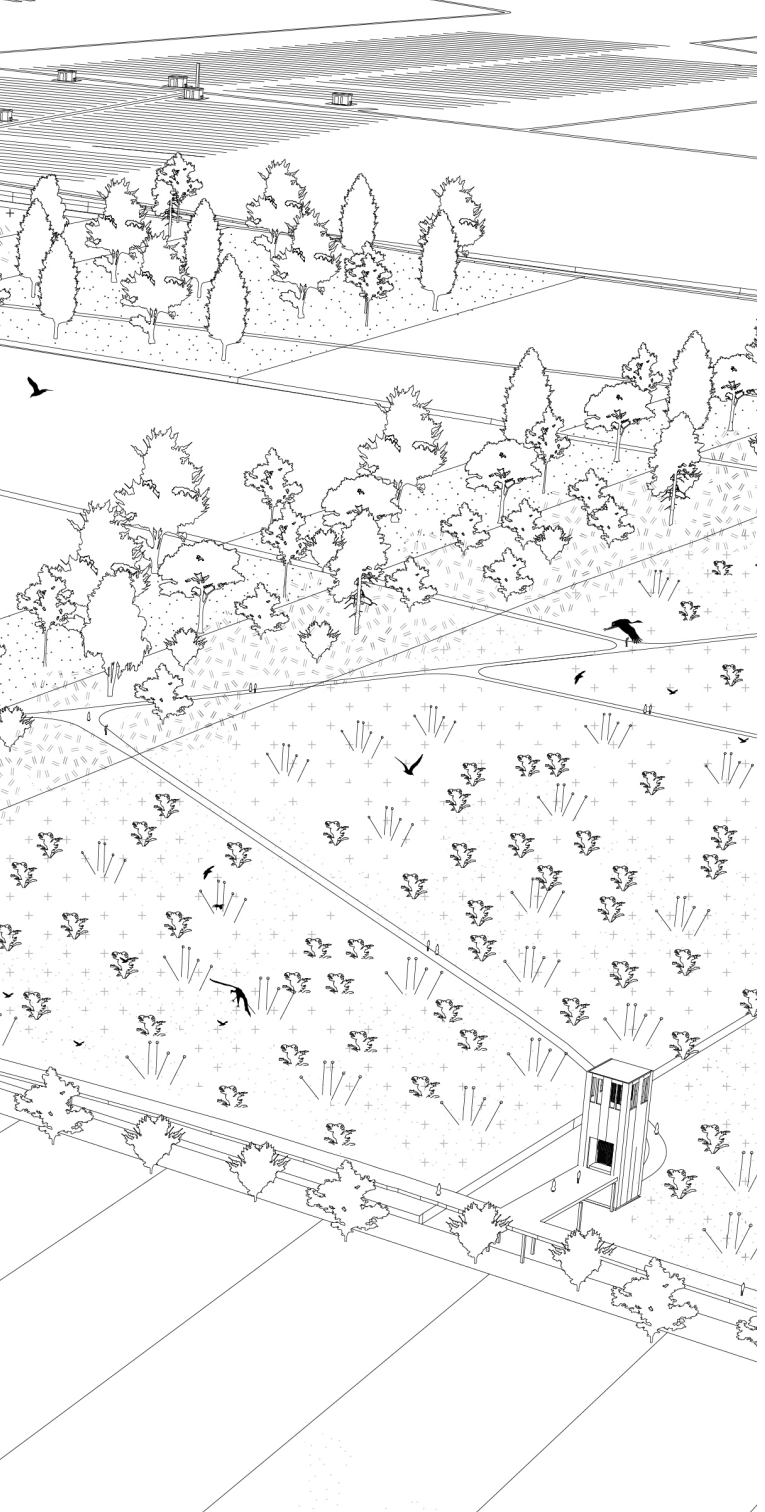

Designing a landscape to promote biodiversity in a solar park

An experimental approach in Canaro Solar Park (RO) for the preservation and enhancement of the local avifauna as a means to strengthen overall biodiversity

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A.A. 2021-2022

Master Degree in

Sustainable Architecture and Landscape Design

POLITECNICO
MILANO 1863

"I paesaggi [...] sono luoghi di incontri, mai completamente stabili, tra specie viventi, e gli esseri umani non sono che un elemento, certamente a volte predominante, di questi incontri e degli insiemi che ne risultano"

Jean-Marc Besse, *Paesaggio ambiente. Natura, territorio, percezione*, 2020

Index

00

ABSTRACT

00. Abstract

As European policies (Directive 2001/77/CE) push toward the development of renewable energies, the solar sector is expected to become the main driver of land-use transformation. In the Po Valley region, GPVs are commonly set up in farmlands or brownfields, taking the place of monocultures and industrial agricultural land. These areas are characterized by a "very low" ecological value, and its implementation can generate an increase in biodiversity. Solar farms have the potential to enhance local biodiversity, especially when placed in an intensive agricultural landscape. As the simplification of land use and the resulting reduction of habitats suitable for reproduction produces quick and visible changes in bird populations, the avifauna is a prompt indicator of the quality of the habitat and biodiversity health.
This research proposes an experimental approach that focuses on the needs and well-being of birds, assuming that the implementation of strategies aimed at their preservation will produce overall habitat restoration relevant to wildlife more broadly.
Focusing on the existing Canaro Solar Park, the project proposes

a series of actions to balance energy efficiency and landscape quality, while giving a direct answer to the protection of the local avifauna. These actions include: changes in the PV panels layout; the implementation of an ecological corridor; the integration of diverting elements (noise towers, localized anthropic disturbance) to deviate the passage of birds, and the restoration of degraded habitats.

01

DEFINING KEYWORDS

01. Defining keywords

01.1. Landscape

Anthropic disturbance

The disorder caused by the presence of human-beings. It can affect the regular development of habitats and ecosystems.

Biodiversity

"The biodiversity can be defined as the life richness on the earth planet: it means the millions of plants, animals and microorganisms, the genes which they contain, the complex ecosystems that they compose in the biosphere. The Convention on Biological Diversity (CBD), proposed during the Earth Summit in Rio de Janeiro in 1992, defines biodiversity as the variety and variability among living organisms and ecological systems in which they live, highlighting that it includes diversity at different level, such as genetic, specific and ecosystem. This variety does not only refer to the shape and structure of living beings, but also includes diversity in terms of abundance, distribution and interactions between the different components of the ecosystem. In conclusion, biodiversity also includes human cultural diversity,

cultural diversity, which also suffer the negative effects of these factors that act on the genetic biodiversity.".[1]

Biodiversity indicators

The indicators are tools that can give information synthesising the number of characteristics. The biodiversity indicators are useful instruments that allow the representativity of this thematic and that are idoneous to give an overview of the trend with a methodological reliability. [1]

1. Gli indicatori di biodiversità dell'Annuario dei dati ambientali, ISPRA, 2021

01.1. Landscape

Energy landscape

It is a landscape characterised by one or more elements of the energy chain (e.g. energy extraction, assimilation, conversion, storage, transport or transmission of energy). The outcome can be a multi-layer energy landscape comprising combinations of technical and natural sources of energy within a landscape. Energy landscape is focused on renewable energy and the impact on landscape quality.[2]

Habitat

Habitat meets all the environmental conditions an organism needs to survive. For an animal, that means everything it needs to find and gather food, select a partner, and reproduce. "For a plant, a good habitat must provide the right combination of light, air, water, and soil"[3]. A habitat or a group of related habitats can be considered an ecosystem. Ecosystems are dynamic complexes

2. Energy Landscape, Glossary on renewable energy and landscape quality, Journal of Landscape Ecology, February 2019

3. NationalGeographic- https://education.nationalgeographic.org/?q=&page[number]=1&page[size]=25

of plant, animal and micro-organism communities and their non-living environment. "The EU Biodiversity Strategy to 2030 is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030 and contains specific actions and commitments".[4]

Landscape quality

"The perception of the holistic environmental, cultural, sensory and psychological characteristics of a landscape with respect to their benefits or significance to people".[5] It is relative, not absolute, requiring interpretation in the context of geographic scale (i.e. local, regional, national) and, or human experience.

Visual impact

The impact of the appearance of changes in a landscape that could have a positive impact (improvement) or a negative one (detraction) and the changes related to the human visual experience of the landscape.

4. European Environmental Agency, An introduction to habitats, 2022
5. Landscape quality Glossary on renewable energy and landscape quality, Journal of Landscape Ecology, February 2019

Photovoltacis (PV)

Photovoltaic technology is the means to convert the sun's radiation directly into electricity by solar cells, these cells are made of semiconducting materials. "When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity"[6]. "This process of converting light (photons) to electricity (voltage) is called the photovoltaic effect".[7] "A single PV device is known as a cell"[8]. An individual PV cell is usually small, and it produces about 1 or 2 watts of power. "To boost the power output of PV cells, they are connected together in chains to form larger units known as modules or panels."[9]

Watt (W)

Unit of measurement of electrical power used to quantify the rate of energy transfer. Megawatt (MW) is equal to one million of Watts. MW is commonly used to estimate the output of power stations.

6. Solareis - https://solareis.anl.gov/guide/solar/pv/index.cfm#:~:text=Solar%20cells%20are%20made%20of,the%20material%20to%20produce%20electricity.
7. necst.eu - http://www.necst.eu/energy-from-the-sun-an-introduction-to-photovoltaics/
8. energy.gov- https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics

01.2. Energy production

Agrivoltaics

The integration of farming activities and the production of electricity using photovoltaic panels on the same piece of land, so crops and PV panels coexist.[9]

Ground-mounted PV (GPV)

A system of PV panels installed on the ground using a rigid metal frame or atop a single pole. They are tilted to an optimal angle to maximise solar utilisation. "The distance between the rows of modules is designed so as to avoid shading effects".[10]

Building integrated PV panels (BIPV)

PV panels that constitute an element of the building. This typology of PV panels can usually be found in roofs, windows or façades.

Solar park

It is a large-scale area dedicated to connected PV panel systems used for energy production. This kind of energy production parks is usually characterised by proper infrastructure including power evacuation and access to services.

Best practice

It is an approach that, through scientific evidence and practical experience, shows processes and outcomes, which are superior to those achieved by other means, and which are used as models and recommendations for others. Best practice in the context of renewable energy development and landscape quality can be defined as the process and outcome of the production of renewable energy with minimal negative impact on people and ecosystems while being compatible with the landscape.[11]

9. Agrivoltaico, un prezioso alleato della transizione ecologica, Stefano Amaducci, Enel Green Power
10. Best practice, Glossary on renewable energy and landscape quality, Journal of Landscape Ecology, February 2019

11. Best practice, Glossary on renewable energy and landscape quality, Journal of Landscape Ecology, February 2019

01.2. Energy production

Sustainable renweable energy produciton

The production of renewable energy in line with the principles of sustainability. Environmental sustainability includes an assessment of the full environmental footprint of the renewable energy production (e.g. Life Cycle Assessment; Environment Impact Assessment). "It also addresses land use requirements and whether renewable energy production is in competition with food production, habitats and biodiversity, or water supply and quality". [12]

12. Sustainable renewable energy production, Glossary on renewable energy and landscape quality, Journal of Landscape Ecology, February 2019

