Appendix 1 Cont'd

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Crataegus crus-galli	Y	cockspur hawthorn	native	full sun, partial shade	fine, medium, coarse	moderate	tree, shrub	30	3 –7	long	available	used as ornamental
Crataegus phaenopyrum	Y	Washington hawthorn	native	full sun, part shade	fine, medium	moderate	tree, shrub	25–30	4–8	long	available	used as ornamental
Fagus grandifolia	Y	American beech	native	part shade, full shade	medium, coarse	slow	tree	30–80	3–9	long	available	
Fraxinus spp.	N	ash	native	full sun, partial shade	medium, coarse	rapid	tree	30	4–9	moderate	available	
Gaylussacia spp.	N	huckleberry	native	full sun, partial shade	medium, coarse	rapid	shrub	3–6	3–8	moderate	available	
Ilex glabra	Y	gray inkberry	native	full sun, part shade, full shade	fine, medium, coarse	slow	shrub	5	4–9	long	available	male and female specific plants
Ilex laevigata	Y	gray smooth winterberry	native	part shade, full shade	fine	moderate	shrub	10–12	5–8	short	available	prefers woodland swamps
Ilex verticillata	Y	common winterberry	native	full sun, part shade, full shade	fine, medium	moderate	tree, shrub	6–10	3–9	moderate	available	
Juglans cinerea	Y	butternut	native	full sun	medium, coarse	rapid	tree	20–80	3–7	short	available	
Juglans nigra	Y	black walnut	native	full sun, part shade	medium	rapid	tree	35–100	4–9	moderate	available	
Juniperus communis	N	common juniper	native	full sun, part shade	medium, coarse	slow	shrub	4	4–9	long	available	
Malus spp.	N	crabapple	native	full sun	medium, coarse	moderate	tree, shrub	30	4–9	long	available	
Morus rubra	Y	red mulberry	native	full sun, part shade, full shade	sand, loam, clay	moderate	tree, shrub	12–36	5– 9	long (120 yr)	available	endangered in CT,MA
Myrica pensylvanica	Y	northern bayberry	native	full sun, part shade, full shade	medium, coarse	slow	tree, shrub	9–12	3–6	long	available	nitrogen fixing; male and female plants separate; berries only on F
Nyssa sylvatica	Y	marshall blackgum	native	full sun, part shade, full shade	medium, coarse	moderate	tree	30–95	5–9	moderate	available	wetland indicator

Appendix 1 Cont'd

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Parthenocissus quinquefolia	Y	Virginia creeper	native	part shade, full shade	fine, medium	rapid	vine	1	3–10	moderate	available	
Picea glauca	Y	white spruce	native	full sun, part shade, full shade		moderate	tree	18–20	5–7	long	available	early seral
Picea pungens	Y	blue spruce	introduced	part sun, part shade	medium, coarse	slow	tree	20–100	4–7	long	available	
Picea rubens	Y	red spruce	native	full sun, full shade	fine, medium, coarse	slow	tree	30–100	5–7	moderate	available	
Pinus rigida	Y	pitch pine	native	full sun	medium, coarse	rapid	tree	20–80	4–7	moderate	available	inhabits coast
Pinus strobus	Y	eastern white pine	native	full sun, part shade, full shade	medium, coarse	rapid	tree	20–80	3–7	moderate	available	requires early weed control
Pinus sylvestris	Y	scotch pine	introduced	full sun	medium, coarse	rapid	tree	30–110	3–8	moderate	available	
Populus deltoides	Y	eastern cottonwood	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree	80–190	3–9	short	available	
Populus grandidentata	Y	bigtooth aspen	native	full sun, part shade, full shade	medium, coarse	rapid	tree	40–65	3–9	short	available	
Populus tremuloides	Y	quaking aspen	native	full sun, part shade, full shade	fine, medium, coarse	rapid	tree	40–65	1–8	short	available	
Prunus pensylvanica	Y	pin cherry, fire cherry	native	full sun	fine, medium, coarse	rapid	shrub, tree	25–30	3–8	short	available	
Prunus serotina	Y	black cherry, rum cherry	native	full sun, part shade, full shade	medium, coarse	rapid	shrub, tree	40–80	4–9	moderate	available	
Prunus virginiana	Y	chokecherry	native	full sun, part shade, full shade	fine, medium, coarse	rapid	shrub, tree	15–25	2–7	short	available	
Quercus alba	Y	northern white oak	native	full sun, part shade, full shade	medium, coarse	slow	tree	25–100	3–8	long	available	

