

Pathways of learning about biodiversity and sustainability in private urban gardens

First and corresponding author:

Alan P. DIDUCK

Department of Environmental Studies & Sciences

The University of Winnipeg

515 Portage Avenue, Winnipeg, Canada R3B 2E9

Email: a.diduck@uwinnipeg.ca

Ph: +1.204.786.9777

Christopher M. RAYMOND

christopher.raymond@helsinki.fi

Helsinki Institute for Sustainability Science (HELSUS), University of Helsinki, Finland

Ecosystems and Environment Research Program, Faculty of Biological and Environmental Sciences, University of Helsinki, Finland

Department of Economics and Management, Faculty of Agriculture and Forestry Sciences, University of Helsinki, Finland

Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, Sweden

Romina RODELA

rominarodela@hotmail.com

School of Natural Sciences, Technology and Environmental Studies, Södertörn University

Robert MOQUIN

rob.moquin@gmail.com

Department of Environmental Studies & Sciences, The University of Winnipeg

Morrissa BOERCHERS

morrissa.boerchers@gmail.com

Department of Environmental Studies & Sciences, The University of Winnipeg

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2 Abstract

3 Nature-based solutions directed at improving biodiversity, on both public and private
4 land, can provide multiple benefits, but many of these benefits are not being fully realized.
5 One reason is the normative and cognitive disconnect between people and nature,
6 highlighting the need for new learning programs to foster better nature connections. More is
7 known about learning in the context of community gardens than in relation to private
8 gardens. Using semi-structured interviews and thematic analysis, this study explores learning
9 among residents engaged in home gardening for biodiversity in Winnipeg, Canada. We
10 uncovered diverse and interconnected learning processes/activities founded on formative
11 childhood experiences. The processes/activities were non-formal and informal, and included
12 individual, social and blended experiences. Learning outcomes were also mutually
13 influencing and multi-levelled, comprising normative, cognitive/behavioural and relational
14 changes. The results support an analytical framework suggesting how learning-focused
15 initiatives can enhance biodiversity on private property and aid in delivery of nature-based
16 solutions.

17 **Key words:** nature-based solutions; biodiversity conservation; private gardens; non-formal
18 and informal learning; multi-level learning

19 **1. Introduction**

20 Urbanization continues as a global megatrend. In 2014, 54% of the world's population
21 lived in urban areas, with this percentage expected to increase to 66% by 2050. This trend,
22 combined with ongoing population growth, will add 2.5 billion people to urban centres by
23 2050 (United Nations 2014). Further, the impacts of urbanization on biodiversity are
24 becoming increasingly clear. Land-cover change, loss of habitat and vegetation biomass, and
25 other anthropogenic factors, and the self-reinforcing feedbacks among them, are contributing
26 to reduced species, functional, structural and ecosystem diversity (e.g., Pickett et al. 2011,
27 Seto et al. 2012, Steffen et al 2018).

28 Given these challenges, a major priority is to understand how urban expansion may be
29 planned to minimise the loss of biodiversity and maintain urban ecosystem service delivery
30 (Luederitz et al. 2015, Schwarz et al. 2017). Another is to unlock the conservation potential
31 of blue and green spaces on private residential lands (e.g., Cameron et al. 2012, Lindemann-
32 Matthies and Marty 2013, Cleveland et al. 2017, Baldock et al. 2019), particularly when
33 faced with increasing population and housing densities (Gaston et al. 2005, Loram et al.
34 2007, Gaston et al. 2007). Additionally, it is clear that multi-level community engagement,
35 including initiatives that engage, educate and empower residents (van Heezik et al. 2012,
36 Goddard et al. 2013, Buijs et al. 2016, Mumaw 2017), is crucial to unlocking the
37 conservation potential of private residential lands, or gardens.

38 Our research objective was thus to understand how learning about biodiversity in
39 urban private gardens informs a range of cognitive, relational, normative and environmental
40 changes, including garden management practices. We used a qualitative case study and
41 thematic analysis to augment established methods and frameworks (i.e., van Heezik et al.
42 2012, Mumaw 2017, Suškevičs et al. 2017) for understanding the multiple pathways of

43 learning, and in doing so we further elucidate the interconnections between learning and the
44 management of private lands for biodiversity conservation.

45 **2. Problematique**

46 ***2.1. Nature-based solutions***

47 Many studies have assessed the relationships among urban infrastructure initiatives,
48 biodiversity and ecosystem services, and found that conserving and enhancing *public* urban
49 blue and green spaces can positively affect resources and habitats for species of interest
50 (Niemelä 2014), and enhance functional and structural connectivity (Iojă et al. 2014). At the
51 same time, although the majority of biodiversity and ecosystem service relationships are
52 positive, in some cases they can be negative, neutral or undecipherable (see: Schwarz et al.
53 2017 for a recent detailed review).

54 Similarly, *private* urban gardens can provide an array of supporting, provisioning,
55 regulating, and cultural ecosystem services (Cameron et al. 2012, Lindemann-Matthies and
56 Marty 2013, Cleveland et al. 2017), including enhanced biodiversity at multiple levels
57 (Galluzzi et al. 2010, Sperling and Lortie 2010, Lerman and Warren 2011, Goddard et al.
58 2013). Further, biodiversity conservation can also have direct positive affects on cultural
59 ecosystem services, e.g., spiritual, intrinsic, recreational and social values (Raymond et al.
60 2009, Freeman et al. 2012, Fish et al. 2016). The extent to which these services and benefits
61 are realized depends on a range of factors, including garden size or vegetated area (Smith et
62 al. 2005, Gaston et al. 2005, van Heezik et al. 2013), housing type and density (Gaston et al.
63 2007, Loram et al. 2007), and garden uses and management practices (Loram et al. 2011),
64 which in turn can be influenced by socio-economic status and ability to discriminate between
65 native and exotic species (van Heezik et al. 2013). Along with ecosystem services and
66 associated benefits, private gardens can have, along with broader negative effects such as
67 greenhouse gas emissions from fertilizer application (Livesley et al. 2010), direct adverse

68 impacts on biodiversity, including spread of non-native and invasive species (Niinemets and
69 Peñuelas 2008).