02

INDICATORS DEFINITION

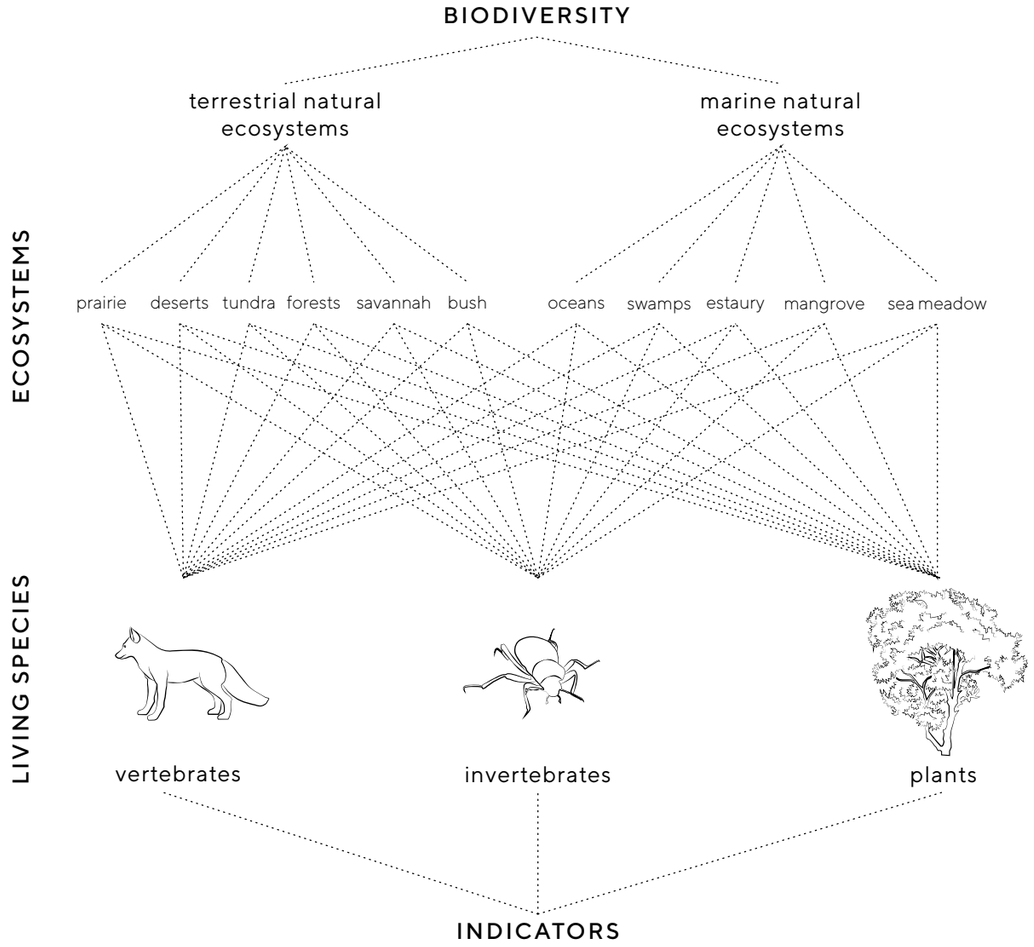
The preservation of biodiversity and the maintenance of a healthy ecosystem has been a shared effort since 1992 when the Convention on Biological Diversity (CBD) opened for signature at the Earth Summit in Rio de Janeiro. In 2010 the CBD set out the "Strategic Plan for Biodiversity 2011–2020" to restore and preserve biodiversity for the benefit of all people by 2050 defined in 20 "Aichi Biodiversity Targets" (ABTs) organised under five strategic goals. However, the Global Biodiversity Outlook (GBO4) in 2014 concluded that many of the defined indicators were problematic, due to a lack of data standardisation and global coverage, other than a lack of long-time series for measurements. To overcome these obstacles and assist in the monitoring phase, the "Group on Earth Observations Biodiversity Observation Network" (GEO BON) has proposed a set of "Essential Biodiversity Variables" (EBV) [13]. The EBVs objective is to "study, report, and manage biodiversity change, focusing on status and trend in elements of biodiversity", with the aim of finding measurable parameters for all relevant dimensions of biodiversity, and to reach a unanimous accord on what to monitor.

13. Pereira, Henrique Miguel, et al. "Essential biodiversity variables." Science 339.6117: 277-278, 2013

02.1. Indicators of biodiversity

Overview of existing literature

The definition of indicators has been indeed part of a complex argument that takes into account the many topics and layers of biodiversity, considering different species of vertebrates, invertebrates, and plants in all their levels of interactions, from the genetic composition to the ecosystem structure. The latest update has come in October of 2021 from the 15th Conference of the Parties (COP) to the Convention on Biological Diversity that took place in Kunming, China, and that produced the formulation of the post-2020 Global Biodiversity Framework. The document proposes 68 indicators, some of which overlapping with the GEO BON's proposal.



	2050 GOALS	MONITORING ELEMENTS		INDICATORS
GA1	Increased extent of natural ecosystems terrestrial, freshwater and marine ecosystems	Trends in area of forest ecosystems	001	Forest area as a percentage of total land area
			002	Tree cover loss
			003	Primary forest deforestation
			004	Human footprint index
		Trends in area of dry and subhumid lands	004	Human footprint index
		Trends in area of grasslands	005	Species Habitat Index
			004	Human footprint index
		Trends in area of other terrestrial ecosystems	005	Species Habitat Index
			006	Biodiversity Habitat Index
			007	Ecosystem Area Index
			008	Ecosystem Health Index
			009	Red list Index of Ecosystems
			004	Human footprint index
		Trends in area of mangroves	010	Continuous Global Mangrove Forest Cover
			011	Trends in mangrove extent
		Trends in area of coral reefs	012	Live coral cover
			013	Coral Reef extent and condition
			014	Global coral reef extent
		Trends in area of seagrass ecosystems	015	Global seagrass extent
		Trends in area of other marine and coastal ecosystems	0016	Global saltmarsh extent
		Trends in area of wetlands	001	Wetland extent trends Index

	2050 GOALS	MONITORING ELEMENTS		INDICATORS
GA2	Ecosystems integrity and connectivity terrestrial, freshwater and marine ecosystems	Trends in fragmentation and quality of forest ecosystems	001	Forest area as a percentage of total land area
			0019	Red List Index
			002	Tree cover loss
			005	Species Habitat Index
		Trends in integrity for all ecosystems	007	Ecosystem Area Index
			008	Ecosystem Health Index
			009	Red list Index of Ecosystems
			020	Proportion of land that is degraded over total land area
			002	Tree cover loss
			021	Forest Landscape Integrity Index
			022	Ecosystem Intactness Index
			005	Species Habitat Index
			023	Temporal biodiversity Intactness Index for all land use type
		Trends in fragmentation and quality of dry and sub-humid lands	022	Ecosystem Intactness Index
			005	Species Habitat Index
		Trends in fragmentation and quality of grassland	022	Ecosystem Intactness Index
			005	Species Habitat Index
		Trends in fragmentation and quality of other terrestrial ecosystems	005	Species Habitat Index
			024	Bioclimatic Ecosystem Resilience Index
			007	Ecosystem AreaIndex
			008	Ecosystem Health Index
			009	Red List Index of Ecosystems

2050 GOALS		MONITORING ELEMENTS		INDICATORS
GA2	Ecosystems integrity and connectivity terrestrial, freshwater and marine ecosystems	Trends in fragmentation and quality of other terrestrial ecosystems	*025*	Biotic Integrity Index
			022	Ecosystem Intactness Index
		Trends in fragmentation and quality of mangroves	*005*	Continuous Global Mangrove Forest Cover
		Trends in fragmentation and quality of coral reefs	*012*	Live coral cover
			026	Fleshy algae cover
			027	Cover of key benthic groups
			028	Red List Index
			029	Structural complexity
			030	Carbonate budgets
		Trends in fragmentation and quality of other marine and coastal ecosystems	*007*	Ecosystem Area Index
			008	Ecosystem Health Index
			009	Red List Index of Ecosystems
			031	Red List Index
		Trends in fragmentation and quality of inland wetlands	*017*	Wetland extent Trends Index
			032	Red List Index
GA3	Prevent extinction and improve the conservation status of species	Trends in number of extinctions	**033**	**Number of species extinctions (birds and mammals)**
			034	**Number of extinction sprevented by conservation actions**
			035	**Red List Index**
			005	Species Habitat Index

2050 GOALS		MONITORING ELEMENTS		INDICATORS
GA3	Prevent extinction and improve the conservation status of species	Trends in conservation status species	**035**	**Red List Index**
			036	Percentage of threatened species that are improving in status
			037	Species Protection Index
			038	**Species Habitat Index**
			036	Number of certified forest areas under sustainable management with verified impacts on biodiversity conservation
GA4	Increase the number and health of common species	Trends in species abundance	*040*	Living Planet Index
			005	Species Habitat Index
			041	Green List of Species
			038	**Wild Bird Index**
			042	Fish abundance and biomass
GA5	Maintain genetic diversity	Trends in the diversity of wild species	*043*	Comprehensiveness of conservation of socioeconomically as well as culturally valuable species
		Trends in the diversity of cultivated plants, farmed and domesticated animals	*044*	Agroobiodiversity Index
			045	Number of plant genetic resources for food and agriculture secured in medium or long-term conservation facilities
			046	Proportion of local breeds classified as being at risk, not at risk or at an unknown level of risk of extinction
			047	Comprehensiveness of conservation of socioeconomically as well as culturally valuable species

2050 GOALS		MONITORING ELEMENTS		INDICATORS
GA6	Protection of critical ecosystems	Trends in area of terrestrial and inland water areas conserved	*050*	Number of certified forest areas under sustainable management with verified impacts on watershed conservation
		Trends in area of coastal and marine areas conserved	*051*	Coastal Protection Index
			038	**Proportion of assessed marine protected areas that are ecologically effective**
		Trends in areas of particular importance for biodiveristy conserved	**053**	**Protected Area Coverage of Key Biodiversity Areas**
			039	Number of certified forest areas under sustainable management with verified impacts on biodiversity conservation
			037	Species Protection Index
			054	**Proportion of KBAs in favourable condition**
		Trends in areas of particular importance for ecosystem services conserved	**055**	**Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type**
			056	Number of certified forest areas under sustainable management with High Conservation Values
			057	Protected Areas Representativeness Index
			037	Species Protection Index

2050 GOALS		MONITORING ELEMENTS		INDICATORS
GB1	Nature's regulating contributions including climate regulation, disaster prevention and other	Trends in habitat creation and maintenance	*058*	Number of certified forest areas under sustainable management with verified impacts on habitat conservation/restoration
		Trends in pollination and dispersal of seeds and other propagules	**059**	**Red List Index**
		Trends in regulation of air quality	--	*to be determined*
		Trends in regulation of climate	*060*	Number of certified forest areas under sustainable management with verified impacts on carbon sequestration/storage
		Trends in regulation of ocean acidification	--	*to be determined*
		Trends in regulation of freshwater quantity, quality, location and timing	*061*	Number of certified forest areas under sustainable management with verified impacts on water quality
		Trends in regulation of freshwater and coastal water quality	--	*to be determined*
		Trends in formation, protection and decontamination of soils and sediments	--	*to be determined*
		Trends in regulation of hazards and extreme events	*062*	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
		Trends in regulation of detrimental organisms and biological processes	--	*to be determined*

	2050 GOALS	MONITORING ELEMENTS		INDICATORS
GB2	Nature's material contributions including food, water and others	Trends in the provision of energy supply from biological resources	--	*to be determined*
		Trends in the provision of food and feed from biodiversity	**059**	**Red List Index**
		Trends in the provision of materials and assistance from biodiversity	--	*to be determined*
		Trends in the provision medicinal, biochemical and genetic resources from biodiversity	--	*to be determined*
GB3	Nature's non-material contributions including cultural	Learning an inspiration	--	*to be determined*
		Physical and psychological experiences	--	*to be determined*
		Supporting identities	--	*to be determined*
		Maintance of options (cultural values)	*064*	Number of certified forest areas under sustainable management with verified impacts on recreational services
GC1	Access to Genetic resources	Trends in access to genetic resources	--	*to be determined*
GC2	Sharing of the benefits	Trends in the benefits from the access to genetic resources shared	*062*	Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
GD1	Availability of sufficient financial resources	Trends in the mobilization of financial resources from public internatnional financial flows	*066*	Official development assistance from biodiversity
		Trends in public domestic resource mobilization	*067*	Revenue from biodiversity related economic instruments

	2050 GOALS	MONITORING ELEMENTS		INDICATORS
GD1	Availability of sufficient financial resources	Trends in the mobilization of financial resources from private sector	--	*to be determined*
		Trends in the mobilization of financial resources from charitable organizations	*068*	Biodiversity related philantropic funding
GD2	Sufficient capacity building, technology transfer and scientific cooperation	Trends in support to capacity building	--	*to be determined*
		Trends in capacity building activities	--	*to be determined*
		Trend sin technology transfer	--	*to be determined*
		Trends in scientific cooperation	--	*to be determined*
GC3	Access to technology	Trends in access to relevant technologies	--	*to be determined*

02.1. Indicators of biodiversity

Overview of existing literature

For the analysis of the biodiversity trends in Canaro Solar Park, we decided to focus our attention on birds while acknowledging the thoroughness of composite or multi-species indicators. **We follow the theories according to which the response of a selected group of species could mirror the response of other species reacting to the same human disturbance, giving us a picture of the ecosystem health**[14]. Indeed, an analysis of the available literature shows how some selected species become candidate taxon for monitoring global environmental change. For the European Environmental Agency (EEA), the abundance and distribution of selected species of birds and butterflies can indicate the health of the environment. Furthermore, **within the new CBD framework, birds and pollinators took on a central role as indicators of the defined monitoring elements**. Birdlife International alone (a global partnership of non-governmental organizations that seek to conserve birds and their habitats) was appointed as the responsible Institution to evaluate 10 out of 67 proposed

indicators. (regarding the goals GA3, GA4, GA5, GA6, GB1, GB2). Another well-known example is represented by the Wild Bird Index (WBI), adopted by the EU and integrated into the "abundance and distribution of selected species", one of the Streamlining European Biodiversity Indicators (SEBI) set to address the EU biodiversity targets [15]. The SEBI01 indicator tells us about the abundance and distribution of common forest and farmland birds, which represent the predominant types in Europe.

