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Jean-Louis Yengué, N. Bech, Hélène Royer

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1 Urban agriculture and its
2 biodiversity: what is it and
3 what lives in it?

4

5 H. Royer^{a-b}, JL Yengue^a, N. Bech^b

6

7 Corresponding Author

8 Hélène Royer ^{a-b}

9 ^aLaboratory of RURALITES, UR13823, Poitiers University,

10 Poitiers, France.

11 MSHS, Bâtiment A5

12 5, rue Théodore-Lefèbvre

13 TSA 21103

14 86073 POITIERS Cedex 9, France

15

16 ^bLaboratory of Ecologie et Biologie des Interactions (EBI),

17 UMR CNRS 7267, Poitiers University, Poitiers, France.

18 Bâtiment B31

19 3 Rue Jacques Fort

20 TSA 51106

21 86073 POITIERS Cedex 9, France

22 helene.royer67@yahoo.fr

23 Co-authors

24 Jean-Louis Yengué^a

25 ^aLaboratory of RURALITES, UR13823, Poitiers University,

26 Poitiers, France.

27 MSHS, Bâtiment A5

28 5, rue Théodore-Lefèbvre

29 TSA 21103

30 86073 POITIERS Cedex 9, France

31 jean.louis.yengue@univ-poitiers.fr

32

33 Nicolas Bech^b

34 ^bLaboratory of Ecologie et Biologie des Interactions (EBI),

35 UMR CNRS 7267, Poitiers University, Poitiers, France.

36 Bâtiment B31

37 3 Rue Jacques Fort

38 TSA 51106

39 86073 POITIERS Cedex 9, France

40 nicolas.bech@univ-poitiers.fr

41

42 Abstract

43 Whereas cities continue to grow at the expense of agricultural

44 and natural areas, the interest for urban agriculture (UA) is on

45 the rise. Its popularity comes from its ability to address issues

46 specific to the city including nature conservation. We question

47 here what is currently known about UA in terms of definition

48 and existing forms and also what biodiversity is able to live in
49 it. Several definitions of UA co-exist, showing three common
50 points: (i) the location on an urban territory, (ii) the activity
51 itself and (iii) its inclusion in conventional or alternative food
52 systems. Some authors suggest studying UA within the inter-
53 communality area as it is difficult to establish a delimitation
54 between rural and urban. Many forms of UA can be found in
55 cities, from old ones: gardens, private or collective, occurring
56 or maintained mainly in times of crisis – to newest forms:
57 (micro)urban farms or green spaces. Activities are diverse with
58 the possibility of growing vegetables, fruit trees and raising
59 animals (recently allowed back in cities of the Global North). A
60 review on the biodiversity found on these areas shows that
61 under favourable conditions of management and surrounding
62 land use, UA would also be able to harbour a noticeable
63 biodiversity and contribute to nature conservation in cities.
64 Further research is needed to better understand the ecological
65 implication of UA. Nevertheless, we recommend considering
66 UA for its benefits provided to humans but also to non-human
67 beings as a habitat.

68

69 Keywords

70 Urban agriculture; biodiversity; allotment gardens; community
71 gardens; urban farm; species richness

72

75 In 2018, 55% of the world's population lived in cities and this is
76 expected to increase to 68% by 2050 (United Nations, 2018) as
77 well as the total number of humans on earth.

79 Although cities occupy only a small part of the emerged lands,
80 urbanisation represents a drastic and sustainable change in
81 landscapes that illustrates the perforation of natural areas
82 worldwide (Sanderson and Huron, 2011; Ramalho and Hobbs,
83 2012). Consequently, urbanisation is often associated with a
84 drastic loss of natural places for citizens as well as for
85 biodiversity occurring in the cities (McDonald et al, 2013).
86 Furthermore, urbanisation also contributes to changes in
87 agricultural systems, whether as a vehicle for changing the
88 dietary habits of urban dwellers or as a cause of agricultural
89 land use changes (Seto and Ramankutty, 2016). As farmlands
90 around cities disappear, a new enthusiasm for urban agriculture
91 (UA) is growing in metropolises around the world. Several
92 origins of this craze are emerging, including the desire to
93 develop “an activity that allows for better food, social, political,
94 economic and environmental resilience of more vulnerable
95 urban communities and citizens” (Duchemin, 2013), “questions
96 about the future and sustainability of the city” (Granchamp-
97 Florentino, 2012), or the “critique of the development model of

98 contemporary societies based on consumerist and capitalist
99 dynamics” (Gisclard and Raymond, 2018).

100
101 Agriculture in an urban context is complex to address and the
102 term UA itself is difficult to define. Indeed, it may seem
103 contradictory because agriculture is an economic and spatial
104 activity commonly attributed to the countryside and associated
105 with rural landscapes (Le Caro et al, 2016). Yet, we find
106 agriculture both inside and outside cities. According to
107 Bertrand et al (2005), UA represents an interesting “meeting
108 between the city and agriculture” especially because of positive
109 externalities such as amenities, social and cultural functions
110 (Lovell, 2010). While it appears that UA can be defined by its
111 geographical localisation (within the cities), the distinction
112 between urban, peri-urban and rural is difficult to delineate,
113 since the expansion of urbanisation is dynamic and has blurred
114 the lines. The concept of an “urban-rural” continuum or
115 gradient seems more appropriate and coexists with the idea of a
116 generalised urbanity (Le Caro, 2016) and a ruralisation of the
117 city (Chalas, 2003). The urban character of this form of
118 agriculture is not to be sought solely in its location.

119
120 According to Duchemin (2013), the dynamics of agriculture,
121 especially within cities, follow the pace of crises experienced
122 by human societies and respond to issues specific to the city.

123 Indeed, it seems that UA can be the result of societal needs in
124 terms of food as well as social and cultural functions (Lovell,
125 2010). For instance, during the crisis in Cuba, UA was
126 developed to provide food security. However, trajectories
127 continue to cross between the countries of the Global North and
128 of the Global South as the multifunctional character of UA
129 asserts itself (Yengué, 2014; 2019). In countries of the Global
130 North, UA are often the result of a new social demand,
131 exclusively urban, aiming to improve the living environment by
132 adding areas offering recreation, cultural heritage and visual
133 quality (Lovell and Johnston, 2009). Indeed, cultivated spaces
134 contrast with the “all urban” idea and constitute “green breaks”
135 in the city. They are places of relaxation and recreation,
136 forming part of a green infrastructure (Robert and Yengué,
137 2017). UA is expected to meet the needs of city dwellers for
138 “authenticity of the lived territory” and to support the
139 “territorial memory of an idealised past.” In terms of social
140 issues, it also serves as a vehicle for the socialisation and
141 reintegration of disadvantaged or marginalised people
142 (Consalès, 2003).

143

144 UA supports a wide range of ecological services (air quality,
145 water quality, natural hazard prevention and control, nature
146 awareness etc.) that benefit the nearby community and society
147 (Consalès, 2003; Lovell and Johnston, 2009) as well as the

148 biodiversity. While urban environments have long been
149 neglected in initiatives aiming to conserve biodiversity
150 (Abadie, 2008), they have finally shown a significant potential
151 for hosting biodiversity and the ability to participate in
152 ecological dynamics (Saint-Laurent, 2000; McKinney, 2008; Di
153 Pietro et al, 2018). However, given the strong anthropic
154 pressures found in urban environments and the increase in their
155 surface area, urban biodiversity is threatened (Abadie, 2008). In
156 this context, UA appears as a potential haven able to shelter
157 urban biodiversity. This UA, combined with urban green
158 spaces, creates an ecological network within the cities that is
159 crucial for resilience and the preservation of the biodiversity
160 (Mehdi et al, 2012; Efese, 2018; Robert & Yengué, 2017;
161 Glatron, 2018). Although some recent programmes are
162 addressing the importance of urban biodiversity, further
163 investigations especially in UA are needed to better define its
164 part in the biodiversity dynamics and conservation (Beniston
165 and Lal, 2012).