70 A paucity of studies investigate these multi-directional effects between biodiversity,
71 ecosystem services and well-being in urban areas. To begin to address these effects, scientific
72 investigations are now examining the co-benefits and -costs of urban green infrastructure
73 initiatives on biodiversity, ecosystem services and human well-being under the wider banner
74 of ‘nature-based solutions’ (NBS) (Raymond et al. 2017). NBS are inspired and supported by
75 nature, bring together established ecosystem-based approaches, provide environmental, social
76 and economic benefits and help build resilience. NBS directed towards improving
77 biodiversity and the supply of ecosystem services, *on both public and private land*, can
78 provide co-benefits for human health and well-being, water management, hazard
79 management and air quality. However, despite this, many of these benefits are not being fully
80 realised (see: Raymond et al. 2017 for a review). One reason for this is the disconnect
81 between people and nature pervading western societies, which highlights that new learning
82 programs are needed to foster better connections to nature (van Heezik et al. 2012, Beery et
83 al. 2017).

84 Given the multiple co-benefits of nature connections through NBS, there are also
85 likely to be multiple pathways of learning about them. However, little is known about how
86 learning processes and outcomes are located in NBS, especially in the context of private
87 garden management. This is a major gap given that NBS are seen as open innovations that
88 require, in their design and implementation, engagement with multiple actors and integration
89 of diverse types and systems of knowledge (Frantzeskaki and Kabisch, 2016; Raymond et al.,
90 2017). One thing that is known is that complementary public and private action is required
91 (Mumaw and Bekessy 2017), including community-driven initiatives that engage, educate
92 and empower residents (Goddard et al. 2013). A crucial aspect of such initiatives is providing

93 opportunities for citizens to expand their gardening skills and knowledge and deepen their
94 understanding of, and attachment to, their local environment and the biosphere (van Heezik et
95 al. 2012, Andersson et al. 2014, [in-text citation deleted to maintain the integrity of the
96 review process]). In other words, learning is an essential element of the governance of private
97 gardens in aid of biodiversity conservation and stewardship.

98 ***2.2. Learning in environmental governance***

99 Learning continues to attract considerable attention in environmental governance, and
100 is thought to be key for addressing complexity and uncertainty and for generating positive
101 social-ecological change (e.g., Wals 2007, Diduck et al. 2012, Suškevičs et al. 2017).

102 Although much is known about learning and governance, important gaps remain in the
103 literature. For example, in their recent review, Gerlak et al. (2017) identified a wealth of
104 research questions and goals but also found lack of precision in defining learning, a need for
105 conceptual clarity and theoretical development, little diversity in cases and methods, and a
106 need for more rigour in assessing learning. Similarly, in their review Suškevičs et al. (2017)
107 found rich conceptual/ theoretical diversity but also identified the need for further empirical,
108 methodological and conceptual contributions regarding the linkages among learning,
109 management and sustainability.

110 In the realm of gardening, much is known about learning in the context of community
111 gardens. The rich community garden literature has, for example, revealed how gardening:
112 permits collaboration and co-creation of outcomes involving different forms and systems of
113 knowledge (Nevens et al. 2013, Frantzeskaki and Kabisch 2016); enables learning about
114 biodiversity and ecosystem services management (Shava et al. 2010); facilitates ongoing
115 interaction among multiple aspects of the socio-cultural and biophysical environment (Bendt
116 et al. 2013, Krasny et al. 2013); and, can result in the development and transmission of socio-

117 ecological memory (Barthel et al. 2010) and shared solutions to sustainability problems
118 (Calvet-Mir et al. 2016).

119 In contrast, the literature on learning, biodiversity and private gardens is less
120 developed. We know that programs in support of gardening for biodiversity are viewed as
121 essential for enhancing voluntary stewardship and improving urban habitat quality
122 (Dewaelheyns et al. 2016). The literature also shows evidence that homeowners are receptive
123 to environmentally friendly alternatives to gardening approaches heavily dependent on
124 exogenous inputs (Peterson et al. 2012, Lindemann-Matthies and Marty 2013, Shaw et al.
125 2017). Van Heezik et al. (2012) conducted one of the first studies of a learning-based
126 intervention aimed at promoting biodiversity conservation in home gardens. Their study,
127 involving 55 gardeners in Dunedin, New Zealand, revealed the efficacy of biodiversity
128 appraisals, dialog, and information feedback for improving knowledge of wildlife and native
129 species and encouraging adoption of native-friendly gardening practices. More recently, in an
130 Australian study, Mumaw (2017) and Mumaw and Beckesy (2017) examined a program
131 designed to improve biodiversity conservation in home gardens and advanced a stewardship
132 development model in which different outcomes emerge at different phases. Learning by
133 doing results in the achievement of improved stewardship behaviour during the initiation
134 phase. In the development phase, the stewardship behaviour can, in turn, lead to a range of
135 co-benefits such as feelings for nature, place and stewardship, the reinforcement of
136 stewardship values and knowledge and improved stewardship competency.

137 In this study, we add to the nascent literature on the nexus spanning learning,
138 biodiversity and private gardens, and respond to the calls in the broader learning and
139 environmental governance literature for precision in terminology, more case diversity, and
140 empirical and conceptual insights into the links between learning and management (Gerlak et
141 al. 2017, Suškevičs et al. 2017). As noted earlier, we build on established frameworks (i.e.,

142 van Heezik et al. 2012, Mumaw 2017, Suškevičs et al. 2017) to further reveal how learning
143 about biodiversity in urban private gardens informs a range of personal, social and
144 environmental changes, including garden management practices.

145 **2.3. Key concepts and terms**

146 First, we defined learning in a broad and inclusive manner, which is important for
147 learning embedded in garden governance. Drawing from seminal adult education literature
148 (i.e. Merriam et al. 2007) and from a framework of multi-level learning in environmental
149 governance (i.e. Diduck 2010), we defined learning as change in response to identifiable
150 stimuli or information. Moreover, our concern in this study is with *non-formal* and *informal*
151 *learning* (Merriam et al. 2007, Paradise and Rogoff 2009). Non-formal learning refers to
152 learning facilitated by *urban environmental education* that occurs outside of formal
153 educational institutions, such as that offered by conservation organizations, government
154 agencies, and community-university partnerships. Urban environmental education aims to
155 create “learning opportunities to foster individual and community well-being and
156 environmental quality in cities” (Russ and Krasny 2017, p. 288). Informal learning refers to
157 the experiences of everyday living from which people learn something; it is learning through
158 observation, participation and self-directed knowledge creation.

159 **3. Research design**

160 We took an exploratory and inductive approach (Creswell 2014), preparing a
161 qualitative case study of non-formal and informal learning (by gardeners) about biodiversity
162 conservation in private gardens in the Canadian city of Winnipeg. Winnipeg is illustrative
163 because it is home to Naturescape, a longstanding education and certification program aimed
164 at increasing biodiversity in private gardens introduced and overseen by FortWhyte Alive an
165 environmental education centre in southwest Winnipeg (FortWhyte Alive 2017).