14. Caro and D'Oherty, 1999, Gregory et al., 2005

15. Fraixedas, Sara, et al. "A state-of-the-art review on birds as indicators of biodiversity: Advances, challenges, and future directions." Ecological Indicators, 2020

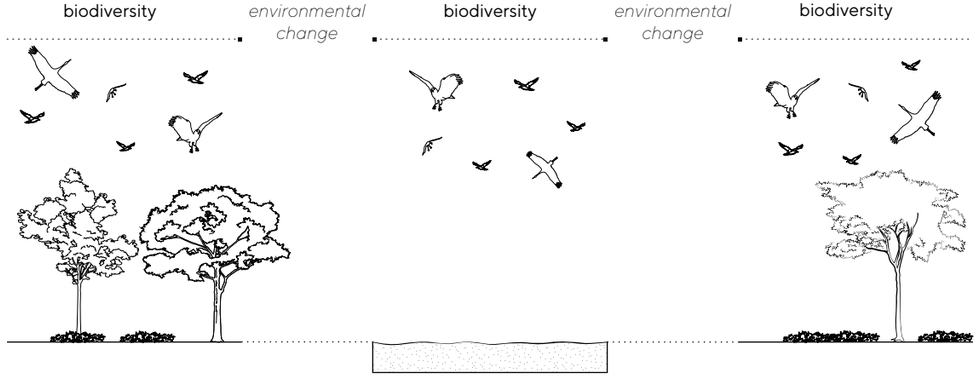
02.2. Birds as indicators of biodiversity

Birds are in fact great indicators because they are **sensitive to changes in the environment and can serve as an early warning**; they are predictable and respond to environmental changes in a foreseeable manner [16]; they are **widespread** (~10,000 species globally), found in all countries and nearly all habitats; they are **widely understood** [17], perhaps the best-known class of organisms on the planet; most of all their populations are responsive to environmental change. Being dependent on habitats functioning in a specific way, **the population trends of birds can give us a picture of the functioning of an ecosystem**. Birds are also good **pollution indicators**, for instance. They were the first group of animals to visibly show a population decline due to the use of DDT, as was brought to attention by Rachel Carson in Silent Spring. The use of birds as biodiversity indicators can also expand to other vertebrate groups [18] affirms that birds and butterflies can be used as surrogates for one another to assess biodiversity at a

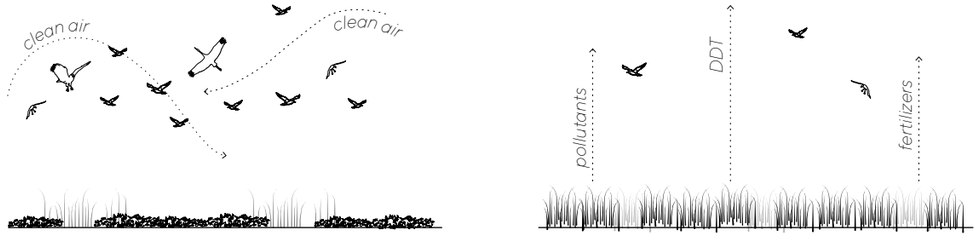
16. Järvinen, Oili, and Risto A. Väisänen. "Changes in bird populations as criteria of environmental changes.",1979 - p. 75-80
17. Venier and Pearce, 2004, Gregory et al., 2005
18.Blair, Robert B. "Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity?" 1999-p. 164-170

BIRDS PREDECTIBILITY

environmental changes
effecting birds behaviour



increased pollution
decreasing birdlife population



community level, arguing that the two species are correlated on a spatial scale of 1 to 10km. This study, therefore, suggests that the number of bird species can indicate the diversity of butterflies in small patches of habitat. A Greek study [19] on biodiversity indicators, examined the correlation between the richness of species across 6 groups of taxa, concluding that the species richness of small terrestrial birds is correlated with some of the other taxonomic groups (woody plants and aquatic herpetofauna), as well as with overall as well as with overall biodiversity. Acknowledging that bird Species Distribution Models (SDMs) can be used as a spectrum from national to regional scales in the development of variables for bird species as a regional indicator, **we propose an experimental approach that focuses on the needs and well-being of birds, assuming that the implementation of strategies aimed at their preservation will produce overall habitat restoration relevant to wildlife more broadly.**

19.Kati, Vassiliki, et al. "Testing the value of six taxonomic groups as biodiversity indicators at a local scale." Conservation biology 18.3, 2004 - p. 667-675

03

IMPACT ON BIODIVERSITY

03.1. PV parks as the main driver of land-use change

In the last decade, the number and size of PV park installations have exponentially increased; global PV capacity has grown from around 5 GW in 2005 to 714 GW in 2020, with a total growth rate of 14180%. Consequently, the attention on land-use transformation has been growing [20] together with concerns about landscape preservation and potential losses of biodiversity[21] and ecosystem services.

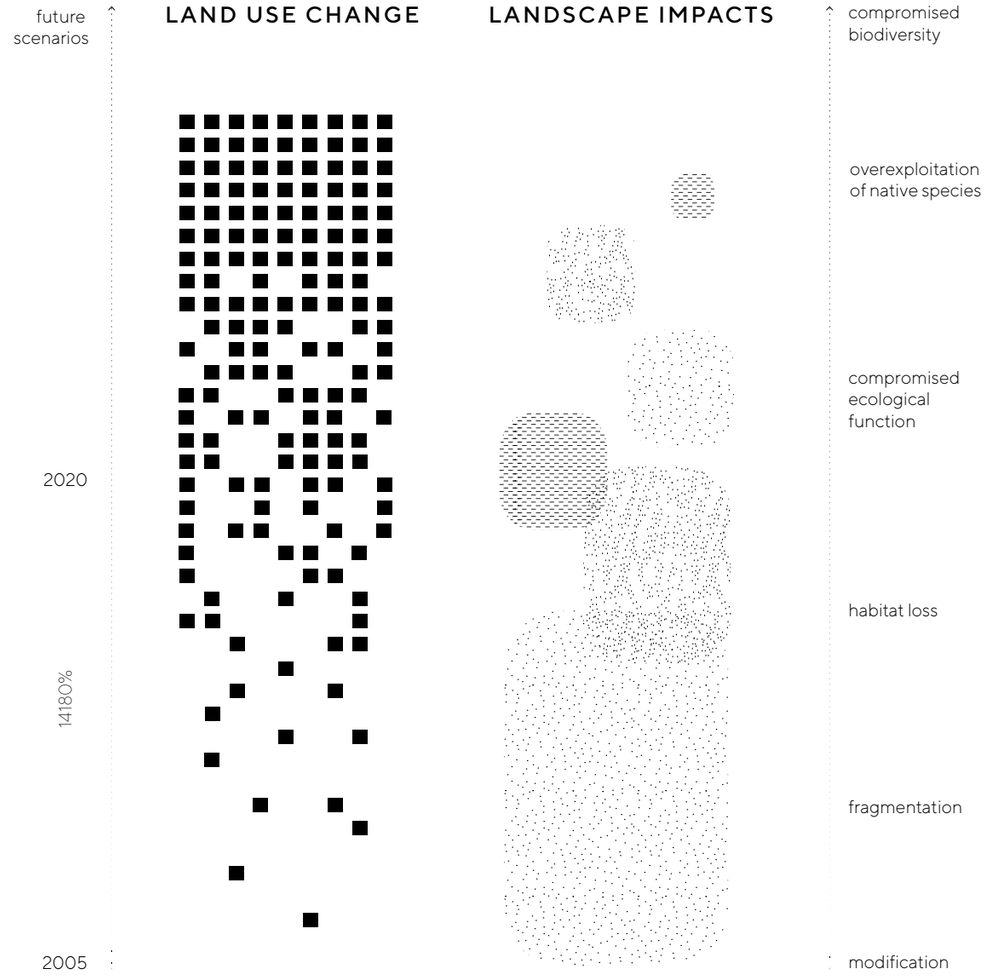
The realisation of ground-mounted photovoltaic (GPV) systems requires suitable space and can have significant environmental impacts on landscapes. Land-use change can be responsible for biodiversity decline as a consequence of habitat loss, modification, fragmentation, overexploitation of native species, and compromised ecological functions [22]. **Trends indicate that the transition to renewable energy will continue and this will likely turn the energy sector into the main driver of land-use change.**

20. Chiabrando,, E. Fabrizio, and G.Garnero. "The territorial and landscape impacts of photovoltaic systems: Definition of impacts and assessment of the glare risk." Renewable and Sustainable Energy Reviews 13.9, 2009: 2441-2451.
21. Lovich and Ennen, 2011; Hernandez et al., 2014
22. Semeraro et al. 2020

03.1. PV parks as the main driver of land-use change

According to van de Ven et al., in The potential land requirements and related land use change emissions of solar energy, if solar energy infrastructure currently only occupies a negligible amount of land globally, "In future scenarios, with a largely decarbonized electricity system, high penetration rates of solar energy will require significant amounts of land to be occupied by solar power plants." According to Van de Ven et al., the solar energy expansion will mostly replace commercial lands such as cropland or commercial forest. Croplands are in fact the most suitable since they require low costs, and they allow easy accessibility for roads and electrical grid networks while requiring minimal intervention to prepare the terrain for installation.[23] In face of these projections, **it is essential to apply ecological tools while developing GPV parks to support biodiversity, improve connectivity between existing habitats, and produce a management plan that takes into account the three main phases: construction, operation and decommissioning**.