166

167

168 Herein, we collected elements from an overview of the
169 different forms of UA to define the latter. Then, a state of
170 knowledge on biodiversity in UA allowed us to answer the
171 following questions: what do we know about biodiversity in
172 UA? For which of these spaces can we conclude that they play

173 a role in the preservation of biodiversity in the city?

174

175

176 1. Urban agriculture: concepts to define

177

178 In 1999, the Food and Agriculture Organization (FAO)

179 produced a report about Urban and Peri-urban Agriculture

180 (UPA) aimed at highlighting its growing importance and the

181 subsequent issues. Despite the lack of a universal definition of

182 UPA, the authors suggest that it is located within and around

183 cities and represents areas modified and maintained by

184 agricultural practices (e.g. labour force) and resources (e.g. soil,

185 water, energy,) to satisfy urban population needs.

186 Later, as the FAO, Mougeot (2010, in Duchemin, 2013) also

187 defined UPA spaces as areas mobilising resources and located

188 within or on the fringe of a town, a city or a metropolis but

189 specified also that UPA distributes a diversity of food and non-

190 food products supplying, in turn, human and material resources.

191

192 In concert with this definition, Van Veenhuizen (2006, in

193 Duchemin, 2013) emphasises the diversity of production

194 systems within UPA (i.e. growing plants and raising animals for

195 food and other uses) ranging from subsistence to production

196 and processing at a household level to fully commercialised

197 agriculture. Nowadays, there are many co-existing definitions.

198 Criteria vary according to their authors but three of them
199 remain constant: (i) the location (on an urban territory), (ii) the
200 activity itself (food production in addition to other functions)
201 and (iii) its inclusion in a conventional or an alternative food
202 system ranging from the international market to self-
203 consumption (Duchemin, 2013). Focused mainly on the
204 materialistic aspects, these definitions and their associated
205 criteria do not consider the social dimension such as the
206 appropriation of urban spaces by the population. Yet, according
207 to Duchemin (2013) both the presence and dynamic of UA
208 forms (profusion or lack) are intimately linked to social events
209 and actions such as crises and its socio-economic
210 consequences. UA can also imply a web-shaped typology
211 gathering connections and possibilities between its components
212 (Duchemin, 2013). Likewise, Nahmias and Le Caro (2012)
213 considered that this “is the relation between agricultural surface
214 and city dwellers that would defines its urban characteristic”.

215
216 Beyond the significant role of UA in the food production, it can
217 also address other positive externalities (Lovell, 2010) such as
218 social issues (socialisation, reinsertion, awareness-raising etc.),
219 ecological issues (air and water quality, biodiversity hosting
220 etc.) and economic issues (food production and selling, food
221 security) (Consalès, 2003; Lovell and Johnston, 2009;
222 Granchamp-Florentino, 2012). Besides, Bertrand et al. (2005)

223 suggest that peri-urban agriculture may be considered as an
224 agriculture at the service of the city, attentive to other functions
225 than food production. In cities, land pressures often result into a
226 general artificialisation of surfaces and city dwellers express
227 their desire for nature and their attachment to the countryside.
228 Consequently, in these artificial landscapes, UA appears as a
229 cultivated space offering a place to relax, to spend leisure time
230 and to connect with an idealised heritage (Consalès, 2003,
231 Robert & Yengué, 2017). However, a study performed in the
232 urban region of Grenoble (France) showed that the UA
233 representations can differ according to people who were
234 interviewed (i.e., professional farmers and local authority'
235 staff). Authors identified a biased representation of both
236 agriculture and rural resources in the implied local authorities'
237 staff. This creates territorial misunderstandings and tensions
238 arise.

239
240 Regarding agricultural activity, three categories are proposed
241 by Nahmias and Le Caro (2012) according to their target: (i)
242 agriculture oriented towards long food supply chains, (ii)
243 agriculture oriented towards short food supply chains and (iii)
244 agriculture oriented towards self-consumption. The connection
245 with the city and the services that UA areas provide to the
246 socio-ecosystems seems obvious in the last two cases (not only
247 food production but also socio-cultural services). Moreover, for

248 the first case, the agricultural spaces do not only produce food
249 for the global market, but they are also turned towards the city
250 by remaining open to the city dwellers (leisure, walks and
251 fruit/vegetable picking) and by contributing to the urban
252 landscape and the expectations of the inhabitants (Le Caro,
253 2007 in Nahmias and Le Caro, 2012).

254

255 Another classification considers the commodities produced by
256 UA. Lovell (2010) lists some of these products: vegetables,
257 medicinal plants, spices and ornamental plants that can be
258 grouped under the activity of horticulture. Other products
259 include livestock (for the production of meat, eggs, wool, dairy
260 products, etc.), aquaculture, arboriculture and beekeeping.

261

262 In this article, a literature review¹ highlighted the blind spots in
263 the study of UA. The publications focus mainly on the forms of
264 “community gardens”, among which vegetable gardening
265 activities are highly represented.

266

267 A definition of UA proposed by Nahmias and Le Caro (2012)
268 seems highly relevant. It considers the three previously cited
269 criteria (i.e. location, activity and inclusion in a food system)
270 and also takes into account the stakeholder diversity and their

¹ Review on Open Edition, Science Direct, HAL and Wiley with keywords “urban agriculture”, “biodiversity”, “urban biodiversity”, “agriculture”, “urban farm”, “orchard” & “green infrastructures” in English and French.

271 relationship to agriculture, including every form and activities.
272 Consequently, UA could be defined as “agriculture that can be
273 practised and experienced in an urban area by farmers and city
274 dwellers on a daily basis and within the urban land use
275 regulations. In these spaces, we consider farmers: professional
276 or not, connected to long or short food supply chains or self-
277 consumption. They maintain mutual functional connections
278 with the city (food, landscape, recreation, ecology) leading to a
279 diversity of agri-urban forms visible in the urban core(s),
280 peripheral neighbourhoods, the urban fringe and peri-urban
281 areas” (Nahmias and Le Caro, 2012). However, this definition
282 does not clarify the spatial delimitation of UA. It should then
283 be supplemented by a recommendation from Le Caro et al.
284 (2016) who suggest that “given the difficulties to establish a
285 limit to peri-urbanity range, it might be useful to study UA
286 within the inter-communality (institutionalised municipal
287 cooperation, T.N.) area “.

288

289 2. A diversity of forms in urban agriculture

290

291 In scientific publications, UA forms are described with various
292 consistency among countries and authors. Gisclard and
293 Raymond (2018) observe multiple UA implementation methods
294 in urban areas. The important diversity of observed forms
295 depends on context (urban, territorial, political, economic,

296 social, etc.), stakeholders invested in this activity (professional,
297 non-professional, individual or familial, etc.), available
298 surfaces, technical tools (highly technologized or in contrast
299 easily reproducible), production aims (food, economic, social,
300 etc.) and distribution modes (self-consumption, gifts, shares,
301 selling, etc.).