166 **3.1. Background to the case**

167 Winnipeg, the political capital and economic centre of the Province of Manitoba, is
168 the seventh largest city in Canada, with a 2016 population of 705,244, population density of
169 1,519 per km², and an area of 464 km². The average age of the population is 39.9 years, the
170 majority of homes are single-detached houses (59.4%), and the average household size is 2.5
171 people (Statistics Canada, 2017). Winnipeg is located at the eastern edge of the northeast
172 North American plains. The soil in the area is typified by heavy lacustrine sediment upon
173 which periodic riverine flooding helps create exceptionally fertile soils (Smith et al. 1998).
174 The regional climate is characterized by short, warm summers and long, cold winters. The
175 annual mean temperature in Winnipeg is 3.0°C, with a daily average of -16.4°C in January
176 and 19.7°C in July. The region receives between 85 and 120 frost-free days, on average. The
177 mean annual precipitation is 521.1 mm, 418.9 mm of which is rainfall (the remainder snow).
178 The majority of rainfall occurs in June through August (Environment Canada 2018).

179 FortWhyte Alive is a 630-acre environmental education centre in southwest
180 Winnipeg. In 2016, it had 25 full-time staff members, 505 volunteers, and a budget over
181 \$2,500,00. One of its programs, Naturescape, aims to enhance biodiversity and increase
182 habitat for native flora and fauna in private gardens. The program offers an array of non-
183 formal education activities for home gardeners, most of which occur at FortWhyte. The
184 activities include presentations and workshops on subjects such as pollinators, composting,
185 creating habitat for insects, birds and wildlife, and organic gardening. The program also
186 provides guidance and advice to gardeners via the telephone and online (FortWhyte Alive,
187 2017). Naturescape attracts gardeners who are sustainability-minded and who have an interest
188 in protecting and enhancing biodiversity ([in-text citation deleted to maintain the integrity of
189 the review process]), and it also offers incentives to its participants, including discounts at the
190 FortWhyte store and local garden centres. A further incentive is that participants whose
191 gardens meet certain biodiversity-related criteria, such as planting native species, creating

192 habitat, providing year-round food sources, and avoiding biocides, receive a “Naturescape
193 certified” garden sign for displaying in their garden.

194 **3.2. *Semi-structured interviews***

195 Our primary method was semi-structured interviews. Using a purposive approach
196 (Creswell 2014), we selected participants who were actively engaged in home gardening for
197 biodiversity conservation or restoration of native plants and animals. We recruited 33
198 participants from among the Naturescape certified gardeners (after FortWhyte obtained
199 permission for us to contact them) and another 17 using a snowball approach, which involved
200 asking the “Naturescapers” to introduce us to people who, while not Naturescape certified,
201 had gardening practices similar to their own. Overall, forty-two (42) interviews were
202 conducted in April and May 2017 (covering 42 gardens), each lasting between 30 and 60
203 minutes. Most of the interviews were conducted in the participants’ home or garden, with
204 four being done at FortWhyte and one via telephone. Prior to, or following, each of the
205 interviews at the participants’ residences, we viewed and photographed the gardens.

206 Each interview was audio recorded and transcribed verbatim. Most interviews (n =
207 35) were conducted with individuals, while the balance were with couples (n = 6) and in one
208 case a family of three. The interview guide had 27 questions and prompts, and was divided
209 into six main parts, which delved into demographic and garden characteristics, learning
210 activities or processes (i.e., how learning occurred), learning outcomes (i.e., what was
211 learned), and other personal, environmental and social benefits resulting from gardening. This
212 paper focuses on the learning questions, but also includes learning-related data obtained in
213 response to the benefit questions.

214 **3.3. *Analysis***

215 We used inductive, or grounded, thematic analysis (Corbin and Strauss 2014,
216 Creswell 2014), using codes and seeking themes and sub-themes (related to learning

217 activities/ processes and outcomes) that were grounded in the language and ideas of the
218 interview participants. Using NVivo 12 qualitative analysis software, we did four rounds of
219 coding (open, axial and thematic), encompassing both non-formal and informal learning. For
220 each individual code we collated all data segments (instances of text) where that code
221 appeared in the dataset, and themes were ultimately developed when codes clustered together.
222 Presence or absence of data was then recorded for each theme, or sub-theme, together with
223 the number and percentage of interviews clustered at each particular theme. In keeping with
224 thematic qualitative analysis, predominance was not the sole measure of thematic
225 significance; the importance of minority viewpoints was also considered.

226 To assist with trustworthiness, we held a verification meeting with research
227 participants in September 2017 in which we distributed a plain language summary of the
228 research, presented the preliminary results, and facilitated a discussion about the results. The
229 results are represented in Section 4 by direct quotations from the interviews. To save space,
230 we selected the one, or sometimes, two quotations that best represent the findings. To protect
231 anonymity, we assigned code names to the participants.

232 **4. Results**

233 *4.1. Demographic and garden characteristics*

234 The research participants were generally older, more formally educated, and came
235 from higher income households than others in Winnipeg (Statistics Canada, 2016), and most
236 had been living in their homes for relatively long periods of time. The average size of their
237 properties was larger than the typical lot (parcel) size in Winnipeg (465 m²) (Pers. Comm.
238 Winnipeg Realtors 2018), and their gardens were located in both back and front yards as well
239 as alongside the house. By way of summary:

- 240 • 74% of the participants were over the age of 50 (\bar{x} =59);
- 241 • 70% were female;

- 242 • 42% were retired;
- 243 • 66% had college or university degrees;
- 244 • 20% were involved in education, law and social, community or government services;
- 245 • 14% were engaged in business, finance or administration;
- 246 • 67% had been living in their homes for more than 15 years ($\bar{x}=21$); and
- 247 • property sizes ranged from 149 to 9,239 m² ($\bar{x}=1,211$).

248 **4.2. Learning activities or processes**

249 The analysis yielded six interrelated, non-mutually exclusive, primary themes about
 250 learning activities or processes (i.e., how learning occurred): 1) childhood experiences; 2)
 251 practice; 3) workshops, classes and conferences; 4) resource material; 5) talking with
 252 gardeners; and 6) observation. Five of the primary themes include secondary themes and, in
 253 one case, tertiary themes. Table 1 identifies the themes and, to show their predominance,
 254 includes the number and percentage of interviews that provided evidence regarding each
 255 theme.