23. Sargentis, G-Fivos, et al. "Agricultural Land or Photovoltaic Parks? The Water–Energy–Food Nexus and Land Development Perspectives in the Thessaly Plain, Greece." Sustainability 13.16 , 2021

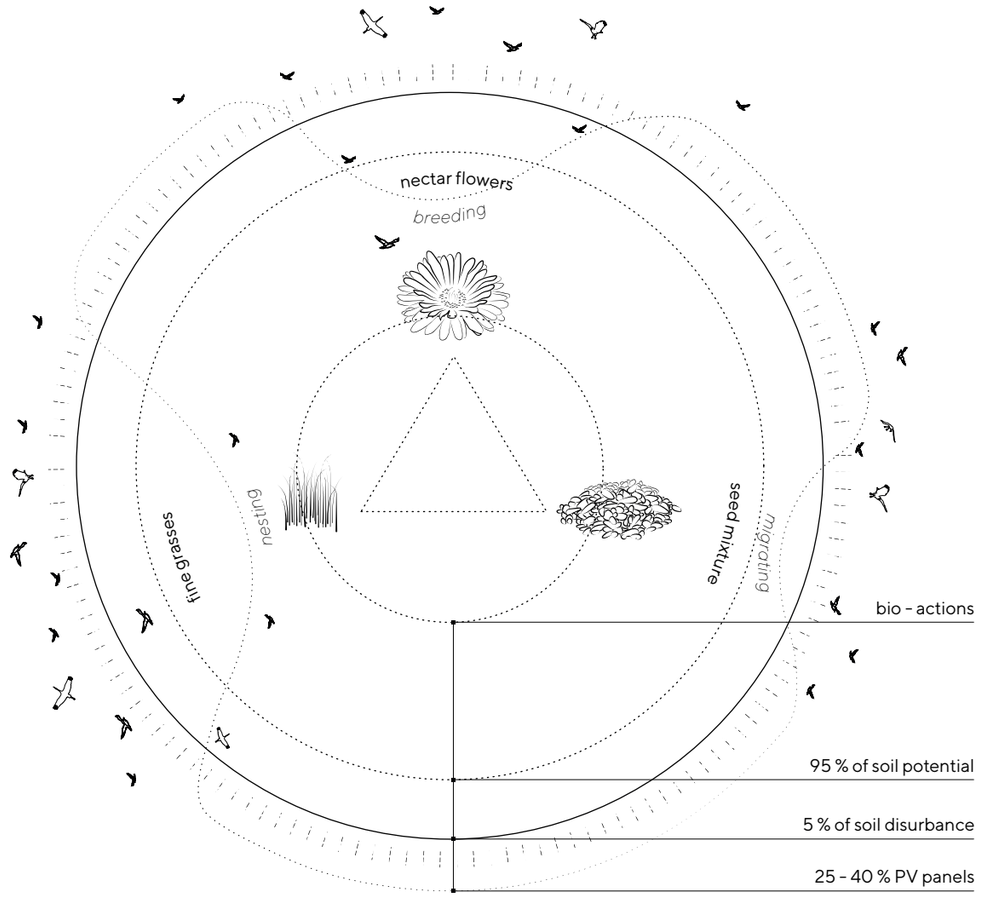


03.2. PV parks as an opportunity to enhance biodiversity

"Solar farms present an excellent opportunity for biodiversity" (G. Parker, 2014), particularly when implemented as a replacement for an intensive agricultural landscape. In most PV parks, in fact, the disturbance to the ground is minimal since panels are set on piles and only 25-40% of the surface is occupied by panels, making the use of pore space (area in between panels) particularly significant. PV infrastructure usually disturbs less than 5% of the ground, leaving the remaining 95% potentially accessible for plant growth and wildlife enhancements. Most importantly, the anthropic disturbance is significantly reduced compared to the former intensive agriculture use. Indeed, following construction, human activity is confined to occasional maintenance visits.

Options to enhance biodiversity are site-specific, and the selected habitat enhancement needs to be guided by the specific environment, location, land use, and existing biodiversity. Commonly used strategies include hedgerows, field margins, wildflowers, meadows, nectar-rich areas, winter bird crops, and others.

PV PANELS AS BIO - TOOL



03.2. PV parks as an opportunity to enhance biodiversity

An example of successful small-scale habitat enhancement can be found in a series of site-specific proposals made by the Royal Society for the Protection of Birds (RSPB). For the new PV installations of the Uphouse Farm, they proposed an array of actions aimed at meeting the seasonal needs to support birdlife. Therefore they implemented:

- nectar flowers for an insect rich habitat, supporting birds during the breeding season
- wild bird seed mixture for a seed rich habitat needed in the winter
- fine grasses for in-field nesting habitats

At Woolpots Solar Farm in North Yorkshire, RSPB partnered with the young solar farm company, Lightrock Power, where they managed to propose a project that will deliver a net biodiversity gain of 208% for nature. The proposed actions include:

- sowing wildflowers to provide food for pollinators
- 'hedgehog highways', created by cutting holes at the bottom of fences
- creating piles of wood to home invertebrates, reptiles, and amphibians
- bird and bat boxes
- planting trees and hedgerows

04

DESCRIPTION OF CANARO SOLAR PARK

Where

Canaro
Province of Rovigo
Veneto Region
Italy

What

Park for the production of electric power through the application of PV panels.

Technical information:
120 ha
206.582 PV panels
48 MW

When

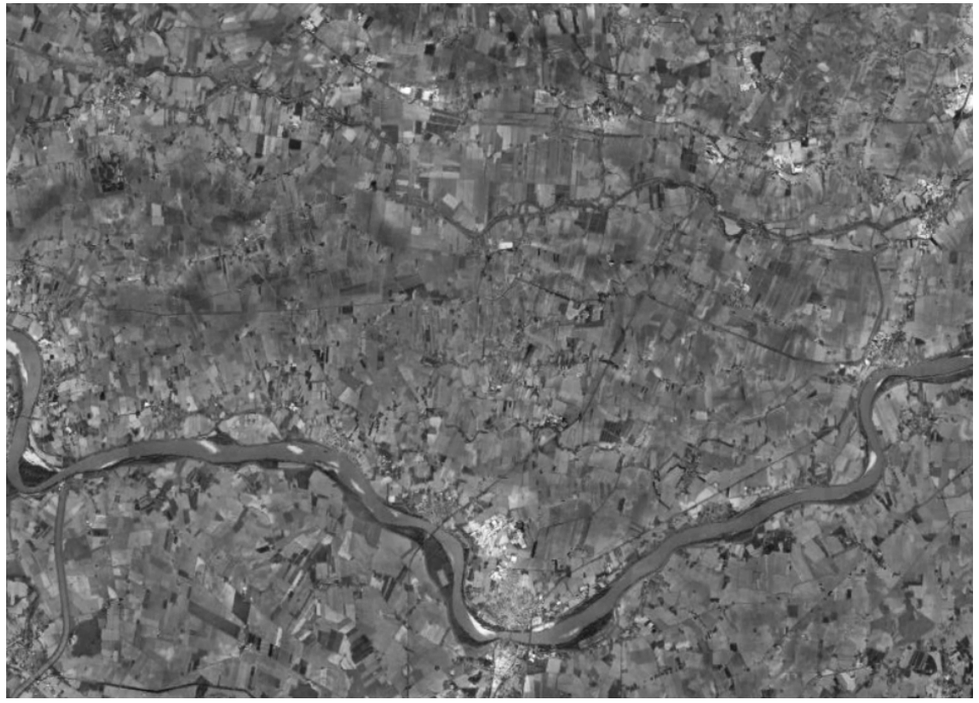
Construction year: 2011

How

Height from the ground: 0.5m - 2.00m
Panels inclination: 26°

04.1. Solar Park identification

The selected case study is a solar park of 48 MW located in Canaro, a small city in the province of Rovigo (Veneto, Italy), which is between Bologna (56 Km) and Verona (78 Km). The Veneto Region is one of the first in Italy for number of PV panels installed in the territory and for the amount of power produced by those devices [24].



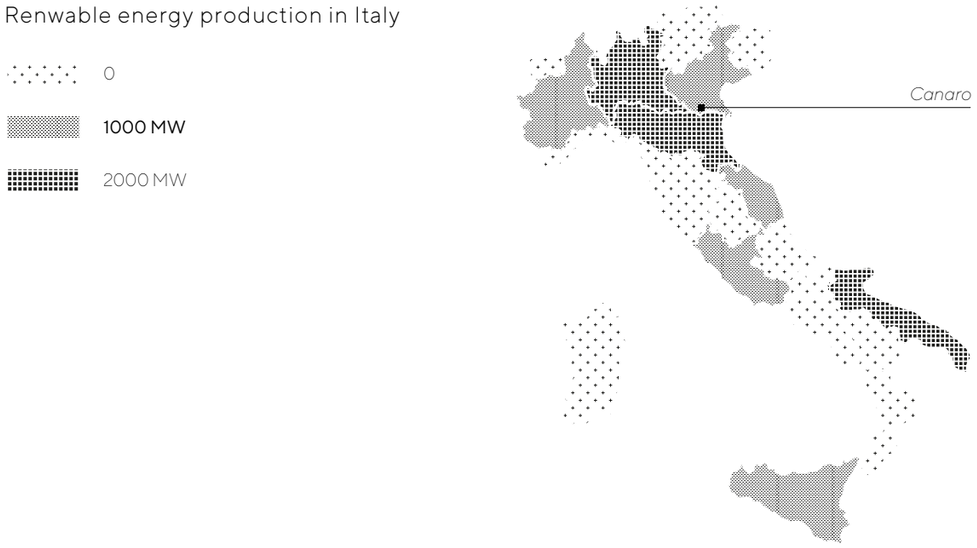
Territorial framework of the Rovigo Province

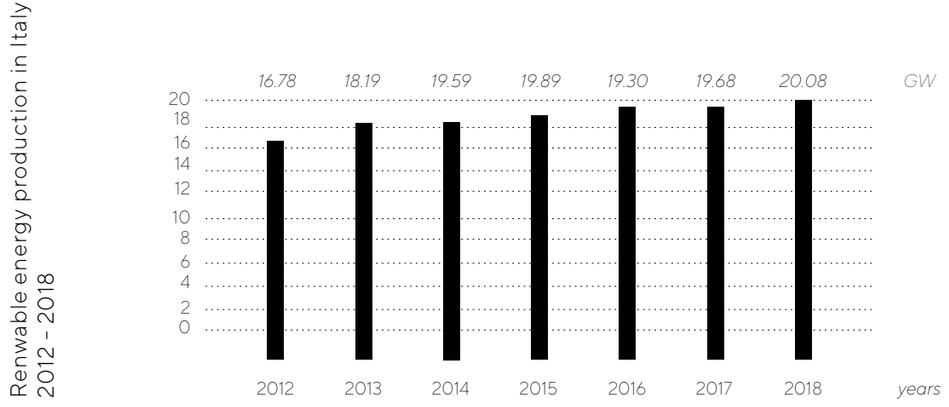
24. Sistema Gaudì, Gestione Anagrafica Unica degli Impianti e Unità di Produzione; Terna

04.2. Physical characteristics

04.2.2. Geographical localization

The geographical localization of Canaro is indicated with the coordinates 44° 56′ 17,16″ N 11° 40′ 37,56″ E, its altitude is variable between 1 m s.l.m. and 13 m s.l.m. with an average of 7 m s.l.m., so a quite flat area. Because of its localization and morphology, the solar irradiation here is estimated to be about 2.053 kWh/m^2.