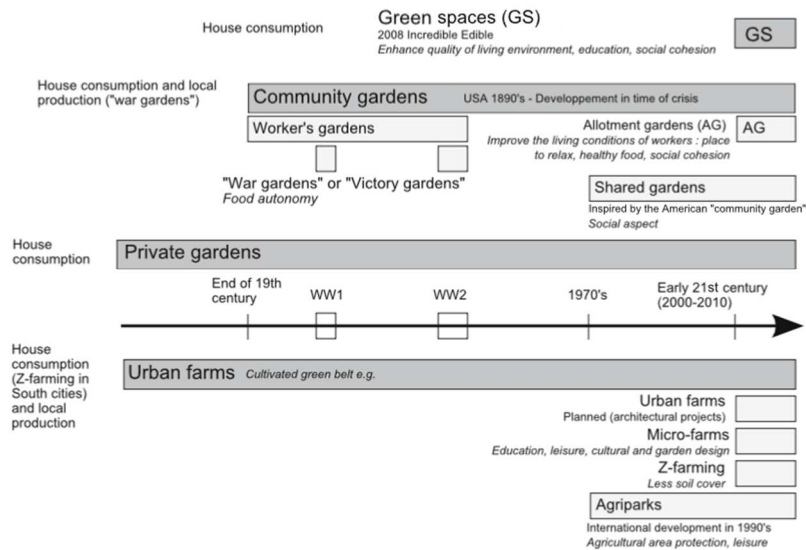
302 The huge number of factor combinations has the capacity for
303 instance to describe more than 8000 different types of
304 associative gardens by considering biophysical (soil, climate,
305 etc.) and organisational criteria (Duchemin, 2013).

306

307 Regarding the numerous classification possibilities, the
308 following typology focuses on the most general and described
309 forms of UA in countries of the Global North in literature.
310 Appearance, disappearance and evolution of the described
311 forms of UA are summarised in figure 1.

312

313 Figure 1. Appearance, disappearance and evolution of the
314 mentioned forms of UA.



315

316

317 2.1. Private gardens: gardens scattered throughout the city

318

319 These gardens can be close to dwellings, next to the main
 320 house, at the front or back, non-buildable areas, balconies or
 321 roofs. Whatever the circumstances, they allow the population to
 322 access food supplies (Duchemin, 2013). They can also set up in
 323 private plots far from the gardener's home. As gardens take up
 324 a lot of space, these UA spaces are very common in cities.
 325 However, they remain poorly known as they are often dispersed
 326 and isolated from each other, witnessing a strong spatial
 327 fragmentation (Di Pietro et al, 2018).

328

329 2.2. Community gardens: strongly present in history and literature

330

331 Community gardens have appeared in the United States as a
 332 series of garden programmes since the 1890's (Lawson, 2004).

333 This represents one of the most studied forms within the dense
334 built-up areas (Mousselin and Scheromm, 2015). Authors are
335 still divided about its definition. The expression “community
336 gardens” and its variations (allotment gardens, shared gardens
337 and worker’s gardens) can display different origins,
338 connections and evolutions. For instance, in France and
339 according to some authors, the different community garden
340 designations illustrate their mutations from “worker’s gardens”
341 to “allotment gardens” then “community gardens” (also named
342 “associative gardens”) or “shared gardens” (Dubost 2007 in Di
343 Pietro et al, 2018). This evolution process is in contrast to a
344 tree-like organisation. Mousselin and Scheromm (2015) report
345 that community gardens in France are “divided under national
346 provisions into two main subsets, allotment gardens and shared
347 gardens” and are legally defined as “land divided into plots,
348 which are used by private individuals for gardening for their
349 own needs and those of their families, to the exclusion of any
350 commercial use” (art. L561-1; Rural Code).

351
352 Community gardens developed in cities during periods of crisis
353 whether economic, social, environmental or war-induced (as
354 evidenced by the existence of “war gardens” or “victory
355 gardens” emerging during the two world wars) (Duchemin,
356 2013). It seems that the current return of agriculture in cities
357 would be part of this dynamic (Mousselin and Scheromm,

358 2015). Through the diversity of their socio-spatial organisation,
359 collective gardens “offer fertile ground for innovation” and
360 open up perspectives for the management of open green spaces
361 in the city (Mousselin and Scheromm, 2015).

362

363 2.2.1. “Allotment gardens”, a legacy of the Industrial Revolution

364

365 Allotment gardens have existed since the end of the 19th
366 century in Northern cities and more recently in the Southern
367 cities as well (Mousselin and Scheromm, 2015). This form of
368 UA is still present nowadays in Europe, particularly in
369 Germany, in France and in The Netherlands (Duchemin, 2013).

370 Historically, allotment gardens appeared in cities as a result of
371 the Industrial Revolution in the form of “worker’s gardens”.

372 These small spaces were often made available to peasants who
373 came to find work in the factories (Duchemin, 2013). In

374 France, after the two world wars and the 1930s’ crisis, the
375 number of gardens increased considerably. This was first

376 initiated by the catholic bourgeoisie, sensitized by Abbot
377 Lemire and then by local authorities willing to improve the

378 living conditions of the most disadvantaged populations. After
379 the "Trentes Glorieuses" (the 30 years of post-war economic

380 growth in France) and the sudden increase in demographics
381 (baby boom, repatriation of French citizens from Algeria,

382 immigration), urbanisation led to the disappearance of gardens.

383 Only those that were defended by the gardeners and those
384 planted on soil unsuitable for development remained (Consalès,
385 2003). However, as these gardens, declined in the 20th century,
386 they developed again in the 21st century and took on the name
387 of allotment gardens (law dated 26 July 1952 in France, in
388 article L 561-1 of the Rural Code: “plots of land divided into
389 parcels, which are allocated to private individuals practising
390 gardening for their own needs and those of their family”). For
391 example, the establishment of allotment gardens in Marseilles
392 is the result of the combination of three main factors: the
393 proximity of industrial and working-class districts, the presence
394 of land available within agricultural areas and the presence of a
395 permanent water supply (Mousselin and Scheromm, 2015).
396 From the 21st century in the Netherlands, the municipalities
397 have worked to make land available for workers. In 1928, the
398 General Confederation of Popular Producers in the Netherlands
399 initiated the creation of nationwide associations (Duchemin,
400 2013). In Germany, the development of allotments was
401 encouraged by the doctor and educationalist Moritz Schreber,
402 whose work focused on public health. This promotion based on
403 his research provided workers with a space to relax and to
404 produce healthy food (Duchemin, 2013).
405
406 Initially dedicated to vegetable production, allotment gardens
407 are now more frequently used for leisure (Duchemin, 2013).

408 The gardener is generally more interested in the quality of the
409 grown products than in the producing food for a household.
410 This suggests an evolution of the farming practice which
411 “involves less the search for a monetary income than that of a
412 way of life” (Van Oort, 1994 in Consalès, 2003).

413

414 In terms of organisation, allotment gardens are managed by
415 associations. The plots are rented to amateur gardeners for
416 subsistence purposes, to the exclusion of any commercial
417 activities (Consalès, 2003). As a result, the sale of any produce
418 from these gardens is not allowed (Mousselin and Scheromm,
419 2015). The allotments are made available by public or semi-
420 public authorities, by housing organisations or by other owners.
421 According to the allotment garden associations, “the use of
422 municipal plots of land remains nevertheless fundamental in
423 order to meet the demands for plots that have been growing
424 since the beginning of the 1980s” (Consalès, 2003). Their
425 surface area can vary from a few hundred square metres
426 depending on the plot (Consalès, 2003; Duchemin, 2013) and
427 the garden is usually provided with a shed (Duchemin, 2013).
428 They are mostly located in urban and peri-urban areas, but not
429 in the vicinity of the gardener’s homes. These are places for
430 community practices that encourage everyone to participate.
431 Cohesion is formalised around a collective regulation
432 (Consalès, 2003). So, allotment gardens play both a food and a

433 social role by allowing interactions between gardeners as well
434 as promoting integration (Consalès, 2003; Mousselin and
435 Scheromm, 2015).