Appendix 1 Cont'd

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Quercus coccinea	Y	scarlet oak	native	full sun	medium, coarse	rapid	tree	30–70	4–8	long	no known source	
Quercus palustris	Y	pin oak	native	full sun, part shade, full shade	fine, medium	rapid	tree	40–100	4–8	moderate	available	
Quercus rubra	Y	northern red oak	native	full sun, part shade	fine, medium, coarse	moderate	tree	36–81	4–8	long	available	
Quercus velutina	Y	black oak	native	full sun, part shade	fine, medium, coarse	moderate	tree	25–80	4–9	moderate	available	
Rhus hirta	Y	staghorn sumac	native	full sun	medium, coarse	rapid	shrub, tree	30	4–7	short	available	
Ribes americanum	Y	American black currant	native	full shade, part shade, full sun	fine, medium, coarse	rapid	shrub	15–30	3–6	short	available	
Rosa carolina	Y	Carolina rose	native	part shade, full sun	medium, coarse	moderate	subshrub	5	5–8	moderate	available	disturbed areas, roadside
Rosa virginiana	Y	Virginia rose	native	part shade, full sun	medium, coarse	moderate	subshrub	6	4–7	moderate	available	
Rubus allegheniesis	Y	Allegheny blackberry	native	full, partial	fine, medium, coarse	rapid	thicket	1–6	6–9	short	available	
Rubus flagellaris	Y	common dewberry	native	full, partial	clay, loam, sand, rocky	rapid	thicket, vine	3	6–9	short	available	threatened in Indiana
Rubus idaeus	Y	American red raspberry	native	full sun	fine, medium, coarse	moderate	subshrub	6–9	5–9	short	available	
Rubus occidentalis	Y	black raspberry	native	part shade, full sun	fine, medium	rapid	subshrub	5–6	4–9	short	available	
Rubus odoratus	Y	purple flowering raspberry	native	part shade, full sun	fine, medium, coarse	rapid	subshrub	5	3–8	short	no known commercial source	

Appendix 1 Cont'd

Species	Observed ?	Common name	Invasive/ native	Sun amount	Soil texture	Growth rate	Growth habit	Size class (ft)	Hardiness (RI 5–7)	Lifespan	Commercial	Additional
Sambucus canadensis	Y	common elderberry	native	part shade, full sun	medium	rapid	shrub, tree	7	4–9	moderate	available	
Sambucus racemosa	Y	red elderberry	native	part shade, full sun	medium, coarse	moderate	shrub, tree	10–20	1–5	moderate	available	historical; early seral; inhabits riverbanks
Sorbus americana	N	American mountain ash	native	full sun	fine, medium, coarse	moderate	shrub, tree	30	3–8	moderate	available	
Spiraea spp.	N	meadowsweet	native	part shade, full sun	fine, medium, coarse	rapid	shrub	4	4–9	long	available	
Symphoricarpos spp.	N	snowberry	native	part shade, full sun	fine, medium, coarse	rapid	shrub	4	4–9	long	available	grows well in urban areas
Ulmus americana	Y	American Elm	native	part shade, full sun	fine, medium, coarse	rapid	tree	50–120	3–9	moderate	available	
Vaccinium angustifolium	Y	low bush blueberry	native	full shade, part shade, full sun	fine, medium, coarse	moderate	subshrub, shrub	1–2	2–5	moderate	available	
Vaccinium corymbosum	Y	high bush blueberry	native	full shade, full sun	fine, medium, coarse	moderate	shrub	12	6–10	moderate	available	
Viburnum dentatum	Y	southern arrowwood	native	part shade, full sun	medium, coarse	moderate	shrub	3–9	5–7	moderate	available	
Viburnum lentago	Y	nannyberry	native	part shade, full sun	fine, medium	slow	shrub, tree	28	5–7	long	available	

Appendix 2: Using the Plant Selector

To use the tool, first download and open the spreadsheet (WoonyBird Plant Selector.xlsm) and enable macro operation. All operations are conducted on the worksheet labeled "Main". Following is a brief description of the layout of this sheet, referencing Figure A-1; 1) reminder to first enable macro operation; 2) touch the blue "Setup" icon to specify run parameters (the Setup form is described further below); 3) a list of run parameters as specified by the user for the current run; 4) the results of a run: a list of plant species names and common names meeting the specifications of the current run, i.e., plants that are appropriate for the site's light and soil conditions and are attractive to the birds specified by the user during Setup; 5) a profile of a plant's features and possible sources where the plant may be purchased. Touch on a name in the species list at left to view that plant's profile; 6) touch the red "Print Report" icon to preview the run results prior to printing the report.