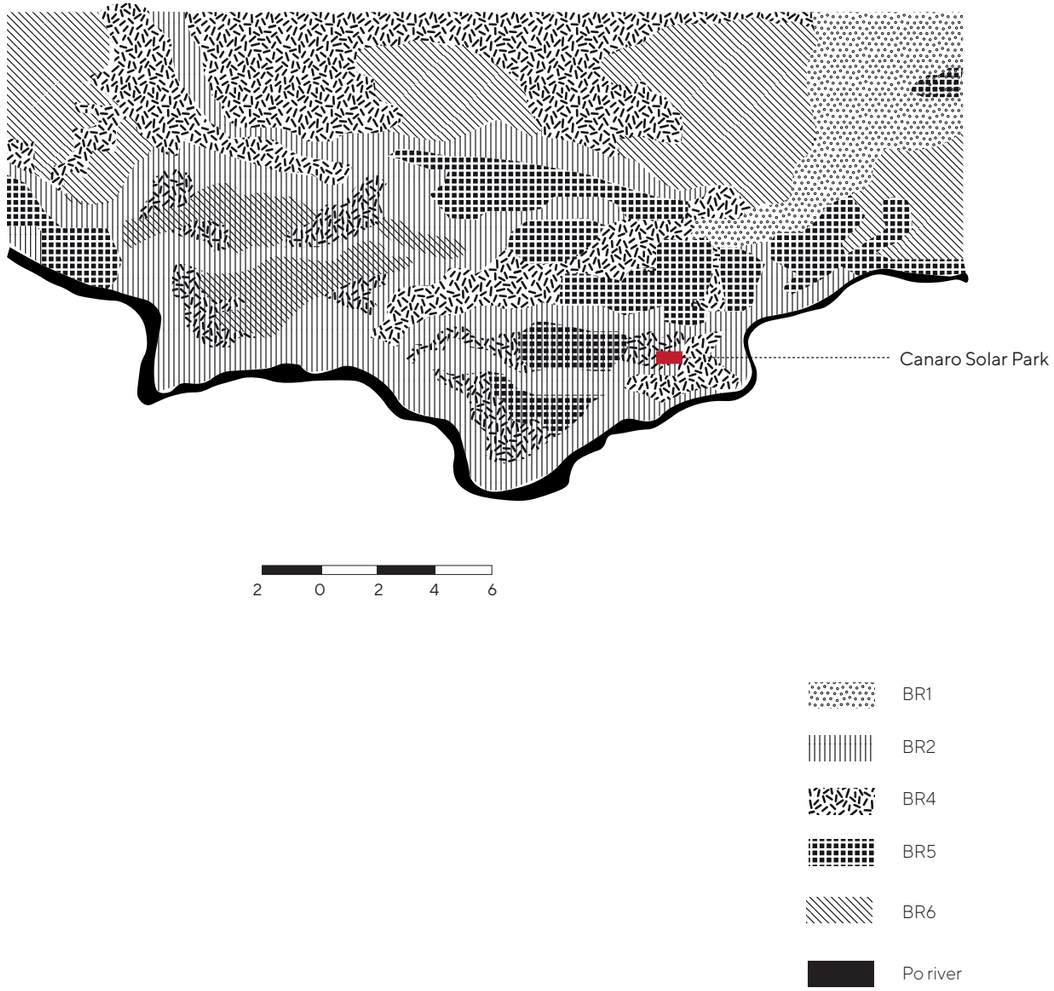




04.2. Physical characteristics

04.2.3. Pedology

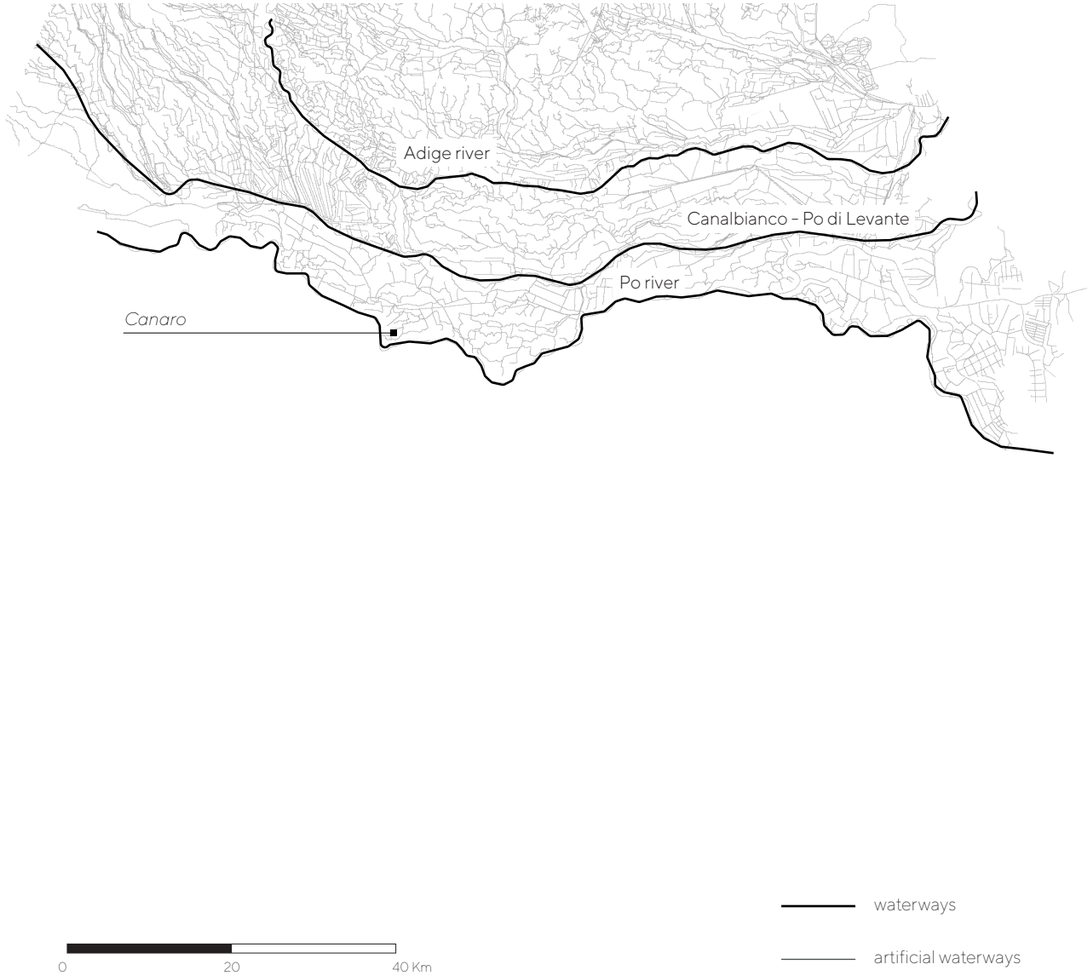
Canaro, as the whole lower part of the Pianura Padana of the Veneto Region, is classified as pedology class "BR": so, a recent lime low valley. The pedological systems in this Province can vary between BR2 and BR5. Specifically, the BR2 system is constituted by sands and calcareous silts; those are deep soils. The BR4 is a very deep silt calcareous. The BR5 is a soil characterised by clay and very calcareous silts with a moderate depth.



04.2. Physical characteristics

04.2.4. Waterways

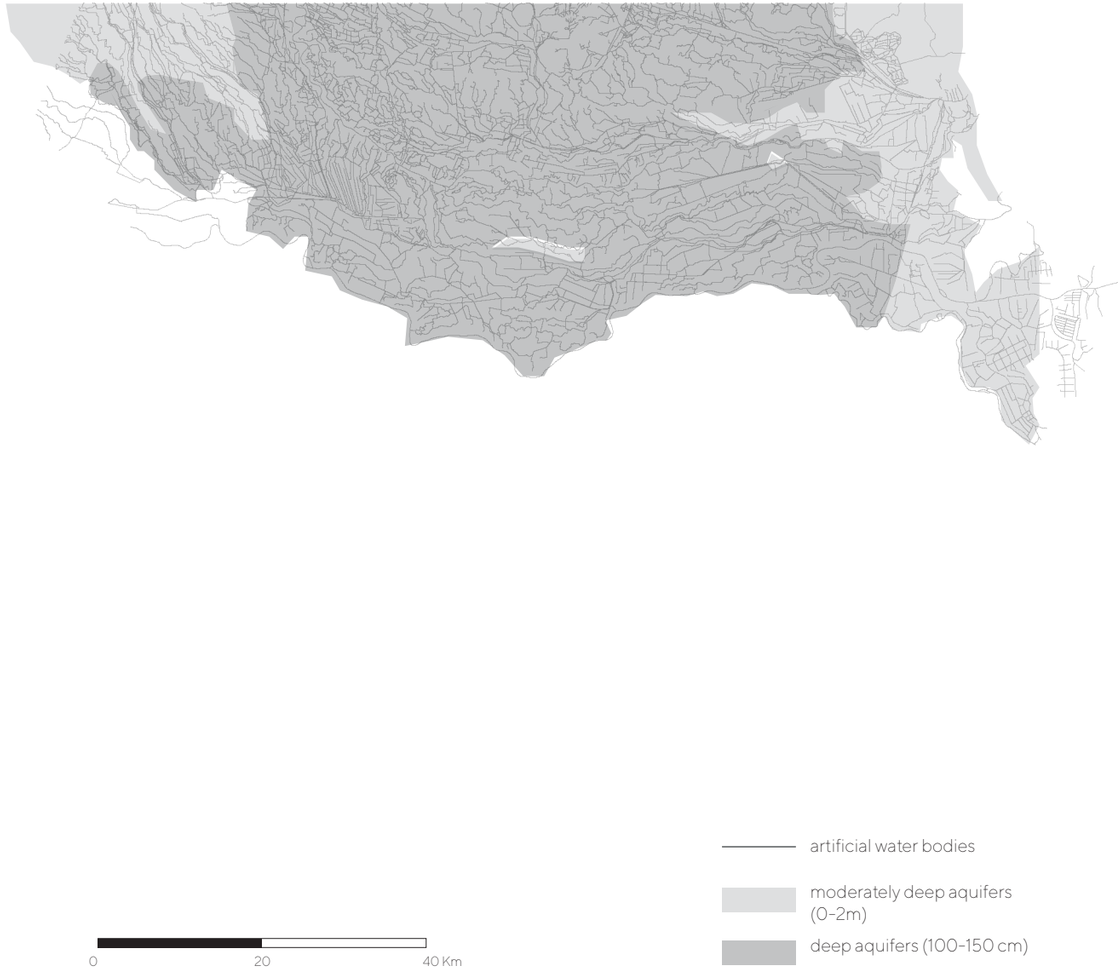
The area where the Solar Park is located is mainly classified as a flooding risk zone. It borders the Po River in its southern part and the Canal Bianco in the northern area. Beyond the Canal Bianco, there is another important waterway that is the Fiume Adige; this combination of waterways creates an extended green corridor that crosses the Canaro Solar Park.



04.2. Physical characteristics

04.2.5. Aquifers

The aquifers in the province of Rovigo, falling within the Lower Plain belt, are generally characterised by low potential and reduced extension. The system is multi-groundwater, typified by superficial aquifers superimposed on deeper confined aquifers, which are fed both directly by atmospheric precipitations (the superficial ones) and, mainly, by subsurface filtrations of superficial waters of the main hydrographic reticulum.



04.2. Physical characteristics

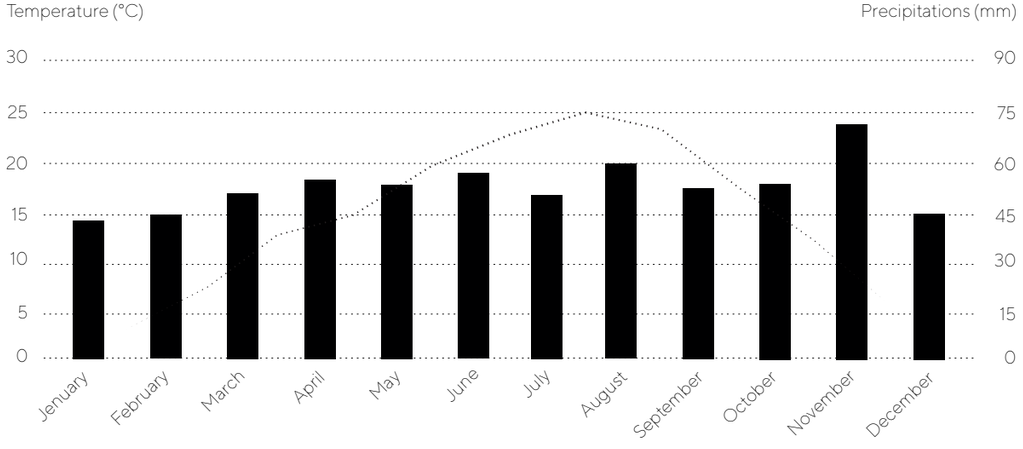
04.2.6. Climatic conditions

The temperature regime, based on Soil Taxonomy[25], is in the mesic class for the whole Rovigo Province territory. This regime is defined by an annual average temperature of the soil (50 cm deep) between 8 and 15 °C, with a difference higher than 5 °C between the average summer temperature and the average winter temperature.

The average annual precipitation is quite scarce (on average 700 - 750 mm per year), however lower than the regional average, and mostly concentrated in the spring and autumn seasons.