436

437 2.2.2. “Shared garden” as a garden focused on social issues

438

439 Present in France and of more recent origin than the allotment
440 gardens, shared gardens are defined according to the law dated
441 17 July 2007 as “gardens created or animated collectively,
442 aiming at developing local social links through social, cultural
443 or educational activities and being accessible to the public”
444 (Mousselin and Scheromm, 2015). They can be managed by an
445 association with land made available by the local authority via
446 a public domain occupation agreement. The objectives focus on
447 the social aspect: urban space appropriation, sharing values
448 diffusion, openness to others, mutual aid, but also learning,
449 creation and even self-reconstruction (Duchemin, 2013).

450

451 Originally inspired by American “community gardens,” “shared
452 gardens” became widespread in France in the 1970s
453 (Pashchenko and Consalès 2011 in Mousselin and Scheromm,
454 2015; Scheromm 2013 in Mousselin and Scheromm, 2015).
455 They were made up of a single plot of 200 to 400 m², the layout
456 of which varied according to the garden. The surface area of the
457 plot can be entirely shared between the gardeners who decide

458 jointly on the organisation and cultivation of this space. In most
459 of the shared gardens in Montpellier (France), other
460 distributions exist; in the same garden, individual plots (about
461 4m²) are placed next to a larger collective plot, which
462 constitutes a hybrid form between the shared gardens and the
463 allotment gardens.

464 Among the “shared gardens”, another type is also widespread:
465 the “back-to-work” garden which consists of a garden created
466 or used to promote the reintegration of people in a situation of
467 exclusion or in social or professional need (Mousselin and
468 Scheromm, 2015; Lagneau, 2015). In Montpellier (France), the
469 authors also identified an “informal garden” which is owned by
470 a private person and cultivated by friends (Mousselin and
471 Scheromm, 2015).

472

473 2.3. Urban farms, a recent form to explore

474

475 While the older types of UA are beginning to be more clearly
476 defined, this is not yet the case for urban farms in its modern
477 form. Whereas urban farming previously exists in cities
478 (cultivated greenbelt for instance), its integration is now
479 planned (in architectural projects for instance; Gisclard &
480 Raymond, 2018; Kleszcz, 2018). Duchemin and Vermette
481 (2020) propose an initial exploratory definition. It is based
482 primarily on three essential elements: (i) a location outside the

483 agricultural area and within an urban perimeter (geographical
484 parameter), (ii) a status of company, organisation or individual
485 growing food (vegetables, fruits etc.) or horticultural
486 (seedlings) production integrated in a local distribution system,
487 offered to the company hosting the project (with a contract) or
488 transformed for sale (economic characteristics) and (iii)
489 participation in the “environmental and social development of
490 cities, by creating islands of greenery and biodiversity, green
491 rooftops, reusing organic matter from food consumption, being
492 spaces for mediation, integration etc. (networking with the
493 city)”. However, in some exceptional cases, the geographical
494 criterion may not be considered. A farm may be located in an
495 agricultural area but have characteristics of urban farms, like
496 the use of off-farm production methods or based on
497 technological innovations.

498

499 As urban farm projects develop rapidly in North America and
500 Europe, the diversity of models allowing an economic viability
501 is increasing. Producers take on other roles and can also
502 become “distributors, food-processors, service and consultancy
503 companies and even companies selling equipment.” The
504 authors propose a nomenclature of urban farms based on the
505 main source of income. They set a threshold of 60% as the
506 main source of income, their main objective being to identify
507 the business model of the companies. They finally establish 6

508 categories of urban farms which have a main activity (more
509 than 60% of their income) consisting of production, processing,
510 distribution, service, sale of equipment and mixed activities
511 (and do not reach 60% of their income in each category).

512

513 Among urban farms, micro-farms can be distinguished on one
514 main criterion, their independence from the landowner and
515 from volunteer labour. These are farms with small plots of land,
516 often in neglected interstices such as unbuilt spaces or even
517 roofs. Plus, they are integrated into alternative food systems
518 (Daniel, 2018). However, this production and distribution
519 activity is not sufficient, they “offer other categories of
520 activities simultaneously (including educational, leisure,
521 cultural and garden design activities)” (Daniel, 2017 in Daniel,
522 2018).

523 Vertical farm projects are also developing and are aimed at
524 addressing issues not only of food security (Aiman and
525 Enriqueta, 2019) but also of urban space availability and
526 environmental issues such as urban heat islands (Elghonaimy
527 and Albadal, 2021).

528

529 Within this form, several production systems exist. Some
530 maintain a connection to the soil and others are turning to
531 alternative practices such as container growing or to new
532 technologies, such as aquaponics or hydroponics (Lagneau,

533 2015). These soilless forms on building roofs or inside
534 buildings (rooftop gardens and greenhouses, indoor farms etc.)
535 and any other related forms can be defined as “ZFarming”
536 (Specht et al, 2014). ZFarming has potential in environmental
537 (landscape architecture integration; food miles, transport
538 emission and rural agriculture land pressure reduction; use and
539 recycling of water resources and organic waste; energy
540 consumption and production), social (community food
541 production improvement; provision of educational facilities,
542 consumers to food production linkage; inspiration for building
543 design) and economic (monetary advantage for urban areas,
544 potential products and yields) terms. It also has to face
545 environmental challenges (technical constraints, lack of
546 experience and bias in food system research), social challenges
547 (lack of acceptance of soilless growing techniques,
548 exclusionary practice and disparities, food quality and health
549 risks) and economic challenges (building construction and
550 retrofitting, competition with other types of use, financing, lack
551 of knowledge on city’s production capacities) (Specht et al,
552 2014).

553

554 Agri-parks can be considered as a variation of urban farms
555 (Mumenthaler and Cavin, 2018). They can be found under the
556 name “agro-urban parks”, “agri-parks” or “agro-parks”
557 (Mumenthaler and Cavin, 2018; Vanempten, 2021). They can

558 be defined as “a network of actors in a peri-urban area with a
559 specific identity where multifunctional agriculture produces
560 food and provides other social services in close relationship
561 with the city” (Vanempten, 2021) and are considered public
562 spaces (Mumenthaler and Cavin, 2018). However, the word
563 “agri-park” and its synonyms still has different meanings
564 depending on the project manager (Jarrige and Perrin, 2017). In
565 Europe, the first agricultural parks appeared in the 1970s.
566 Twenty years later, they were recognised by institutions and
567 began to spread successfully around the world (ibid.).

568

569 2.4. Green spaces

570

571 UA can also get integrated into cities as a form of green spaces
572 covering various surface areas from a tree stand to a landscape
573 project and taking place where ornamental plants are usually
574 found, inside or outside, thus contributing to improving the
575 living environment (Bertrand et al, 2022). The green spaces can
576 be handled by inhabitants or companies and require regular
577 maintenance to uphold an aesthetic aspect (ibid.).

578 The most famous example is the Incredible Edible, a citizen
579 movement started in 2008 in response to social, environmental
580 and economic changes in the UK. It has now been developed
581 worldwide and consists of the plantation of edible plants in
582 public spaces, cultivated for and by everyone (Clarke, 2010;

583 Bertrand et al, 2022).

584

585 3. Biodiversity in urban agricultural areas

586

587 UA is in essence multifunctional. We have seen previously the
588 different functions that UA can invest in (food production,
589 well-being, water and air cycles etc.). Hosting biodiversity is
590 also considered as an ecosystem service recognised and
591 favoured by UA (Muratet et al, 2008). However, studies
592 demonstrating this are still lacking (Guitart et al, 2012). Here,
593 we will focus on the capacity of UA to host biodiversity. We
594 conducted another review that gathers the knowledge acquired
595 to date on the species living in these environments. The choice
596 was made to select only the articles that explicitly mentioned
597 urban or peri-urban environments. Although the previously
598 accepted definition of UA is free of any geographical limit, it
599 does not allow a relevant selection of references. Articles for
600 which the study sites are recognised as urban by their authors
601 have been selected.