256 INSERT TABLE 1

257 **4.2.1. Workshops, classes, conferences**

258 The predominant primary theme was *workshops, classes and conferences*, referenced
 259 in 88% of the interviews. These learning activities were sponsored by *universities, the city,*
 260 *churches or conservation organizations* (36% of the interviews), *the Manitoba Master*
 261 *Gardener Association* (21%), *garden clubs, societies or nurseries* (17%), and
 262 *Naturescape/FortWhyte* (62%), and covered a host of topics, such as butterfly gardens,
 263 compost tea, container gardening, medicinal plants, moon gardening, native species, and pest
 264 and disease control.

265 Regarding Naturescape/FortWhyte activities, in 24% of the interviews (representing
266 36% of interviews with Naturescape participants) people referred to *applying for certification*
267 *and attending workshops or classes*. In contrast, in 40% of the interviews (or 61% of the
268 Naturescape interviews) people said they had not attended educational events but simply
269 *applied for certification*. Janis said, “No I haven’t done any of the workshops or the
270 volunteering; it’s yeah, really just the certification side.” Bonnie reported, “I haven’t been to
271 any of the offerings of Naturescape, because in a sense I know a lot of that stuff. I’ve spent a
272 lot of time at FortWhyte, apart from that, so I don’t need to go back for more.”

273 4.2.2. *Childhood experiences*

274 In 74% of the interviews, participants traced how they learned about gardening to
275 formative *childhood experiences*. For example, Joni said, “I grew up with it. I’ve been a farm
276 kid. It’s just something you did. I mean, you just planted your garden in the springtime; you
277 did the harvesting over the course of the summer and fall. So, it’s just always been a part of
278 me.” Similarly, Grace reported that, “When I was a kid my mum had a big vegetable garden
279 and I always had my little couple of rows at the end that I could plant whatever I wanted in so
280 I guess that’s where I first got the gardening bug.” Janis put it this way: “I mean it was kind
281 of always around, but it wasn’t like “Come into the garden with me”. So, osmosis. Is that a
282 good answer?”

283 4.2.3. *Practice*

284 Learning through *practice* was another common primary theme (74% of interviews).
285 Participants often expressed themselves in terms of *experimentation, exploration or trial and*
286 *error* (50%). For Mick, “You just have to kind of learn and experiment as you go and figure
287 out what is going to work in your space and for the things that you are growing.” Similarly, in
288 many interviews (48%) participants spoke in terms of *learning by doing*. When asked how
289 she learned to garden, Aretha said, “Well actually, by doing it. And for many years I did

290 certain things wrong.” *Volunteering in the community* (24%) was another important process
291 of learning through practice: “I’ve been involved with [Nature Manitoba] since long before
292 we moved here. So, I built up a good knowledge of native plants, especially native prairie
293 plants, and I just wanted to grow some of them” (Diana).

294 4.2.4. Talking with gardeners

295 *Talking with gardeners* was the fourth most common primary theme (43%), and its
296 two predominant secondary themes were *technical experts* and *friends and peers*, both of
297 which were referenced in 26% of the interviews. Regarding *technical experts*, Dolores
298 described the following experience when asked why she began gardening: “There were some
299 botanists in the room who would talk about native plants and then we started talking about
300 putting in flower gardens and the ideas just bloomed one after the other with what to plant.
301 And not just to do hybrid perennials that are on the market but to put in something that
302 wildlife will benefit from as well and things that we can harvest food from.”

303 About *friends and peers*, Van had the following to say when asked how he learned
304 how to garden: “I learned from just gardening and trying a whole bunch of stuff and meeting
305 people and learning from community members and friends. I think it is an invaluable
306 resource to try to learn as much from people as possible. I don’t think there is a right or
307 wrong way [to garden]. Some things are going to work better than others and some people
308 have methods they’ve used for many years and it’s always worked perfectly for them.”

309 4.2.5. Resource material

310 *Resource material* was another primary theme (40% of interviews), and included the
311 *Internet* (10%), *brochures and pamphlets* (7%) and generic references to *reading* (7%).
312 *Books and magazines* was the predominant secondary theme (31%). Keith said, “I’ve got tons
313 of books and all kinds of stuff that I could always find something on”. Eric talked about, “...a
314 magazine called Harrowsmith – maybe it is dead now – but they had some articles about

315 gardening that really caught my fancy. I read some articles about wildflowers and I really
 316 thought it was cool”.

317 4.2.6. *Observation*

318 The sixth primary theme dealing with learning activities or processes was *observation*
 319 (24% of interviews), which includes *watching family* (10%) and *garden tours and field trips*
 320 (14%). About the former, Ronnie said he first learned to garden “from my grandmother, my
 321 baba. Just from observation.” Regarding the latter, George and Patti said: “We had gone on a
 322 garden tour and we saw a yard that had that [Naturescape] sign and we were curious about it,
 323 what that meant. And then I think [Patti] tripped across it maybe at FortWhyte and then we
 324 sort of got the application and looked at it and said oh that’s really cool and thought, gee,
 325 we’re really close [to qualifying for certification].”

326 4.3. *Learning outcomes*

327 We found three primary themes about learning outcomes (i.e., what was learned): 1)
 328 normative; 2) cognitive or behavioural; and 3) relational. The primary themes were
 329 interconnected and not mutually exclusive, and each contained secondary themes and, with
 330 one exception, tertiary themes (Table 2).

331 INSERT TABLE 2

332 4.3.1. *Normative*

333 4.3.1.1. *Personal fulfilment or identity*. Evidence regarding *normative* changes, i.e., changes
 334 relating to norms, standards or ethics, was found in all the interviews. The predominant
 335 secondary theme was *personal fulfilment or identity* (76% of interviews), which included
 336 general comments such as Carole’s statement that gardening is “a whole undertaking and part
 337 of our lifestyle and what we get excited about.” *Personal fulfilment or identity* also consisted

338 of four tertiary themes, the two most prominent of which were *mindfulness, reflection or*
339 *relaxation* (45%) and *happiness, gratification or creativity* (26%). Regarding the former,
340 Charlie said gardening has helped him clarify what is important in his life, “everything from a
341 spiritual sense – not in the sense of religion – to an ethical sense of understanding all the life
342 forms or not understanding all the life forms.” With respect to *happiness, gratification or*
343 *creativity*, Diana reported that, “When I see things doing well, when I see birds using trees
344 and shrubs that I’ve planted, it’s hugely gratifying.” About her garden, Linda said, “it’s my
345 creative side that I can release there.” The remaining tertiary themes pertained to gardening
346 helping people develop a *sense of home* (17%) and giving them *direction, motivation or*
347 *purpose* in life (12%).