25. Soil Survey Staff - Keys to Soil Taxonomy. 11th Edition, USDA-NRCS, 2010

Annual Temperature and Precipitation in Veneto Region (°C)



Precipitation avarage: 634 mm/year
Temperature avarage: 13,4 °C

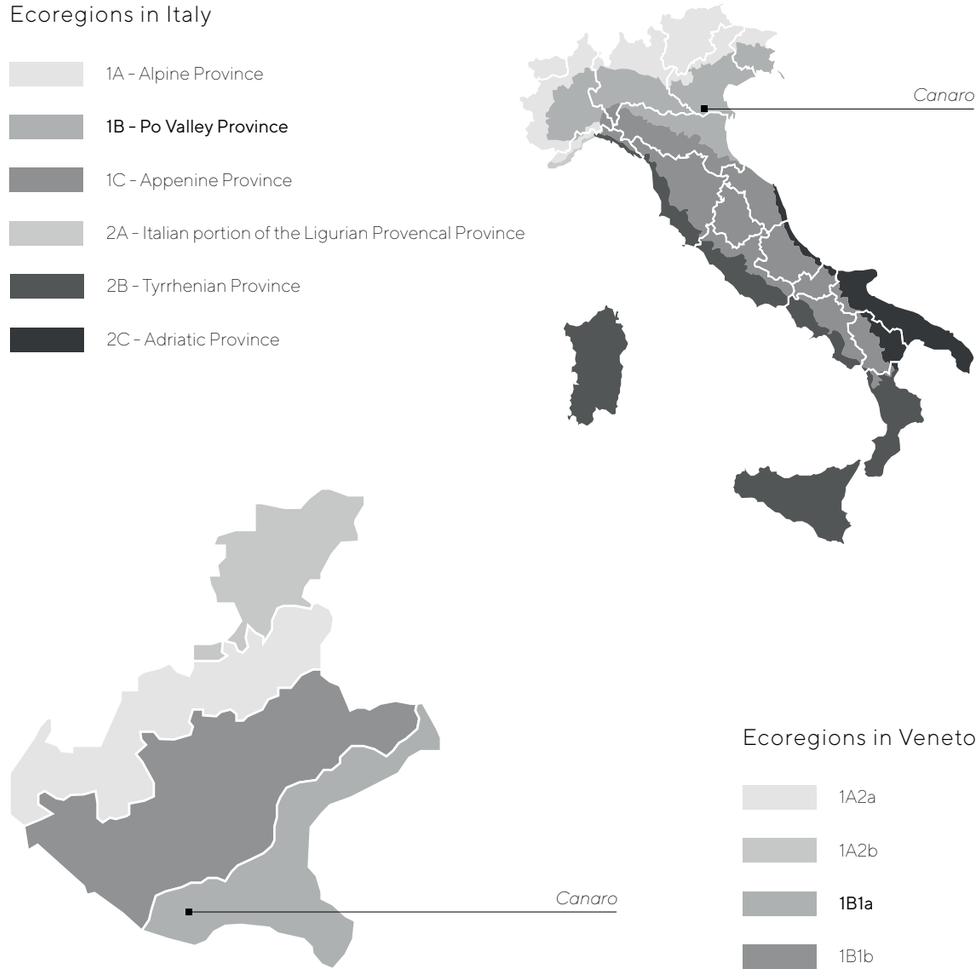
P mm

T avarage

04.2. Physical characteristics

04.2.7. Phytogeographical area

Ecoregions: Temperate Division (1) Padanian Province (1B) Padanian Section (1B1), Lagunar subsection (1B1a).
The Padanian Province is located in the south-eastern sector, the section covers 58% of the Veneto Region. Moderate subcontinental bioclimate. Potential for neutral basic forests of Quercus robur and Carpinus betulus and for mosaics of hygrophilous vegetation in the floodplains.

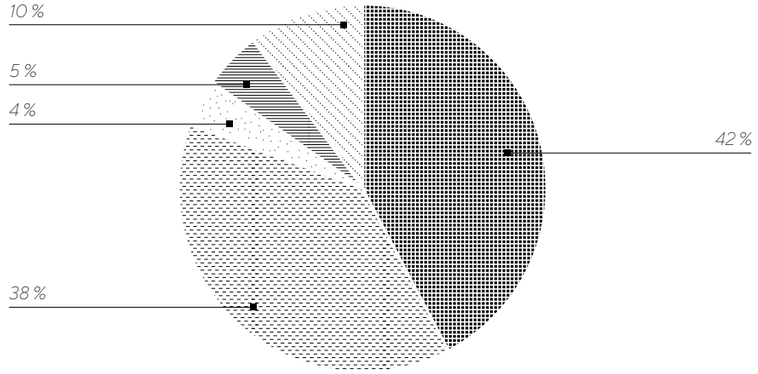


04.3. Habitat definition

Based on the Corine Index (*Corine Land Cover, CLC*) , it is possible to understand the habitats that compose the Veneto Region. Starting from the water, Veneto is rich in the quantity of sweet water that crosses the region. There are a lot of lagoons, mainly developed on the east coast of the region between the Delta del Po and Venice.
In the northern part of the Region, the bushland and the grassland are the main components of the habitats, the *Prunus spinosa* and the *Cornus sanguinea* are largely diffused just like the *Berberis vulgaris, Crataegus monogyna,* and the *Cornus mas* that are mainly present on the upper part of the soil surface.
The hill and mountain habitats, instead, are largely covered by deciduous trees such as oaks, hornbeams, ash trees, beeches, and maples. Another remarkable habitat in this part of the region is the forest which has a total area of 497.032,70 ha.
The southern area of the region, instead, **is mainly composed of cultivation and built-up areas**, **so a habitat where the anthropic presence modified the existing situation**, with traditional and extensive cultivations, industrial areas, and urban centres.
The cultivations that compose 38% of the Veneto surface, are predominantly composed of arable lands like corn, soy, sunflowers, and horticulture.

The built-up areas play a fundamental role in the development of the Veneto habitats since they constitute 10% of the surface of the Region. The total surface of this category is 190.690 ha and they are mainly present in the valley, in the Province of Treviso and Padova.
Moving closer to the Rovigo Province, it is possible to find a large presence of intensive and continuous cultivations and some fruit trees combined with the occupancy of built-up areas.

The cultivations are the 69,36% of the surface with a predominance (68,61%) of arable lands in irrigated areas, while the wetlands are the 5,34% of the covering surface with a total surface of 9.719,64 ha. The anthropic presence in the Rovigo Province, just like in the whole Veneto Region, has a remarkable interest since the urban residential area is the 5,16% of the surface mainly composed of a discontinuous urban texture (88 inhabitants/km²), and the industrial, commercial, and infrastructure coverage is 3,27% of the territory[26].



Surface composition

other

intensive and continuous arable land

cities, inhabited centers

Ostrya Carpinifolia thicket

extensive crops and complex agricultural systems

26. Carta dei Suoli della Provincia di Rovigo, Direzione Tecnica - Servizio Centro Veneto Suolo e Bonifiche, 2018

04.4. PV panels characteristics

The Canaro Solar Park is an active ground-mounted solar park with a footprint of 120 ha, with an energy production of 48 MW. It generates 64.000 MW/h electricity that allows the coverage of 14.000 households nearby the park. The project was developed by S.A.G. Solar (a subsidiary of Shunfeng International Clean Energy Limited) with a cost of €83mln financed by Deutsche Bank and it was sold in 2012 to BNP Paribas. The project was commissioned in April 2011, and it was completed in a few months, in August 2011, to achieve the FIT rate of € 0.256/kWh (USD 0.364/kWh).

In the Solar Park, there are 206.582 PV modules in silicon, with a layered structure composed of glass, ethylene-vinyl acetate (EVA), silicon cells, and EVA as protection of the silicon cells and the back sheet to cover the panel. The PV modules are divided into 44 stations, connected to the central station.

Nowadays the layout of the park is based on the shape that the cultivated fields used to have before the project, punctuated by artificial water canals that were realised to avoid the flooding risk.

To access the solar park there is one main way of connection that is Via Vittorio Emanuele II, located on the southern border of the park, and from there one main street crosses the park longitudinally with the insertion of transversal streets that allows the maintenance of the PV panels, connecting the stations with the main way of access.

04.5. Recognising the set of problems

The presence of a Solar Park in an area that used to be dedicated to intensive and traditional agriculture has consequences on the biodiversity, since **the panels, the stations and the high-voltage power line totally change the habitats where the local biodiversity used to grow and pass**, removing trees, cultivations, bushlands and grasslands. The biodiversity damage is not only related to the vegetation and to the animals, but also to the soil itself that could be gradually destroyed by the erosion, depleted from its chemical and biological natural configuration due to the PV panels shadows.

The 206.582 PV modules organised in 44 stations disposed one near the other, create large reflective surfaces that can threaten birds and insects. Those poultry can be burnt by the refraction of the panels while they pass by the solar park surface. Another phenomenon that can be observed is the nose-diving flight of the migratory birds that fly above the PV panels, they could confuse those panels as bodies of water, launching themselves on the rigid glass surface, provoking death or injuries.

There are also problems that are directly related to the layout of the PV panels themselves. Since a large part of those devices are located in high flooding risk zones, the risk is that water could cover the area where the PV panels are located causing damages and short-circuits.

05

THE AVIFAUNA OF CANARO

05.1. Wildlife management as a means to increase biodiversity

According to the aforementioned literature, "solar farms can lead to an increase in the diversity and abundance of broad-leaved plants, grasses, butterflies, bumblebees, and birds". [27]

In the comparative study "The effect of Solar Farms on Local Biodiversity" the authors argue that **the greater the focus on wildlife management on the site, the greater will be the benefit to biodiversity**. In the study, a high ranking in overall biodiversity was linked to a greater management focus on wildlife. Specifically, SP with a focus on wildlife management as reported "limited their use of pesticides, lower livestock stocking densities, and the re-establishment of field margins".

Our approach to increment biodiversity in the existing Canaro SP is based on the aforestated literature and hence follows the assumptions:

27. H. Montag, G Parker & T. Clarkson. 2016

-SP can be a source of biodiversity when placed within an intensive agricultural landscape;
-when focusing on wildlife management we can achieve greater overall biodiversity benefit.
The following step was to establish some criteria of selection, to focus our conservation measurements on the specific species that could benefit the most from our proposed interventions.
For Canaro we focus on birds since the area is crossed by a variety of birds during their migration toward the Po river delta, and solar parks increase the number of bird individuals and species diversity. Furthermore, large SPs are also connected to a high rate of birds fatalities due to predation (birds get injured when colliding with panels), starvation (water-obligate birds rely on water take-offs and become stranded without aquatic food sources), impact trauma (form flying into panels, power lines, and structures).

05.2. Birds selection

For Canaro we focus on birds, looking at the endangered species and proposing a series of targeted actions to promote the conservation of the specific species we expect to attract.
The process is composed of 4 steps:

Checklist of the birds of Rovigo:
In the following sheets, we reinterpret the checklist realized by E. Verza and M. Sighele which proposes a taxonomic listing of all the birds recorded in the province of Rovigo since 1965, in conformance to the Italian list of birds[28].
The research shows a picture of migrating, nesting, and wintering birds, as well as their degree of permanence in the area, classified as regular, irregular, and occasional. To overcome the bias caused by the species richness found in the Delta area on the other side of the province, we added a further element of research, the sighting in the proximity of Canaro.[29]

28. Brochetti & Fracasso, 2015
29. Atlante FotoSonoro degli Uccelli del Veneto - ed. 2019, Emanuele Stival & Maurizio Sighele

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
1	*Oca granaiola*	Bean goose							
2	*Oca selvatica*	Greylag goose							
3	*Oca lombardella*	Greater white-fronted goose							
4	*Oca del Canada*	Canada goose							
5	*Oca facciabianca*	Barnacle goose							
6	*Oca collorosso*	Red-breasted goose							
7	*Cigno nero*	Black swan							
8	*Cigno reale*	Mute swan							
9	*Oca egiziana*	Egyptian goose							
10	*Volpoca*	Common shelduck							
11	*Casarca*	Ruddy shelduck							
12	*Anatra mandarina*	Mandarin duck							
13	*Canapiglia*	Gadwall							
14	*Fischione*	Eurasian wigeon							
15	*Germano reale*	Mallard							
16	*Mestolone*	Northern shoveler							
17	*Codone*	Northern pintail							
18	*Marzaiola*	Garganey							
19	*Alzavola*	Eurasian teal							
20	*Fistione turco*	Red-crested pochard							
21	*Moriglione*	Common pochard							
22	*Moretta tabaccata*	Ferruginous duck							
23	*Moretta*	Tufted duck							
24	*Moretta grigia*	Greater saup							
25	*Edredone*	Common eider							
26	*Orco marino*	Velvet scoter							
27	*Orchetto marino*	Common scoter							
28	*Moretta codona*	Long-tailed duck							
29	*Quattrocchi*	Common goldeneye							
30	*Pesciaiola*	Smew							
31	*Smergo maggiore*	Common merganser							
32	*Smergo minore*	Red-breasted merganser							
33	*Gobbo della Giamaica*	Ruddy duck							
34	*Gobbo rugginoso*	White-headed duck							
35	*Starna*	Grey partridge							
36	*Quaglia*	Common quail							
37	*Fagiano comune*	Ring-necked pheasant							
38	*Strolaga minore*	Red-throated loon							
39	*Strolaga mezzana*	Black-throated loon							
40	*Strolaga maggiore*	Common loon							