602 When focus is placed on the biodiversity within an agricultural
603 area, it can be observed that the species level of plant
604 communities expresses a range of measurable responses when
605 exposed to different agricultural practices (Fried et al, 2012).
606 Similarly, in cities, bird species are known to be sensitive to
607 variations in habitat quality (Crocì et al, 2011). It has been

608 established that urban green spaces including agricultural
609 spaces are integrated into green infrastructures and are able to
610 shelter significant biodiversity (Mehdi et al, 2012; Efese, 2018;
611 Robert & Yengué, 2017; Glatron, 2018). Besides, the
612 spontaneous plant communities found in cities are still
613 qualified as “weeds” and remain perceived as disorderly,
614 compromising the aesthetic aspect of urban green spaces
615 (Aggeri, 2006; Mehdi, 2010). This ordinary biodiversity plays a
616 fundamental role in the maintenance and structure of
617 ecosystems. For example, it contributes to the spatial richness
618 of plant and animal communities, and serves as a foundation
619 for remarkable biodiversity (Selmi, 2014).

620

621 In an urban socio-ecosystem, two sorts of biodiversity can be
622 distinguished: one is managed, i.e. chosen for its own
623 characteristics and the second is hosted, “i.e. that which
624 develops naturally in the environment following management
625 practices” (Alard et al, 2020). Specific terms can be used for
626 vegetation, it can be spontaneous (established without human
627 intervention) or cultivated (introduced and maintained by
628 humans) (Selmi, 2014).

629

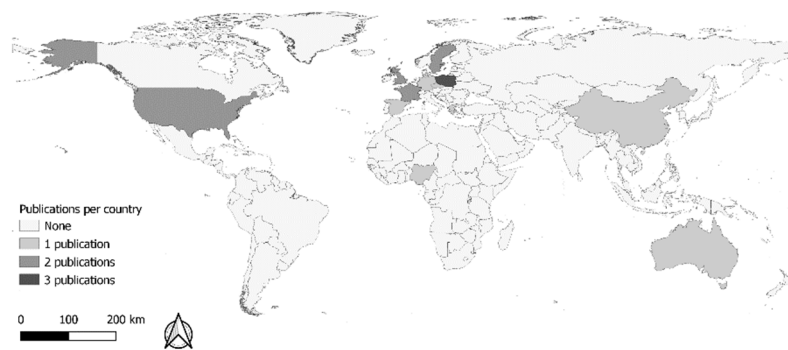
630 Urban ecosystems are subjected to strong anthropogenic
631 pressures. The urbanisation process profoundly modifies spaces
632 and causes changes that are generally irreversible, especially on

633 an environmental level. Habitats are increasingly fragmented as
634 the land becomes more artificial (Hubert-Moy et al, 2011),
635 which can affect the dispersal of many species (Crocì et al,
636 2011; Daniel et al, 2011).

637 Urban ecosystems also have specific characteristics compared
638 to non-urban ecosystems. For instance, abiotic differences can
639 be observed: temperatures are higher than in the countryside (at
640 least 1 degree on average per year), rainfall is 5 to 10% higher,
641 the atmosphere is polluted with discharges that can impact soil
642 fauna (Eitminaviciute, 2006) and vegetation (Bui et al., 2021),
643 artificial lighting is almost constant, the soil is systematically
644 destructured and human disturbance is permanent. In addition
645 to these characteristics, there are biotic differences: a lower
646 quality of the plant species with essentially the presence of
647 cultivated exotic species, a lack of wild carnivorous species
648 which are replaced by domestic species, and a management of
649 the areas by humans who select the species by weeding or
650 scaring away undesirable animals (Clergeau & Hubert-Moy,
651 2011). In short, animal and plant populations respond to
652 urbanisation: species richness can increase or decrease along an
653 urbanisation gradient depending on many variables (McKinney,
654 2008; Crocì et al., 2011; Daniel et al., 2011) or respond to the
655 quality of urban habitats, as it is the case for birds (Crocì et al.,
656 2011).

657

658 In urban landscapes, agriculture spaces are presented as areas
659 able to shelter significant biodiversity. Herein, we establish a
660 literature review dealing with the state of biodiversity
661 according to the different UA activities, i.e., market gardening,
662 arboriculture and grazing. This part proposes more in-depth
663 research on the activities of arboriculture, grazing and
664 livestock². Herein, we present studies about biodiversity
665 including both “chosen” and “hosted” species through an
666 ecological point of view. Results are summarised in table 1.
667 Locations of studies are presented in figure 2.



668
669 Figure 2. Publications found per country. The published papers
670 contain data about biodiversity in urban agriculture (species
671 richness at least).

672
673
674

² Review on Google Scholar, Open Edition, Science Direct and Wiley with keywords “urban orchard”; “urban agroforest”; “urban vineyard”; “garden roof”; “biodiversity”; “urban biodiversity”; “livestock farming” and “urban” & “pasture” in English and French.

675

676

677

678

679

680 Table 1. Species richness on studied urban agriculture areas

681 (allotment gardens = AG and community gardens = CG) and

682 non-agricultural urban spaces when a comparison is made in

683 the study (species number). * these numbers refer to a range of

684 species richness among several sites of each type. In contrary to

685 other studies, the data have not been gathered into beta-

686 diversity. ** the number in parenthesis represents the number

687 of spontaneous species.

688 Table 1a. Species richness on studied gardens

Study	Location	Studied taxa	UA			Non-UA				
			Private gardens	Commons gardens CG** AG**	Abandoned sites/wasteland	Forest	Island	Reserve	Urban park	Industrial area
Smith et al, 2006	Sheffield (United Kingdom)	plant	1166							
Bigirimana et al, 2012	Bujumbura (Burundi)	plant	567							
Prendergast et al, 2022	Perth (Australia)	wild bees	93		137					
Biaduń, 2005	Lublin (Poland)	(winter)bird	31	34	39				52	20
Matteson et al, 2008	New York (USA)	insects (bees)		54		144	128	130	57-69*	
Cohen et al, 2021	Monterey, Santa Clara and Santa Cruz (USA)	insects (bees)		59						
Cabral et al, 2017	Leipzig (Germany)	plant		255 (157)	290 (140)					
Speak et al, 2015	Manchester (UK)	plant		87					56	
Speak et al, 2015	Poznan (Poland)	plant		357						
Joimel, 2015	Marseille (France)	plant		40						
Joimel, 2015	Nantes (France)	plant		48						
Joimel, 2015	Nancy (France)	plant		28						
Borysiak et al, 2017	Poznan (Poland)	plant		358 (257)						

Bjorkman (2000) in Colding et al, 2006	Stockholm (Sweden)	plant	447
Ahrné et al, 2009	Stockholm (Sweden)	insect (bumblebees)	11

689

690 Table 1b. Species richness on pasture

Study	Location	Studied taxa	Pasture	Non-UA		
				Abandoned sites/wasteland	Forest	Urban park
Kantsa et al, 2013	Ioannina (Greece)	plant	133	106-149*	128	151

691

692 Table 1c: Species richness on orchard

Study	Location	Studied taxa	Orchard
Zhao et al, 2021	Shenzhen (China)	bryophytes	24
Ezukanma et al, 2019	Ibadan (Nigeria)	bryophytes	19
Horák et al, 2018	Prague (Czech Republic)	plant	108
Horák et al, 2018	Prague (Czech Republic)	lichen	33
Horák et al, 2018	Prague (Czech Republic)	insect (butterfly)	21
Horák et al, 2018	Prague (Czech Republic)	insect (beetle)	27
Horák et al, 2018	Prague (Czech Republic)	insect (orthopteroid)	14
Horák et al, 2018	Prague (Czech Republic)	bird	16
Cohen et al, 2015	Marseille (France)	plant (olive groves)	51
Cohen et al, 2015	Marseille (France)	plant (vineyard)	29

693 3.1. Vegetable farming

694

695 Vegetable gardening activities in the city are recorded in private
696 and collective gardens as well as in (micro)farms. The number
697 of studies that measure biodiversity (fauna and flora) in these
698 agricultural environments remains scarce compared to studies
699 in the humanities and social sciences that deal with these same
700 environments. Moreover, researchers are still mainly interested
701 in agrobiodiversity i.e., a subset of natural biodiversity which
702 includes the plant genetic resources used for food and
703 agriculture (cultivars, landraces, ecotypes, weedy races and
704 wild relatives) (Negri et al. 2009 in Galluzzi et al, 2010) and

705 less in “wild”, non-managed biodiversity (Borysiak et al, 2017;
706 Pearsall et al, 2017; Klepacki and Kujawska, 2018). There is
707 also a disparity between the areas studied, with Europeans
708 cities being far more represented than others (Galluzzi et al,
709 2010; Guitart et al, 2012).