348 *4.3.1.2. Nature connections.* The second most prominent normative theme was *nature*
349 *connections*, including greater appreciation for land, nature and plants (74% of interviews).
350 Here, as above, people sometimes spoke in general terms, e.g., “[Gardening] connects us to
351 the land. We have planted prairie so it is sort of a reminder of our place here on the prairies”
352 (Mick). Additionally, specific connections coalesced around three tertiary themes, the two
353 most prominent of which were *wildlife and birds* (45%) and *biodiversity* (29%). The first of
354 these pertained to increased enjoyment of outdoors, and in particular attracting and viewing
355 wildlife and birds. For example, Carole said, “We’re also really excited to see what birds we
356 get and what critters we get. Last year, I woke up to this horrible ruckus. I’m like, “What is
357 going on outside?” And I look outside the window and that squirrel buster that I told you
358 about, we used to have it back there, hanging on the fence, and we looked and a giant raccoon
359 had taken it and was just shaking it like this.”

360 The *biodiversity* sub-theme encompassed general comments as well as references to
361 specific aspects of biodiversity, namely native species, habitat and pollinators. An example is
362 Bonnie’s comment that for her gardening has reinforced the importance of “providing habitat

363 for endangered species, for both migratory species, and also for species that live here –
364 whether it's insects or for birds.” The remaining tertiary theme encompassed greater
365 recognition of the *balance or beauty* (12%) of nature.

366 *4.3.1.3. Environmental consciousness.* Another prominent normative theme, *environmental*
367 *consciousness* (67% of interviews), was reflected in both general comments, e.g.,
368 “[Gardening] has made me aware that we really have to be more environmentally conscious”
369 (Keith), and in specific references grouped by tertiary themes. The two most common themes
370 were *environmental protection or conservation* (24%) and *stewardship* (24%). With regard
371 the first of these, Etta said, “I did use some sprays years and years ago, early on when I first
372 got started. But I've come a long way and I do not want anything to do with chemicals,
373 because I mean it's not good for the environment, it's not good for me, for people.”
374 *Stewardship* involved a sense of responsibility for the land or a desire to give something back
375 to nature, as seen in the following comment: “I guess what working on this yard and
376 converting it from basically a blank piece of lawn to this chunk of habitat, has made me
377 realize how important it is to look after a piece of [land] no matter how small or how
378 immersed in an urban environment” (Diana).

379 *4.3.1.4. Engaging with community.* The fourth secondary normative theme pertained to how
380 gardening helped people clarify the importance of *engaging with community* (21% of
381 interviews), e.g., “I think that gardening should not be limited just to the home yard but the
382 whole community. For example, boulevards, why do we only grow grass on boulevards?
383 There are people who are hungry and people who need vegetables. Why don't we encourage
384 people to plant a garden on the boulevard and then donate or share it? Gardening should be
385 something that unifies and is broader than just the individual homeowner” (Johnny and June).
386 This theme included a tertiary theme regarding *teaching or helping others* (12%), e.g., “I
387 always trust and believe in gardening and also I'm more interested in teaching young minds

388 because I see that the new generation is way away from gardening or nature” (Bob, Sara and
389 Jakob).

390 4.3.2. Cognitive or behavioural

391 4.3.2.1. Nature. We found evidence of *cognitive or behavioural* changes in all of the
392 interviews. The predominant secondary theme was *nature* (93% of interviews), which
393 included four tertiary themes. *Ecosystems* (69%) was predominant and covered three broad
394 aspects: habitat, shelter and food; pollinators (butterflies, bees, bats); and ecological
395 connections. Talking about Naturescape, Courtney said, “What I’ve taken away from it is to
396 try to keep things as natural as possible, so I don’t clear everything out in the fall. I don’t
397 clear up all the leaves or the brush; I leave places for birds and frogs and toads to shelter.”

398 *Plants* (53%) was the second most prominent tertiary theme, covering basic biology, a
399 wide array of species, biodiversity, native species and heritage species. For example, in
400 answer to what he has learned through gardening, Mick said, “Another thing is just the
401 structure of plants, like how things grow. I couldn’t really give you specifics about that but
402 paying attention to when the potato plant flowers or pulling up a raspberry plant and looking
403 at the roots and figuring out the root connections.” Regarding biodiversity, Bonnie said, “I’ve
404 become much more conscious of the endangered prairie ecosystem, as a whole, and of the
405 diminishing acreages of tall grass/mixed grass prairie and of the species that find their home
406 on that land.”

407 *Birds* (45%) was also a prominent tertiary theme, comprising species diversity,
408 biology, behaviour and feeding. For example, in speaking about Naturescape, Carly said,
409 “I’ve tried a number of things to attract certain birds, like orioles. Having certain colours out
410 there, having certain types of food for them; I’ve learned that through Naturescape.” Talking
411 about his garden, Elvis said, “The birds usually are out there [in the garden] and so I know
412 how the different birds are going to respond. Some fly away, some hang around.” *Outdoor*

413 *living and nature observation* (31%) was the final tertiary theme, capturing activities that take
414 advantage of the benefits of having garden, e.g., bird watching and socializing.

415 4.3.2.2. *Gardening*. Another notable secondary theme, *gardening* (83% of interviews), was
416 made up of four tertiary themes, the predominant one being *management* (69%). This theme
417 covered composting, mulching, organic approaches, soil conservation and water
418 conservation. Stevie said the following about water: “I’m a little more conscious, maybe, of
419 the water sources, keeping a damp spot for butterflies and so on. We’ve got a couple of bird
420 baths and the pond, so we’ve always had a water feature”. Carole discussed her organic
421 approach to pest control: “We actually had an inundation of aphids on our plum. So, instead
422 of spraying it, we just bought a whole bunch of ladybugs and let them go, and that took care
423 of our problem. It was a really cool idea to use something natural like that, and it worked like
424 a charm”.

425 *Design* (38%) and *methods* (36%) were two additional tertiary themes. The former
426 includes companion gardening. For example, Aretha said, “I go to [workshops or classes] to
427 learn about plants, communities and more like the ecology of this type of gardening because I
428 think this is fascinating. What shall we grow together, what thrives together and that’s what I
429 learned from these organizations.”