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
41	*Berta maggiore*	Scopoli's shearwater							
42	*Berta minore*	Yelkouan shearwater							
43	*Tuffetto*	Little grebe							
44	*Svasso collorosso*	Red-necked grebe							
45	*Svasso maggiore*	Great crested grebe							
46	*Svasso cornuto*	Horned grebe							
47	*Svasso piccolo*	Black-necked grebe							
48	*Fenicottero*	Greater Flamingo							
49	*Cicogna nera*	Black stork							
50	*Cicogna bianca*	White stork							
51	*Ibis sacro*	African sacred ibis							
52	*Mignattaio*	Glossy ibis							
53	*Spatola*	Eurasian spoonbill							
54	*Tarabuso*	Eurasian bittern							
55	*Tarabusino*	Little bittern							
56	*Nitticora*	Black-crowned night heron							
57	*Sgarza ciuffetto*	Squacco heron							
58	*Airone guardabuoi*	Cattle egret							
59	*Airone cenerino*	Grey heron							
60	*Airone rosso*	Purple heron							
61	*Airone bianco maggiore*	Great egret							
62	*Garzetta*	Little egret							
63	*Airone schistaceo*	Western reef heron							
64	*Pellicano comune*	Great white pelican							
65	*Sula*	Boobies							
66	*Marangone minore*	Pygmy cormorant							
67	*Marangone dal ciuffo*	European shag							
68	*Cormorano*	Great cormorant							
69	*Falco pescatore*	Osprey							
70	*Falco pecchiaiolo*	European honey buzzard							
71	*Grifone*	Griffon vulture							
72	*Biancone*	Short-toed snake eagle							
73	*Aquila anatraia*	Greater spotted eagle							
74	*Aquila minore*	Booted eagle							
75	*Aquila imperiale*	Eastern imperial eagle							
76	*Sparviere*	Eurasian sparrowhawk							
77	*Astore*	Northern goshawk							
78	*Falco di palude*	Western marsh harrier							
79	*Albanella reale*	Hen harrier							
80	*Albanella pallida*	Pallid harrier							

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
81	*Albanella minore*	Montagu's harrier	■	■	■	■	■		
82	*Nibbio reale*	Red kite	■	■	■				■
83	*Nibbio bruno*	Black kite	■	■	■				
84	*Aquila di mare*	White-tailed eagle							■
85	*Poiana calzata*	Rough-legged buzzard							■
86	*Poiana codabianca*	Long-legged buzzard							■
87	*Poiana*	Common buzzard	■		■	■	■	■	
88	*Porciglione*	Water rail	■		■	■	■	■	
89	*Re di quaglie*	Corn crake	■	■					■
90	*Schiribilla*	Little crake	■	■	■		■		
91	*Voltolino*	Spotted crake	■	■	■				■
92	*Gallinella d'acqua*	Common moorhen	■		■	■	■	■	
93	*Folaga*	Coots	■		■	■	■	■	
94	*Gru*	Cranes	■	■	■				■
95	*Occhione*	Eurasian stone-curlew	■	■					■
96	*Beccaccia di mare*	Eurasian oystercatcher	■		■	■	■	■	
97	*Cavaliere d'Italia*	Black-winged stilt	■	■	■	■	■	■	
98	*Avocetta*	Pied avocet	■	■	■	■	■	■	
99	*Pavoncella*	Northern lapwing	■		■	■	■	■	
100	*Piviere dorato*	European golden plover	■	■	■			■	
101	*Pivieressa*	Grey plover	■		■	■		■	
102	*Corriere grosso*	Common ringed plover			■			■	
103	*Corriere piccolo*	Little ringed plover	■		■	■	■		
104	*Fratino*	Kentish plover	■	■	■	■	■	■	
105	*Corriere di Leschenault*	Greater sand plover							■
106	*Piviere tortolino*	Pygmy cormorant							■
107	*Beccaccia*	Eurasian woodcock	■		■			■	
108	*Frullino*	Jack snipe	■		■			■	
109	*Croccolone*	Great snipe							■
110	*Beccaccino*	Common snipe	■		■			■	
111	*Pittima reale*	Black-tailed godwit	■		■	■		■	
112	*Pittima minore*	Bar-tailed godwit			■			■	
113	*Chiurlo piccolo*	Eurasian whimbrel			■				
114	*Chiurlo maggiore*	Eurasian curlew	■		■	■		■	
115	*Totano moro*	Spotted redshank	■		■	■		■	
116	*Pettegola*	Common redshank	■		■	■	■	■	
117	*Albastrello*	Marsh sandpiper			■				
118	*Pantana*	Common greenshank	■		■	■		■	
119	*Piro piro culbianco*	Green sandpiper	■		■	■		■	
120	*Piro piro boschereccio*	Wood sandpiper	■	■	■	■		■	

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
121	*Piro piro del Terek*	Terek sandpiper							■
122	*Piro piro piccolo*	Common sandpiper	■		■	■		■	
123	*Voltapietre*	Ruddy turnstone	■		■	■		■	
124	*Piovanello maggiore*	Red knot	■		■	■		■	
125	*Piovanello tridattilo*	Sanderling	■		■			■	
126	*Gambecchio comune*	Little stint	■		■			■	
127	*Gambecchio nano*	Temminck's stint			■				
128	*Piovanello pettorale*	Pectoral Sandpiper							■
129	*Piovanello comune*	Curlew Sandpiper			■				
130	*Piovanello pancianera*	Dunlin			■	■		■	
131	*Gambecchio frullino*	Broad-billed Sandpiper			■				
132	*Combattente*	Ruff	■	■	■	■		■	
133	*Falaropo beccosottile*	Red-necked Phalarope							■
134	*Falaropo beccolargo*	Grey Phalarope							■
135	*Pernice di mare*	Collared Pratincole	■	■	■	■		■	
136	*Pernice orientale*	Black-winged Pratincole							■
137	*Gabbiano tridattilo*	Black-legged Kittiwake							■
138	*Gabbiano di Sabine*	Sabine's Gull							■
139	*Gabbiano roseo*	Slender-billed Gull	■	■	■	■	■	■	
140	*Gabbiano comune*	Black-headed Gull	■		■	■	■	■	
141	*Gabbianello*	Little Gull	■	■	■	■			
142	*Gabbiano corallino*	Mediterranean Gull	■	■	■	■	■	■	
143	*Gavina*	Common Gull			■			■	
144	*Mugnaiaccio*	Great Black-backed Gull			■			■	
145	*Gabbiano reale nordico*	Herring Gull	■		■			■	
146	*Gabbiano reale pontico*	Caspian Gull	■		■			■	
147	*Gabbiano reale*	Yellow-legged Gull	■		■	■	■	■	
148	*Zafferano*	Lesser Black-backed Gull	■		■			■	
149	*Sterna zampenere*	Gull-billed Tern	■	■	■	■	■		
150	*Sterna maggiore*	Caspian Tern			■	■		■	
151	*Sterna di Rueppell*	Lesser Crested Tern							■
152	*Beccapesci*	Sandwich Tern	■	■	■	■	■	■	
153	*Fraticello*	Little Tern	■	■	■	■	■		
154	*Sterna comune*	Common Tern	■	■	■	■	■		
155	*Mignattino piombato*	Whiskered Tern	■	■	■	■			
156	*Mignettino alibianche*	White-winged Tern	■		■	■			
157	*Mignettino comune*	Black Tern	■	■	■	■			
158	*Stercorario maggiore*	Great Skua							■
159	*Stercorario mezzano*	Pomarine Skua							■
160	*Labbo*	Arctic Skua			■	■			

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
161	*Labbo codalunga*	Long-tailed Skua							
162	*Piccione di citta'*	Feral Pigeon							
163	*Colombella*	Stock Dove							
164	*Colombaccio*	Wood Pigeon							
165	*Tortora selvatica*	Turtle Dove							
166	*Tortora dal collare*	Collared Dove							
167	*Cuculo dal ciuffo*	Great Spotted Cuckoo							
168	*Cuculo dal ciuffo*	Cuckoo							
169	*Barbagianni*	Barn Owl							
170	*Assiolo*	Scops Owl							
171	*Allocco*	Tawny Owl							
172	*Civetta*	Little Owl							
173	*Gufo comune*	Long-eared Owl							
174	*Gulo di palude*	Short-eared Owl							
175	*Succiacapre*	Nightjar							
176	*Rondone maggiore*	Alpine Swift							
177	*Rondone comune*	Common Swift							
178	*Rondone pallido*	Pallid Swift							
179	*Ghiandaia marina*	Roller							
180	*Martin pescatore*	Kingfisher							
181	*Gruccione*	Bee-eater							
182	*Upupa*	Hoopoe							
183	*Torcicollo*	Wryneck							
184	*Picchio rosso minore*	Lesser Spotted Woodpecker							
185	*Picchio rosso maggiore*	Great Spotted Woodpecker							
186	*Picchio verde*	Green Woodpecker							
187	*Grillaio*	Lesser Kestrel							
188	*Gheppio*	Common Kestrel							
189	*Falco cuculo*	Red-footed Falcon							
190	*Falco della regina*	Eleonora's Falcon							
191	*Smeriglio*	Merlin							
192	*Lodolaio*	Hobby							
193	*Lanario*	Lanner							
194	*Sacro*	Saker Falcon							
195	*Falco pellegrino*	Peregrine Falcon							
196	*Parrocchetto monaco*	Monk Parakeet							
197	*Parrocchetto dal collare*	Rose-ringed Parakeet							
198	*Averla piccola*	Red-backed Shrike							
199	*Averla isabellina*	Isabelline Shrike							
200	*Averla cenerina*	Lesser Grey Shrike							

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
201	*Averla maggiore*	Great Grey Shrike							
202	*Averla capirossa*	Woodchat Shrike							
203	*Rigogolo*	Golden Oriole							
204	*Ghiandaia*	Jay							
205	*Gazza*	Magpie							
206	*Taccola*	Jackdaw							
207	*Corvo comune*	Rook							
208	*Cornacchia nera*	Carrion Crow							
209	*Cornacchia grigia*	Hooded Crow							
210	*Beccofrusone*	Bohemian Waxwing							
211	*Cincia mora*	Coal Tit							
212	*Cinciarella*	Blue Tit							
213	*Cinciallegra*	Great Tit							
214	*Pendolino*	Penduline Tit							
215	*Bassettino*	Bearded Reedling							
216	*Tottavilla*	Woodlark							
217	*Allodola*	Skylark							
218	*Cappellaccia*	Crested Lark							
219	*Calandrella*	Greater Short-toed Lark							
220	*Calandra*	Calandra Lark							
221	*Topino*	Sand Martin							
222	*Rondine*	Barn Swallow							
223	*Balestruccio*	House Martin							
224	*Rondine rossiccia*	Red-rumped Swallow							
225	*Usignolo di fiume*	Cetti's Warbler							
226	*Codibugnolo*	Long-tailed Tit							
227	*Lui grosso*	Willow Warbler							
228	*Lui piccolo*	Chiffchaff							
229	*Lui bianco*	Western Bonelli's Warbler							
230	*Lui verde*	Wood Warbler							
231	*Lui forestiero*	Yellow-browed Warbler							
232	*Cannareccione*	Great Reed Warbler							
233	*Forapaglie castagnolo*	Moustached Warbler							
234	*Forapaglie comune*	Sedge Warbler							
235	*Cannaiola comune*	Reed Warbler							
236	*Cannaiola verdognola*	Marsh Warbler							
237	*Canapino comune*	Melodious Warbler							
238	*Canapino maggiore*	Icterine Warbler							
239	*Forapaglie macchiettato*	Grasshopper Warbler							
240	*Locustella fluviatile*	River warbler							