710

711 3.1.1. Home gardens

712

713 Home gardens in cities can harbour significant cultivated and
714 spontaneous flora. In Sheffield (United Kingdom), Smith et al
715 (2006) inventoried vascular plant taxa in 61 urban domestic
716 gardens. Specifically, 1166 species from 146 families were
717 counted (between 41 and 264 species per garden) with a
718 notable predominance of alien flora (70%). Bigirimana et al
719 (2012) found similar results in Bujumbura (Burundi) after
720 surveying 1045 gardens. The measured flora numbered 567
721 species and among the 85% that were not native, 121 taxa were
722 identified as plants at risk of biological invasion. According to
723 these two authors, private gardens, because of the high
724 proportion of non-native plants, may be a potential source of
725 invasive alien plants. However, Smith et al (2006) temper this
726 hypothesis by specifying that alien plants may dominate the
727 floristic assemblages, but they are not very abundant. They can
728 also potentially interact with local fauna and provide them with
729 fruit, pollen or nectar. For honeybees (*Apis mellifera*), home

730 gardens represent a proven food source because of their broad
731 diet, which allows them to feed on both native and alien plants.
732 This is not the case for wild bees which are more likely to
733 exploit native vegetation. In the Perth metropolitan area
734 (Australia), wild bees prefer bushland remnant (137 species on
735 7 sites) to domestic gardens (93 species on 7 sites) partly for
736 this reason (Prendergast et al, 2022). They also tested the effect
737 of sites area on biological variable and found no correlation.
738 Contrary to plants (Smith et al, 2006; Bigirimana et al, 2012),
739 bee richness and abundance are not affected by site area. In
740 Niamey (Niger), the agro-biodiversity of 51 urban and peri-
741 urban private gardens was surveyed by Bernholt et al (2009).
742 The authors also warned against a decrease in the number of
743 vegetable species planted in commercial gardens.

744
745 For animals, private gardens can enhance the ecological
746 connectivity of the city for several bat species, such as the
747 common pipistrelle (*Pipistrellus pipistrellus*) for which private
748 gardens in Paris (France) can “contribute up to 47.9% of bat
749 habitat availability” (Mimet et al, 2020). Consequently, private
750 gardens are expected to enhance the dispersion and so the gene
751 flow. Thus, Galluzzi et al (2010) showed the importance of
752 home gardens for the genetic diversity of species of agronomic
753 interest while current trends veer towards a gradual
754 simplification of agricultural systems and landscapes.

755

756 3.1.2. Community and allotment gardens

757

758 In 2012, Guitart et al (2012) published a review on the scope of
759 publications in English interested in allotment gardens and
760 pointed out an imbalance in the disciplines studied: the
761 humanities and social sciences are largely overrepresented
762 while the natural sciences are largely underrepresented (1 study
763 out of 87 in total). Since then, the number of studies on
764 biodiversity in allotments is slowly increasing but it is still
765 considered insufficient (Cabral et al, 2017; Borysiak et al,
766 2017).

767 Community and allotment gardens are similar to private spaces
768 but are subjected to stricter regulations (e.g., prohibitions on
769 planting trees with overgrown canopies or requirements to
770 allocate 1/3 of the plot to growing vegetable crops; Cabral et al,
771 2017). These gardens are composed of multiple plots cultivated
772 by gardeners who exhibit a diversity of gardening practices
773 (Joimel, 2015; Cabral et al, 2017; Pearsall et al, 2017). They
774 are identified as being rich in biodiversity (Joimel, 2015; Speak
775 et al, 2015; Borysiak et al, 2017; Cabral et al, 2017; Pearsall et
776 al, 2017), “for example, the 80 allotment areas in Stockholm,
777 Sweden tend to be extremely rich in plants, with 447 different
778 plant species recorded in a 400-M2 allotment garden”
779 (Bjorkman (2000) in Colding et al, 2006).

780
781 The location of gardens within the urban fabric (nature of
782 adjacent land for example), the internal organisation of gardens
783 (presence of vacant lots for example) and the functional and
784 spatial organisation of the plot are factors operating at different
785 scales on vegetation composition (Speak et al, 2015; Borysiak
786 et al, 2017). The intensity of gardening practices, in particular
787 weeding and mowing, will impact the species richness of the
788 vegetation since a moderately managed plot can serve as a
789 habitat for both spontaneous and cultivated species (high
790 structural complexity and variety of microhabitats) (Joimel,
791 2015; Cabral et al, 2017). This effect of management intensity
792 on vegetation in allotment gardens and community gardens has
793 been demonstrated in several cities. In three French cities
794 (Nancy, Nantes and Marseille), the specific richness and
795 composition of vegetation can be explained by the application
796 of two filters: the urban environment and gardening practices
797 (Joimel, 2015). In Leipzig (Germany), allotment gardens
798 exhibit a higher diversity in the moderately managed plots (221
799 species recorded, including 110 spontaneous species) with the
800 richness of spontaneous species being up to twofold higher in
801 vacant and medium intensity plots compared to high intensity
802 plots (Cabral et al, 2017). The authors noted that community
803 gardens in Leipzig tended to provide more diverse
804 microhabitats than allotments, such as habitats for amphibians

805 (ponds and stone walls), beehives and livestock shelters. In
806 Poznan (Poland), gardener's practices in allotment gardens are
807 considered as "wildlife-friendly" and the authors argued that
808 "in the future the main factor influencing the richness and plant
809 diversity of AGs will be recreation, and the composition of
810 flora will be shaped by spatial and functional organisation of
811 plots according to the user's lifestyle and way of spending
812 leisure time" (Borysiak et al, 2017). Speak et al (2015)
813 investigated the ecosystem services provided by allotment
814 gardens and parks in two cities: Poznan (Poland) and
815 Manchester (UK). Allotment gardens and parks in Manchester
816 have similar median size thus allowing comparison. However,
817 differences in site area and methods only allow qualitative
818 comparison between allotment garden in Poznan and
819 Manchester. The results obtained show an important diversity
820 of vascular plants in the Polish gardens with the notable
821 presence of threatened species, which supports the interest of
822 AGs for conservation policies. As for the English gardens, they
823 show a higher biodiversity than in the parks, highlighting the
824 impact of management methods (repeated mowing in
825 particular) on the establishment of vegetation. Finally, in
826 Poznan and in Manchester (Speak et al, 2015; Borysiak et al,
827 2017), most of the species recorded in allotment gardens are
828 native species, in contrast to the compositions found in
829 domestic gardens where the majority of plants are ornamental

830 and where native species are weeded. As a result, “allotment
831 gardens can therefore be considered as biodiversity hotspots for
832 native species within urban green infrastructure” (Borysiak et
833 al, 2017).