430 *Methods* covers day-to-day routines, such as pruning, weeding and deadheading along
431 with seasonal routines, such as seed saving and planting seedlings. In contrast to those who
432 emphasized environmental protection or organic methods, in three interviews people
433 indicated that their gardening experiences led them to realize that using pesticides is
434 sometimes necessary, e.g., “Some people are absolutely drug free, nothing, no chemicals,
435 nothing in their yard. But they’re people who don’t have a life and they like to sit there all
436 day and pick the damned lily beetles. I work for a living, so I have to spray them” (Keith).

437 *Challenges* (14%) was the final tertiary theme of gardening, largely reflecting concerns about
438 the effects of climate change on growing seasons and plant hardiness zones.

439 4.3.2.3. *Validation or empowerment*. The final secondary theme, *validation or empowerment*
440 (40% of interviews), captured suggestions that gardening or being involved in Naturescape
441 validated people's understandings or practices. As an example, Bonnie said, "I love the idea
442 that [Naturescape] is encouraging people to see their garden as a haven for wildlife, to garden
443 responsibly. And for me, it was important to be supporting that and to have what I've done
444 here validated in some kind of way." Along the same lines, Lucinda stated, "It gave me
445 courage to really focus on tall grass and to be brave with that. It gave me confidence to do
446 that. Yeah, that's really important."

447 4.3.3. *Relational*

448 4.3.3.1. *Community building*. We found evidence of *relational* changes in 40 of the 42
449 interviews. The predominant secondary theme was *community building* (81% of interviews),
450 which included four tertiary themes. In 48% of interviews, people discussed how gardening
451 or being involved in Naturescape influenced their friendships through development of *shared*
452 *interests in nature* (48%). For example, Elvis reported, "I have one friend who gardens. She's
453 English and she likes to do it in traditional manner but I've introduced her to some native
454 shrubs and other plants and I think she's altering her habits a little bit." Forty eight per cent
455 (48%) of interviews also revealed evidence of *reciprocity or gifting*, e.g., "[Gardening] has
456 changed our relationships with our neighbours. We will give some produce to our neighbours
457 if we have extra. Sometimes our produce grows over the fence so we say, just help yourself
458 to whatever grows on the other side of the fence" (Mick). Further, in 24% of interviews,
459 participants discussed how gardening or Naturescape *enhanced friendships*, e.g., "Working
460 with gardens has helped [Niko] and I become better friends, because we have something in

461 common that we both love” (Mavis). In another 24%, people revealed how they made new
462 acquaintances because of their garden. For example, Janis said, “There’s a lot of community
463 interest and people introducing themselves and asking questions in that way.”

464 *4.3.3.2. Family bonding.* Yet another notable secondary theme was *family bonding* (64% of
465 interviews), which encapsulated two tertiary themes. Similar to the theme of community
466 building, people discussed how gardening or Naturescape influenced their family connections
467 through the development of *shared interests and activities* (50%). “My husband and I have
468 grown into gardening and grown to being excited about nature in our backyard together”
469 (Carole). “My brother and I have become a lot closer, and found something to talk about – a
470 shared interest” (Paul and Linda). Several interviews referenced that gardening evoked fond
471 *family memories or sentiments* (21%), e.g., “I’ve got a bleeding heart that belonged to my dad
472 and I mean that thing’s – like he’s been gone, he died in ’88 but I still have the perennial. So
473 it’s a continuation of life almost” (Billie).

474 *4.3.3.3. Civic engagement.* Another noteworthy secondary theme was *civic engagement* (43%
475 of interviews), which included three tertiary themes. Nine interviews (21%) revealed
476 evidence of *new or wider networks*, e.g., “I have another whole community now when I got
477 involved with [XYZ Garden Club]. I’m now good friends with a couple of excellent
478 gardeners. Socially has it changed me? I guess that’s it (Gladys). A further 21% of the
479 interviews referenced *volunteering* for a gardening, conservation or other community
480 organization. For example, Aretha explained that her gardening experiences led her to
481 volunteer at [XYZ House] taking care of its raised garden beds, “mostly container things and
482 being available to the families who stay there because they have a sick child in the hospital”.
483 Finally, in eight interviews (19%), people discussed how gardening or Naturescape, has led
484 them to engaging in advocacy. For example, with respect to the Naturescape sign, George
485 and Patti said, “Because we live in a suburban landscape we always make jokes that we are

486 the neighbourhood hippies so we wanted to put that sign out and show people that this yard
 487 isn't a mess. It's intentional and that they could try new things other than just grass and lawn
 488 surface.”

489 *4.3.3.4. Conflict or isolation.* The final secondary theme was *conflict or isolation* (29% of
 490 interviews), which stood in contrast to the building and bonding themes noted in Sections
 491 4.3.3.1 and 4.3.3.2. Several people commented on how gardening for biodiversity created
 492 conflict with their neighbours. Annie discussed being the subject of multiple nuisance
 493 complaints by her neighbours because of her seemingly untidy garden. Lucinda reported a
 494 similar experience. In three interviews, people (Diana, Carly, Janis) noted how their
 495 neighbours think they are “weird” or “crazy”. Chrissie summed it up like this: “I think the
 496 biggest problem I have is that permaculture and its whole philosophy is so contrary to
 497 conventional life in North America and certainly conventional gardening practice, and so I
 498 feel at odds all the time.”

499 **5. Discussion**

500 From the results we conceptualised a multi-layered analytical framework outlining
 501 *pathways of learning about biodiversity and sustainability in private urban gardens* that
 502 combines both processes / activities and outcomes (Figure 1). The framework is underpinned
 503 by two guiding principles.

504 INSERT FIGURE 1

505 ***5.1. Learning processes / activities are mutually influencing, multi-leveled and both non-*** 506 ***formal and informal***

507 Figure 1 presents interconnected learning processes / activities founded on formative
 508 childhood experiences (section 4.2.2). The processes / activities include both non-formal
 509 (4.2.1 – workshops, classes, conferences; 4.2.5 – resource material) and informal types (4.2.3

510 – practice; 4.2.4 – talking with gardeners; 4.2.6 – observation). Further, they are multi-
511 levelled in the sense that they include highly individual (resource material) (the dark grey
512 circle in the processes / activities box of Figure 1), highly social (workshops, classes,
513 conferences; talking with gardeners) (the white circles) and blended individual / social
514 (practice; observation) (the light grey circles) experiences. The left-to-right feedback arrow
515 represents the influences that processes / activities have on outcomes, as reported by the
516 research participants.

517 The framework builds upon important insights from the informal and non-formal
518 learning literatures. It supports earlier research where formative informal childhood learning
519 experiences were found to have an impact on recreational and environmental preferences,
520 interests, and attitudes later in life (e.g., Fisman 2005, Bourke et al. 2018). It also establishes
521 the importance of such experiences in relation to gardening for biodiversity and
522 sustainability, particularly when combined with multiple informal and non-formal adult
523 learning processes / activities.