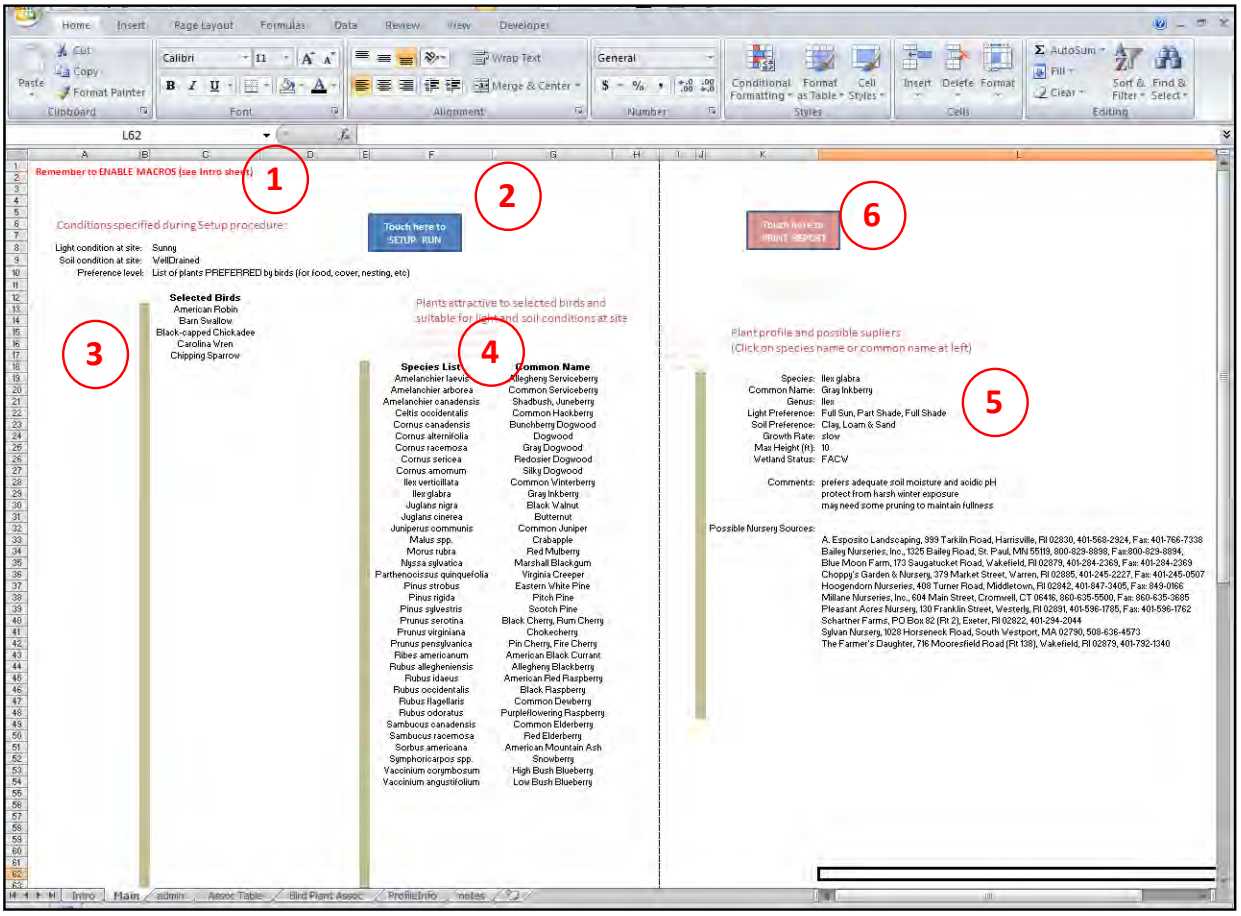

Figure A-1. Main screen of Plant Selector spreadsheet tool.