834

835 Regarding animals, studies are even more scarce. Given the
836 abundance of plant species in community gardens, and in
837 particular the potential high proportion of native plants,
838 community gardens seem to have the potential to also harbour
839 significant invertebrate and bird biodiversity. Indeed, Cohen et
840 al (2021) found out that 18 community gardens in Monterey,
841 Santa Clara, and Santa Cruz counties (USA) can host a high
842 number of bee species but that urbanisation act as a filter for
843 bee settlement. Bee richness, abundance, and traits are driven
844 by local and landscape features of the urban environment. With
845 an increasing urban land cover, there is a preference for small
846 size, scopa presence, below ground nesting behaviour and
847 solitary behaviour. However, the authors point out that these
848 global traits are to test for each context, as cities can strongly
849 differ between each other. In 19 community gardens in New
850 York (USA) (Matteson et al, 2008), diversity and abundance of
851 soil-nesting species are relatively low compared to other areas
852 in the city and bee composition presents a surprisingly high
853 proportion of exotic species (19% of the species and 27% of
854 individuals collected are non-native to North America). Despite

855 the small proportion represented by the gardens in New York
856 City and compared to the other studied areas, the authors
857 consider that the strong sampling effort suggest that species list
858 in UA is comprehensive and comparable to other studied areas.
859 Here, ecological value of community gardens can be attested as
860 most species are hosted by only a few gardens (Matteson et al,
861 2008). Ahrné et al (2009) investigated 16 allotment gardens in
862 Stockholm (Sweden) along an urban-rural gradient. For bumble
863 bees, species diversity is mostly affected by urbanisation (urban
864 landscape). Species abundancy is mostly affected by local
865 factors (flower abundance) rather than surrounding landscape
866 and species composition is mostly affected by local factors
867 such as flower richness and type of allotment garden. Despite
868 the negative effect of urbanisation, the total number of species
869 observed in the 5 most urban sites (11 out of the 22 species
870 found in the region) was rather high, leading the author to
871 conclude that allotment gardens can serve as important
872 alternatives to natural habitats for bumble bees (Ahrné et al,
873 2009).

874
875 Further studies are required to better understand what the
876 involved urban filters are and how the available surrounding
877 landscape promotes or limits urbans bees by providing nesting
878 sites or more attractive food resources for instance (Matteson et
879 al, 2008; Cohen et al, 2021).

880

881 Other taxa also need investigation. For now, few studies take an
882 interest on soil fauna (Joimel, 2015) and on birds (Biaduñ,
883 2005). Allotment gardens in France (Marseilles, Nantes et
884 Nancy) show a medium microarthropods density of 32 020
885 ind.m² (0 to 248 000 ind.m²) and 82 taxa were identified.
886 Gardening practices appear to have an indirect effect on
887 composition and traits selection through increasing heavy
888 metals concentration in soil and modifying plant cover (Joimel,
889 2015). Winter-avifauna was studied in Lublin (Poland) on the
890 whole administrative area by Biaduñ (2005) regardless of sites
891 areas. The bird richness in allotment gardens stays close to
892 housing estate and wasteland results. No study concerns other
893 vertebrate animals.

894

895 In summary, with regards to common and private gardens
896 (areas with vegetable farming), most of the studies focus on
897 vegetation. Ethnobotany researchers are also interested in such
898 gardens and focus on plant species planted by gardeners and on
899 the cultural and social role of gardening (Pearsall et al, 2017;
900 Klepacki and Kujawska, 2018 among others). For vegetable
901 farms, the issue of biodiversity is mostly addressed from the
902 perspective of agro-diversity and no article mentions activities
903 in an urban environment.

904

905 3.1.3. Roof gardens

906

907 A review of Kohler and Ksiazek-Mikenas (2018) shows that
908 green roofs as anthropogenic habitats similar to rocky cliffs are
909 able to host a wide range of planted and spontaneous vegetation
910 whose specie richness varies between roofs. In the cases
911 studied, green roofs can fulfil the role of “stepping-stone”
912 habitats in green infrastructures and consist of numerous
913 microhabitats for urban insects and other wildlife (ibid). Today,
914 no studies which consider green roofs with edible vegetation as
915 an agro ecosystem have been identified.

916

917 3.2. Arboriculture

918

919 Whereas fruit trees can be individually planted in gardens, they
920 are also planted in orchards. Under suitable conditions
921 (landscape and management), traditional orchards in rural
922 contexts can be of great importance for many species,
923 particularly less specialised ones (Horák et al, 2013).

924 Urban orchards have the capacity to host bryophytes species. In
925 Ibadan (Niger), agroforests of the National Horticultural
926 Research Institute are located in the west part of city,
927 surrounded by the urban fabric. Ezukanma et al (2019) sampled
928 bryophytes on the trunk of orange and mango trees (*Citrus L.*
929 and *Mangifera L.*). Twelve species were recorded per plantation

930 and 5 species were found in both plantations, indicating the
931 interest of these environments for bryophyte preservation (19
932 species in total). The number of bryophyte species found is
933 considered numerous by the authors. They conclude that urban
934 agroforests can support an important species richness, provided
935 that bryophytes are not considered as harmful by the gardener.
936 This finding is shared by Zhao et al (2021). In the city of
937 Shenzhen, China, there are more than 3000ha of lychee and
938 longan orchards (about 70% of the total orchard area in the
939 city). The authors compared the bryophyte populations in these
940 orchards and in the surrounding forests. The results show that
941 the species richness of bryophytes is higher in the orchards than
942 in the secondary forests (24 species in the orchards, 14 in the
943 young secondary forests and 13 in the old secondary forests).
944 The composition in orchards differs significantly from that in
945 secondary forests. This shows that orchards may support a
946 different diversity of bryophytes than the species found in
947 secondary forests. The differences observed between different
948 types of plantations could be due to practices (which may cause
949 a different microclimate) or host tree characteristics (tree size,
950 bark chemistry and texture and tree species) (Ezukanma et al,
951 2019; Zhao et al, 2021).

952

953 Horák et al (2018) studied the restoration of a traditional urban
954 orchard in Prague (Czech Republic) and measured the impacts

955 of the restoration on several taxa (table 2). This study shows
956 that restoration actions on artificial ecosystems can increase
957 biodiversity and the conservation potential of associated areas.

958

959 Table 2

960 Species richness evolution after a traditional urban orchard in
961 Prague (Czech Republic). Species richness changed as well as
962 the composition (Horák et al, 2018).

963

Taxa	Before restoration (2014)	After restoration (2016)
Plants	65	108
Lichens	25	33
Birds	17	16
Lepidopterans	19	27
Beetles	12	27
Orthopterans	18	14

964

965 Contrary to many Mediterranean countries, in France, olive
966 groves, near cities, stay the same size or increase their surface
967 area (Angles, 2017). Within the framework of the Patermed
968 project, botanical surveys were carried out in 44 olive plots and
969 revealed high levels of specific biodiversity. Compared to
970 parallel surveyed vineyard plots, natural floristic richness is
971 higher in olive groves (29 and 51 species respectively; Cohen et

972 al, 2015). Olive groves actively contribute to the maintenance
973 and even development of local biodiversity (40.2%, some of
974 which warrant protection at the national or regional level). It is
975 mainly the agricultural practices that explain these levels of
976 floristic richness. Depending on the agricultural practices, olive
977 groves could be included in ecological networks as reservoirs
978 or corridors (Angles, 2017).

979

980 Other articles focus on food security, on the increase of urban
981 sustainability (Clark and Nicholas, 2013; Martinez et al, 2018;
982 Vannozzi Brito and Borelli, 2020), on socio-environmental
983 impacts of public orchards (Colinas et al, 2019) and on
984 financial profitability for municipalities and producers
985 (Lafontaine-Messier et al, 2016).