524 While we assumed that Naturescape’s non-formal learning programs would be a
525 primary influence on learning outcomes, we found that other non-formal events (e.g., those
526 organized by garden clubs, societies or nurseries – 4.2.1) and a wealth of informal processes /
527 activities (i.e., practice, dialogue and observation) were just as influential, or perhaps more
528 so. The framework thus illuminates the importance of, and the linkages among, non-formal
529 learning events, practice, dialogue (i.e., talking with gardeners), observation, and individual
530 study / reflection (i.e., engaging with resources). This diverse bundle of processes / activities
531 might be indicative of a meaningful search learners put in place for a type of exchange and
532 learning opportunities from which they can benefit in terms of gardening for biodiversity
533 conservation.

534 Additionally, the framework is consistent with Salomon and Perkins' (1998)
535 continuum of individual and social aspects of learning. It links learning as experienced by
536 individual gardeners to the broader context where they are embedded inclusive of the social
537 network with which they interact. Moreover, it does so in the specific context of gardening
538 for biodiversity and connects learning opportunities gardeners develop on their own (i.e.,
539 with hands-on practice, observation, and engagement with resources) with learning
540 opportunities gardeners experience during interaction with others / like-minded people (i.e.,
541 attending events, workshops and talks and exchange with gardeners). This sheds light on the
542 processes / activities that could play a role in learning at different levels of social aggregation
543 (i.e., individuals, groups, organizations, etc.), which continues to be an under explored
544 question in the environmental governance and learning literature (e.g., Gerlak et al. 2017).

545 ***5.2. Learning outcomes are multiple (normative, cognitive / behavioural, relational),***
546 ***mutually influencing, and encompass feedbacks with the processes / activities that support***
547 ***them***

548 Figure 1 shows that, similar to processes / activities, the learning outcomes (4.3.1 –
549 normative; 4.3.2 – cognitive / behavioural; 4.3.3 – relational) are interconnected. An example
550 is the clear overlap among greater appreciation for land, nature and plants (4.3.1.2), better
551 understanding of ecosystems (4.3.2.1) and development of shared interests in nature
552 (4.3.3.1.). As well, the outcomes are multi-levelled in that they include largely individual
553 (normative) (the dark grey circle in the outcomes box of Figure 1), largely social (relational)
554 (the white circle), and blended (cognitive / behavioural) (the light grey circle) experiences.
555 Further, they are multi-levelled in the sense that by spanning cognitive / behavioural,
556 normative and relational change they encompass different aspects of a person's meaning
557 perspective. The right-to-left feedback arrow represents that learning outcomes influence

558 processes / activities. The two feedbacks depict that learning was continuous, iterative and
559 dynamic, as suggested in the results.

560 The broad types of outcomes (normative, relational and cognitive / behavioural) we
561 found resonate with what others working with social learning in natural resource management
562 have reported before (for a review: Rodela 2014). The novel contribution of our framework is
563 that learning outcomes are not laid out in the abstract but are contextualised to biodiversity,
564 sustainability and urban gardens, which then allows assessment and collection of evidence
565 about each. Further to this, having these outlined may help to fine tune the design and
566 delivery of future programs which aim to perform as a (non-formal) learning intervention
567 targeting urban gardeners and to that end structure activities at different levels (individuals,
568 groups, organizations) meant to best address issues and needs present in that area.

569 The framework is consistent with the observation by Suškevičs et al. (2017), who
570 noted that natural resource and environmental managers develop a sense of direction for their
571 own learning that is influenced by social networks. Our study builds on that by highlighting
572 that a wider social and institutional context influences strategies gardeners adopt when
573 navigating different learning opportunities available to them, and how that context then
574 influences their choices about gardening. Our study, although encompassing a wider array of
575 learning processes and outcomes, also aligns with the study by van Heezik et al. (2012), who
576 showed the effectiveness of garden appraisals, dialogical non-formal learning activities, and
577 information feedback for enhancing capacity for biodiversity gardening. Additionally, our
578 work is consistent with Mumaw's (2017) stewardship development model of non-formal
579 learning for biodiversity conservation in home gardens. A point of distinction is the extent to
580 which our framework highlights formative childhood learning experiences. Another is our
581 framework's emphasis on informal learning and multiple and diverse non-formal learning

582 processes / activities. This emphasis is consistent with Heimlich et al.'s (2017) observation
583 about the wealth of non-formal environmental education programs found in many cities.

584 Another contribution of the 'pathways of learning' framework is the direction it offers
585 for future research, such as testing its applicability among gardeners who were less interested
586 and involved in gardening for biodiversity than were our participants. The people in our
587 sample were noticeably sustainability-minded and highly motivated to protect and enhance
588 biodiversity in their gardens. A sample with different formative childhood experiences, and
589 less access to learning activities/ processes, might have revealed different types of learning
590 outcomes. Other promising avenues of further research include identifying the most effective
591 NBS policy and governance measure for promoting biodiversity conservation initiatives
592 across private and public lands and exploring how learning-based initiatives can be used to
593 advance biodiversity conservation at the landscape scale. Further, there is a need to apply
594 different research designs and methodologies, such as longitudinal studies, mixed methods
595 and narrative-based constructivist approaches, so we can build theory through both deep
596 understanding of learning pathways and generalizable results across individuals and groups,
597 and across time.

598 **6. Conclusions**

599 This research reveals the extent to which learning about biodiversity and
600 sustainability in private urban gardens is multi-form, multi-layered and dynamic. It adds to
601 the literature interested in the nexus between learning, biodiversity and private gardens by
602 providing descriptive evidence about individual experiences conducive to learning, including
603 contact with nature, contact between different individuals and groups, and other activities and
604 sources. The study also finds how this involves varied cognitive, behavioural, relational and
605 normative changes that emerge in an iterative and ongoing fashion at different parts of the
606 various pathways. As well, these changes are not only associated with one nature-based

607 solution or learning program but are constituted in a larger socio-ecological context. These
608 features suggest how learning-based initiatives can support the expansion and enhancement
609 of biodiversity on private property. Ongoing and decentralized initiatives, making use of
610 diverse informal and non-formal opportunities, can aid the design and delivery of nature-
611 based solutions. They can also support policy makers, urban planners and natural resource
612 managers in reflecting on what NBS interventions are meant to achieve in the short and long
613 term. Looking at interventions not only as solutions to given problems but as learning
614 pathways can better help policy makers and practitioners to consider among competing
615 components and select those better favouring learning and change.