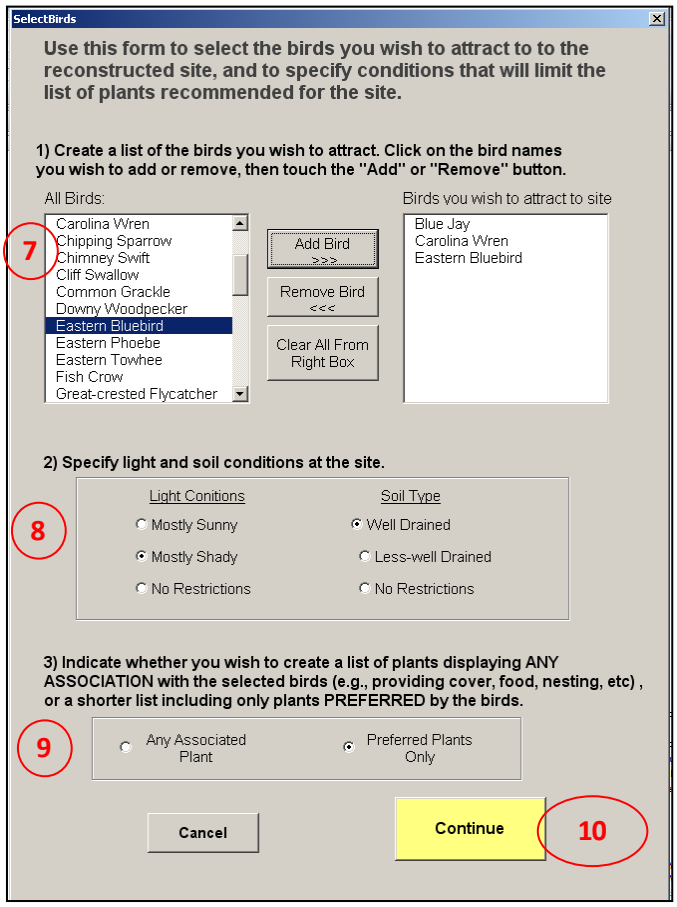

Figure A-2. Setup Form of Plant Selector spreadsheet tool.

Touch the blue "Setup" icon on the "Main" worksheet to launch the Setup Form. Refer to Figure A-2; 7) create a list of birds you wish to attract to the restored site by adding bird names to the right-hand box; 8) specify light and soil conditions at the site; 9) indicate whether the suggested plant list should include plants that have ANY ASSOCIATION with the selected birds (i.e., plants providing any degree of cover, food, or nesting service), or include only a shorter list of plants PREFERRED by the birds for cover, food, nesting, etc.; 10) touch the yellow "Continue" icon to initiate the analysis. The run results will appear on the Main sheet.

Other worksheets contain information and calculation regions (alter them with caution). The plant-bird "Association Table" and "Profile Info" contained on separate worksheets may be of interest to the user. Nursery contact information is contained on the ProfileInfo sheet (near column X).These Tables can be printed in the usual Excel manner, and may be modified or expanded along with minor modification of the macro code. All operations are generally conducted from the MAIN worksheet alone.

Appendix 3: Designating a target list of bird species

This section provides two hypothetical examples of designating a target list of bird species for use with the WoonyBird Restoration Plant Selector tool. The first is a 1.5 ha restoration site in the more urbanized segment of the Woonasquatucket watershed, adjacent to a riparian buffer area but surrounded by high density residential and commercial land use. The second is a 10.1 ha site in the more rural northern segment of the watershed, surrounded by several wetlands and in close proximity to a state forest. In both cases designation of the target list of species will be driven by the existing conditions at the restoration site, including i) size of the site; ii) the type of restoration planned; iii) any restrictions on vegetation at the site; iv) land use surrounding the site; and v) proximity of the site to existing natural habitats or known breeding habitat. In this example we will assume that each site will be restored for stormwater management, with no restrictions on vegetation at the site.

Site 1.

The primary considerations for this site are its relatively small size and proximity to high density residential and commercial land use. Based on an area of 1.5 ha, 11 of the 40 regional bird pool species with territory size > 1.5 ha can be eliminated from consideration: the site will presumably not be large enough for these birds to nest. Hairy Woodpeckers, Least and Willow Flycatchers, Cliff Swallows and Purple Martins, although having sufficiently small territory size, will generally avoid high density residential areas and therefore should not be included in a target list. Of the remaining twenty-three species after size and proximate land use have been taken into consideration, Wild Turkeys may be inappropriate for high density residential areas even though they tolerate human presence because they can sometimes be over-aggressive towards humans. Red-winged Blackbirds generally will nest in wetlands and would therefore not be included in the target list. Several species, including American Robin, House Sparrow, and Common Grackle, are already abundant in the urban parts of the watershed and should therefore be excluded. Of the remaining eighteen species, Chimney Swift, Barn Swallow, Blue Jay, Northern Mockingbird, Grey Catbird, Chipping Sparrow, and Song Sparrow have Partners In Flight Population Trend classifications of three or greater, or are of regional conservation concern. These seven species could therefore be justified as target bird species for this restoration.

Site 2.

This site is both larger than site 1 and is either bordered by or is closer to areas of natural vegetation or wetlands. Therefore essentially all of the regional bird pool species, except for Red-tailed Hawks and Great Horned Owls, are candidates for a target list based on territory size. In this situation, it would be beneficial to target species which are less likely to use urban areas or human intolerant species. Willow and Least Flycatchers, as well as Eastern Towhee have relatively high Partners In Flight Population Trend classifications and therefore would be good candidates for a target list. In addition, Hairy and Pileated Woodpeckers are of regional conservation concern. These five species could therefore be justified as target bird species for this restoration.

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