986

987 3.3. Pasture and urban livestock

988

989 Most of the articles found in this review deal with urban
990 farming with a sanitary approach. It is mainly about organic
991 pollution of soil and water and health risks for populations
992 (contamination of food by E.Coli or heavy metals for example)
993 (Dumat et al, 2018a). Urban livestock farming is also of interest
994 for fertilizer production (manure, slurry. etc..) that can re-feed
995 the surrounding farms and enter into circular economy
996 approaches.

997

998 In Southern Africa, urban and peri-urban sheep and goat
999 farming is still practised for subsistence reasons and for socio-
1000 religious uses (Centrès, 1996; Ali et al, 2003) or by tradition
1001 (Lawal et al, 2018). Cattle, poultry and pigs may also be kept
1002 (Centrès, 1996). In South Africa, poor urban households keep a
1003 few animals on land provided by the municipality (Meissner et
1004 al, 2013). This is mainly an economic supplement and a labour
1005 force (Cesaro and Apolloni, 2020).

1006

1007 In the countries of the Global North, livestock farming
1008 disappeared from the cities during the 20th century and
1009 gradually reappeared from the 1970s-1980s (Cesaro and
1010 Apolloni, 2020). Today it is mainly manifested in the form of
1011 sheep and goat eco-pasture (Darly, 2014; Boris and Eychenne,
1012 2015; Cesaro and Apolloni, 2020), whose establishment and
1013 perpetuation depend on the consultation and acceptance of local
1014 populations (Boris and Eychenne, 2015). Livestock farming
1015 can also include small gardens, plots in some urban farms, or
1016 any other complex system that uses the animal (Cesaro and
1017 Apolloni, 2020). Since the 2000s, urban chickens have become
1018 more and more popular worldwide and contribute to improved
1019 food safety, reduced waste and invest citizens in democratic life
1020 (Dumat et al, 2018b).

1021

1022 Only one study reports a biodiversity (vegetation) inventory in
1023 a peri-urban pasture in the city of Ioannina, Greece. This site
1024 was compared with three other land use of similar area (16ha).
1025 Considered a semi-natural environment, 133 mostly native taxa
1026 (7.5% aliens) were recorded (Kantsa et al, 2013). Regarding the
1027 works interested in biodiversity in grazed areas in cities, it
1028 seems that they are still very marginal and very little is
1029 published.

1030

1031 Conclusion

1032

1033 The definition of UA used here emphasises its ubiquitous
1034 nature within the boundaries of municipalities. However, it is a
1035 definition proposed by geographers that does not meet with
1036 consensus in all the works that deal with UA, which limits the
1037 identification of studies that could still involve UA. In ecology,
1038 one approach to studying urbanised land (and the impact of
1039 urbanisation on species) is to consider it from an urbanisation
1040 gradient perspective. We believe that this approach is highly
1041 suitable for future studies.

1042

1043 The implantation of UA depends on social, economic and
1044 political context (Lawson, 2004; Duchemin, 2013; Mousselin
1045 and Scheromm, 2015). It is therefore recommended to study
1046 UA while considering the specificities of the city (and of the

1047 country). Since the beginning of the 21st century, many new
1048 forms of UA have been discovered and some are continuing to
1049 develop, especially urban farms (figure 1). As the expansion of
1050 UA is linked to crisis, it can be expected that the current forms
1051 will continue to evolve sooner or later. It is also recommended
1052 to be attentive and update changes in organisation and
1053 objectives in UA forms.

1054

1055 Despite the growing interest in UA, the biodiversity carrying
1056 capacity of UA areas remains a topic of study that is struggling
1057 to gain traction in literature.

1058 It is mainly vegetation that is the focus of research interest. On
1059 the other hand, there is also a distinction between agro-diversity
1060 and “wild” biodiversity, where “hosted” biodiversity remains
1061 mainly in the domain of ecology (but also includes “managed”
1062 biodiversity) and agro-diversity, “managed” biodiversity
1063 remains in the domain of human and social sciences and
1064 agronomy.

1065

1066 Compared to other urban environments, UA areas appear to
1067 have similar interest for vegetation and similar or lesser interest
1068 for other taxa such as insects and birds (except for highly
1069 degraded environments such as industrial areas; Table 1).
1070 However, data are still lacking to draw more precise and
1071 reliable conclusions about the state of biodiversity in urban

1072 agricultural environments. This statement is shared by Clucas
1073 et al (2018). We recommend conducting more studies in this
1074 field that (i) include more quantitative analysis with more
1075 standardised protocols and with a wider range of studied taxa to
1076 enable meta-analysis (which is not the case at this stage), (ii)
1077 cover a wider geographical range as most of the studies are still
1078 mainly limited to countries of the Global North (figure 2)
1079 which will enhance our understanding of the diversity of forms
1080 and functions of UA worldwide, (iii) explore other forms and
1081 activities of UA, since collective gardens and vegetable
1082 gardening are still the main ones studied and/or (iv) compare
1083 different land use within the same city and/or over time, before
1084 and after land use changes to UA (see Horák et al, 2018).

1085

1086 Nevertheless, it is possible to conclude that UA areas are
1087 environments capable of hosting an interesting array of animal
1088 and plant species and that the management practices applied to
1089 these spaces must be thought through to better conserve
1090 biodiversity. The study of UA as a green infrastructure element
1091 in cities can also be improved thanks to the progress in
1092 modelling (Cerema, 2020) and in remote sensing (Morin et al,
1093 2022). All these recommendations are summarised in figure 3.

1094

1095 Our review includes several biases. First, concerning UA forms
1096 and biodiversity, we focused on French and international papers

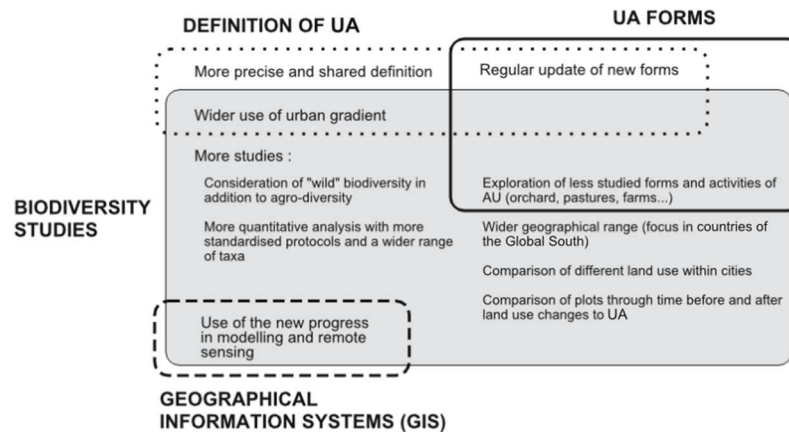
1097 as such limiting our geographical range as some studies might
1098 be published in other languages and/or in more local journals.
1099 Second, we did not consider grey literature which may concern
1100 many local cases and provide data about species richness in
1101 UA. Finally, we could have missed some studies that did not
1102 use our research terms.

1103

1104 It has been demonstrated extensively that UA provides
1105 numerous services to humanity. In this review, it is assessed
1106 that UA can be used as a source of food and habitats by animals
1107 and plants. Not all land uses within UA might harbour a
1108 reliable biodiversity. Actual results show that open spaces
1109 connected to the green and brown infrastructures seem to play a
1110 role in the biodiversity conservation, but little is known about
1111 others forms such as soilless forms. More research is needed to
1112 fully appreciate how valuable these spaces can be for urban
1113 species. It is therefore suggested here to consider UA not only
1114 through what it brings to humans but also through its
1115 importance to other non-human living beings as a habitat. This
1116 questions further how in cities humans and non-human beings
1117 can live together and share their living environment.

1118

1119 Figure 3. Schematic expression of recommendation for future
1120 research.



1121

1122

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1138

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