616

Table 1: Summary of themes about learning activities or processes and the number and percentage (n = 42, 100%) of probative interviews. The themes are interrelated and not mutually exclusive (with the exception of certification vs. certification and workshops or classes).

Primary themes	Secondary themes	Tertiary themes
Workshops, classes, conferences (37, 88%)	Naturescape/FortWhyte (26, 62%)	Certification (17, 40%)
		Certification and workshops or classes (10, 24%)
		Consultation (2, 5%)
	Universities, the city, churches or conservation organizations (15, 36%)	
	Manitoba Master Gardener Association (9, 21%)	
	Garden clubs, societies or nurseries (7, 17%)	
Childhood experiences (31, 74%)		
Practice (31, 74%)	Exploration, experimentation, or trial and error (21, 50%)	
	Learning by doing (20, 48%)	
	Volunteering in the community (10, 24%)	
Talking with gardeners (18, 43%)	Technical experts (11, 26%)	
	Friends and peers (11, 26%)	
	Family (3, 7%)	
Resource material (17, 40%)	Books and magazines (13, 31%)	
	Internet (4, 10%)	
	Brochures and pamphlets (3, 7%)	
	Reading (3, 7%)	
Observation (10, 24%)	Garden tours and field trips (6, 14%)	
	Watching family (4, 10%)	

Table 2: Summary of themes about learning outcomes and the number and percentage (n = 42, 100%) of probative interviews. The themes are interrelated and not mutually exclusive.

Primary themes	Secondary themes	Tertiary themes
Normative (42, 100%)	Personal fulfilment or identity (32, 76%)	Mindfulness, reflection or relaxation (19, 45%), Happiness, gratification or creativity (11, 26%), Sense of home (7, 17%), Direction, motivation or focus (5, 12%)
	Nature connections (31, 74%)	Wildlife and birds (19, 45%), Biodiversity (12, 29%), Balance or beauty (5, 12%)
	Environmental consciousness (28, 67%)	Environmental protection or conservation (10, 24%), Stewardship (10, 24%), Food sovereignty (7, 17%), Permaculture or sustainability (3, 7%)
	Engaging with community (9, 21%)	Teaching or helping others (5, 12%)
Cognitive or behavioural (42, 100%)	Nature (39, 93%)	Ecosystems (29, 69%), Plants (22, 52%), Birds (19, 45%), Outdoor living and nature observation (13, 31%)
	Gardening (35, 83%)	Management (29, 69%), Design (16, 38%), Methods (15, 36%), Challenges (6, 14%)
	Validation or empowerment (17, 40%)	
Relational (40, 95%)	Community building (34, 81%)	Shared interest in nature (20, 48%), Reciprocity or gifting (20, 48%), Enhanced friendships (10, 24%), New acquaintances (10, 24%)
	Family bonding (27, 64%)	Shared interests and activities (21, 50%), Family memories or sentiments (9, 21%)
	Civic engagement (18, 43%)	New or wider networks (9, 21%), Volunteering (9, 21%), Advocacy (8, 19%)
	Conflict or isolation (12, 29%)	

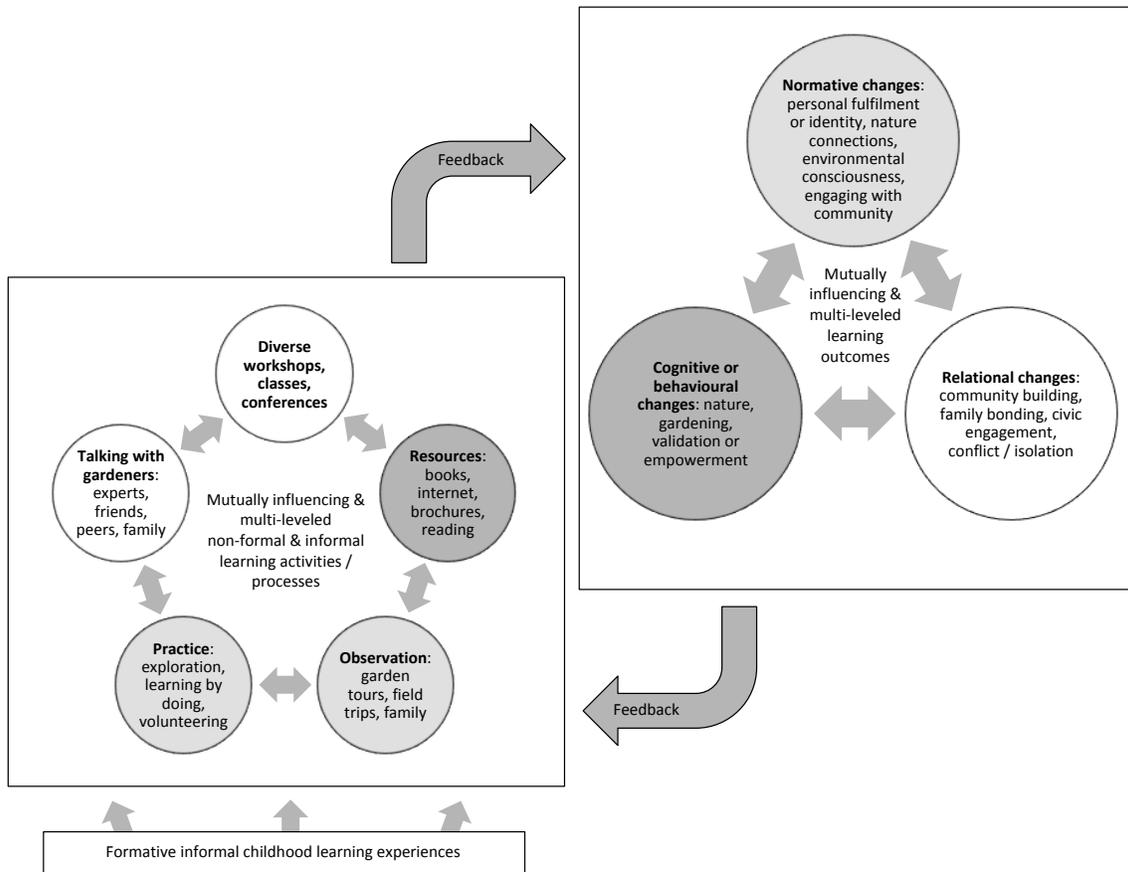


Figure 1: Multiple pathways of learning about biodiversity and sustainability in private urban gardens

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