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
241	*Salciaiola*	Savi's Warbler							
242	*Beccamoschino*	Zitting Cisticola							
243	*Capinera*	Blackcap							
244	*Beccafico*	Garden Warbler							
245	*Bigiarella*	Lesser Whitethroat							
246	*Sterpazzola*	Common Whitethroat							
247	*Sterpazzolina comune*	Eastern Subalpine Warbler							
248	*Occhiocotto*	Sardinian Warbler							
249	*Fiorrancino*	Firecrest							
250	*Regolo*	Goldcrest							
251	*Scricciolo*	Winter Wren							
252	*Picchio muratore*	Nuthatch							
253	*Storno roseo*	Rosy Starling							
254	*Storno*	Common Starling							
255	*Merlo dal collare*	Ring Ouzel							
256	*Merlo*	Blackbird							
257	*Cesena*	Fieldfare							
258	*Tordo sassello*	Redwing							
259	*Tordo bottaccio*	Song Thrush							
260	*Tordela*	Mistle Thrush							
261	*Pigliamosche*	Spotted Flycatcher							
262	*Pettirosso*	European Robin							
263	*Pettazzurro*	Bluethroat							
264	*Usignolo maggiore*	Thrush Nightingale							
265	*Usignolo*	Common Nightingale							
266	*Balia nera*	Pied Flycatcher							
267	*Balia dal collare*	Collared Flycatcher							
268	*Pigliamosche pettirosso*	Red-breasted Flycatcher							
269	*Codirosso spazzacamino*	Black Redstart							
270	*Codirosso comune*	Common Restart							
271	*Codirossone*	Rock Thrush							
272	*Stiaccino*	Whinchat							
273	*Saltimpalo*	Stonechat							
274	*Culbianco*	Northern Wheatear							
275	*Monachella*	Western black-eared wheatear							
276	*Monachella dorsonero*	Pied Wheatear							
277	*Passera d'Italia*	Italian Sparrow							
278	*Passera sarda*	Spanish Sparrow							
279	*Passera mattugia*	Tree Sparrow							
280	*Passera scopaiola*	Dunnock							

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
281	*Cutrettola*	Yellow Wagtail							
282	*Ballerina gialla*	Grey Wagtail							
283	*Ballerina bianca*	White Wagtail							
284	*Calandro maggiore*	Richard's Pipit							
285	*Calandro*	Tawny Pipit							
286	*Pispola*	Meadow Pipit							
287	*Prispolone*	Tree Pipit							
288	*Pispola golarossa*	Red-throated Pipit							
289	*Spioncello*	Water Pipit							
290	*Fringuello*	Chaffinch							
291	*Peppola*	Brambling							
292	*Frosone*	Hawfinch							
293	*Ciuffolotto*	Bullfinch							
294	*Ciuffolotto scarlatto*	Common Rosefinch							
295	*Verdone*	Greenfinch							
296	*Fanello*	Linnet							
297	*Crociere*	Common Crossbill							
298	*Cardellino*	Goldfinch							
299	*Verzellino*	Serin							
300	*Lucherino*	Siskin							
301	*Strillozzo*	Corn Bunting							
302	*Zigolo giallo*	Yellowhammer							
303	*Zigolo golarossa*	Pine Bunting							
304	*Ortolano*	Ortolan Bunting							
305	*Zigolo nero*	Cirl Bunting							
306	*Migliarino di palude*	Reed Bunting							
307	*Zigolo delle nevi*	Snow Bunting							

The project area is characterized by high species richness since most birds cross the vast agricultural land during their migration and towards the Po River Delta. Out of 307 birds populating the Veneto region, 31 have been spotted within a radius of 20Km and 64 within 40Km from the PV site. The following steps in the research process are aimed at understanding which birds currently present in the area are in higher need of conservation measurements, and which birds will be attracted by the increment in biodiversity of the Oasis.

Current situation:

Because of the **high presence of rare and protected birds** in the area, the analysis narrows the focus on those, following the list of endangered species compiled in the Birds Directive (Directive 2009/147/EC).

The resulting list includes 23 species selected by the following criteria:

- classified as "particularly protected"
- spotted in the Canaro area during their migration

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
48	*Fenicottero*	Greater Flamingo	■	■	■	■		■	
54	*Tarabuso*	Eurasian bittern	■	■	■	□		■	
55	*Tarabusino*	Little bittern	■	■	■	■	■		
56	*Nitticora*	Black-crowned night heron	■	■	■	■	■	■	
57	*Sgarza ciuffetto*	Squacco heron	■	■	■	■	■		
60	*Airone rosso*	Purple heron	■	■	■	■	■		
61	*Airone bianco maggiore*	Great egret	■	■	■	■	□	■	
62	*Garzetta*	Little egret	■	■	■	■	■	■	
66	*Marangone minore*	Pygmy cormorant	■	■	■	■	■	■	
70	*Falco pecchiaiolo*	European honey buzzard	■	■	■				
78	*Falco di palude*	Western marsh harrier	■	■	■	■	■	■	
79	*Albanella reale*	Hen harrier	■	■	■			■	
81	*Albanella minore*	Montagu's harrier	■	■	■	■	■		
94	*Gru*	Cranes	■	■	■			□	
97	*Cavaliere d'Italia*	Black-winged stilt	■	■	■	■	■	□	
120	*Piro piro boscherecio*	Wood sandpiper	■	■	■	□		□	
132	*Combattente*	Ruff	■	■	■	□		□	
157	*Mignettino comune*	Black Tern	■	■	■	■			
179	*Ghiandaia marina*	Roller	■	■	■	■	■		
180	*Martin pescatore*	Kingfisher	■	■	■	■	■	■	
189	*Falco cuculo*	Red-footed Falcon	■	■	■	■			
195	*Falco pellegrino*	Peregrine Falcon	■	■	■	■	■	■	
198	*Averla piccola*	Red-backed Shrike	■	■	■	■	■		

	NAME		compatible habitats
61	*Airone bianco maggiore*	Great egret	farmland, lakes, wetlands, rivers & streams
70	*Falco pecchiaiolo*	European honey buzzard	farmland, woods
78	*Falco di palude*	Western marsh harrier	farmland, lakes, wetlands
79	*Albanella reale*	Hen harrier	farmland, wetlands
81	*Albanella minore*	Montagu's harrier	farmland
94	*Gru*	Cranes	farmland, wetlands
120	*Piro piro boscherecio*	Wood sandpiper	farmland, lakes, wetlands, rivers & streams
132	*Combattente*	Ruff	farmland, lakes, wetlands, rivers & streams
179	*Ghiandaia marina*	Roller	various open habitats
189	*Falco cuculo*	Red-footed Falcon	farmland, wetlands
195	*Falco pellegrino*	Peregrine Falcon	various open habitats, rocky terrain

For each bird, we afterward identify the respective habitat, classifying them within:

(1) **woodland habitats**—coniferous or deciduous trees

(2) **aquatic habitats**—water bodies, swamps, and marshes, oceans, and shorelines

(3) **scrub-shrub habitats**—short woody plants and bushes

(4) **open habitats**—grasslands, agricultural fields, and tundra

Since the current situation is mostly characterized by intensive farmland, we decide to focus our attention on all the birds spotted in the Canaro area during their migration and whose habitat is " open habitats: grasslands, agricultural fields ". These are the birds that will likely be present in the PV park area, and that we wish to divert into the Oasis.

	NAME		protected species	habitat	feed	migratory behaviour
61	*Airone bianco maggiore*	Great egret		farmland, lakes, wetlands, rivers & streams	fish, small mammals, amphibians	predominantly short-distance migrant
70	*Falco pecchiaiolo*	European honey buzzard		farmland, woods	amphibians, vespaie	long-distance migrant
78	*Falco di palude*	Western marsh harrier		farmland, lakes, wetlands	small mammals, birds, amphibians	predominantly long-distance migrant
79	*Albanella reale*	Hen harrier		farmland, wetlands	small mammals, birds	short-distance migrant
81	*Albanella minore*	Montagu's harrier		farmland	insects, small mammals, birds	long-distance migrant
94	*Gru*	Cranes		farmland, wetlands	insects, plants, seeds	predominantly short-distance migrant
120	*Piro piro boschereccio*	Wood sandpiper		farmland, lakes, wetlands, rivers & streams	insects, crustaceans	predominantly long-distance migrant
132	*Combattente*	Ruff		farmland, lakes, wetlands, rivers & streams	insects, seeds, snails	predominantly long-distance migrant
179	*Ghiandaia marina*	Roller		various open habitats	insects	long-distance migrant
189	*Falco cuculo*	Red-footed Falcon		farmland, wetlands	insects	long-distance migrant
195	*Falco pellegrino*	Peregrine Falcon		various open habitats, rocky terrain	birds	predominantly resident

Newly attracted birds:

As a result of the necessary speculative process, we had to take a step back, evaluate the potential consequences of our intervention, and which **new habitats and nesting opportuning will be implemented through the Oasis**. The grassland, the bushland, the forest, and the artificial water bodies that compose the park, will draw a variety of species that could not be observed at the present moment within the 40 Km radius that has previously been considered.

In the following list, these factors were taken into account. The resulting list includes nesting and migrating species found in a variety of habitats.

	NAME		endengered	in the area	migration	summer	nesting	winter	occasional
MIGRATING									
54	*Tarabuso*	Eurasian bittern	■	■	■	■		■	
48	*Fenicottero*	Greater Flamingo	■	■	■	■		■	
70	*Falco pecchiaiolo*	European honey buzzard	■	■	■				
79	*Albanella reale*	Hen harrier	■	■	■			■	
94	*Gru*	Cranes	■	■	■			■	
120	*Piro piro boscherecio*	Wood sandpiper	■	■	■	■		■	
132	*Combattente*	Ruff	■	■	■	■		■	
157	*Mignettino comune*	Black Tern	■	■	■	■			
189	*Falco cuculo*	Red-footed Falcon	■	■	■	■			
198	*Averla piccola*	Red-backed Shrike	■	■	■	■			
NESTING									
55	*Tarabusino*	Little bittern	■	■	■	■	■		
56	*Nitticora*	Black-crowned night heron	■	■	■	■	■	■	
57	*Sgarza ciuffetto*	Squacco heron	■	■	■	■	■		
60	*Airone rosso*	Purple heron	■	■	■	■	■		
61	*Airone bianco maggiore*	Great egret	■	■	■	■	■	■	
62	*Garzetta*	Little egret	■	■	■	■	■	■	
66	*Marangone minore*	Pygmy cormorant	■	■	■	■	■	■	
78	*Falco di palude*	Western marsh harrier	■	■	■	■	■	■	
81	*Albanella minore*	Montagu's harrier	■	■	■	■	■		
97	*Cavaliere d'Italia*	Black-winged stilt	■	■	■	■	■	■	
179	*Ghiandaia marina*	Roller	■	■	■	■	■		
180	*Martin pescatore*	Kingfisher	■	■	■	■	■	■	
195	*Falco pellegrino*	Peregrine Falcon	■	■	■	■	■	■	

According to the data, when focusing the attention on nesting species the main habitats to target for the preservation of the protected birds potentially drawn by the park are (2) aquatic habitats (lakes, ponds, swamps, marshes, oceans, and shorelines) and (3) scrub-shrub habitats (short woody plants and bushes). Hence the **newly developed park represents an opportunity to provide a diversified experience for birds through a changing landscape composed of wetlands, canals, and artificial bodies, as well as shrubs and bushes**. Furthermore, we analyzed the feeding and nesting behavior of each species within the defined habitats, to provide suitable conditions to promote avian well-being. This knowledge was used to develop guidelines aimed at protecting the most fragile users of the park, the endangered birds, while promoting coexistence with the human counterpart. **Here, people are one small component in a complex matrix of relationships, and the needs of the birds define the boundaries of the human presence**.

	NAME		protected species	habitat	feed	migratory behaviour
55	*Tarabusino*	Little bittern		lakes, wetlands, rivers & streams	fish, insects, snails, amphibians	long-distance migrant
56	*Nitticora*	Black-crowned night heron		lakes, wetlands, rivers & streams	fish, insects, amphibians	predominantly long-distance migrant
57	*Sgarza ciuffetto*	Squacco heron		lakes, wetlands, rivers & streams	fish, insects, amphibians	predominantly short-distance migrant
60	*Airone rosso*	Purple heron		lakes, wetlands, rivers & streams	fish, small mammals, amphibians	long-distance migrant
61	*Airone bianco maggiore*	Great egret		farmland, lakes, wetlands, rivers & streams	fish, small mammals, amphibians	predominantly short-distance migrant
62	*Garzetta*	Little egret		lakes, wetlands, rivers & streams	fish, insects, crustaceans, amphibians	predominantly long-distance migrant
66	*Marangone minore*	Pygmy cormorant		lakes, rivers & streams	fish	predominantly resident
78	*Falco di palude*	Western marsh harrier		agricultural areas, lakes, wetlands	small mammals, birds, amphibians	mainly long-distance migrant
81	*Albanella minore*	Montagu's harrier		agricultural areas	insects, small mammals, birds	long distance migrant
97	*Cavaliere d'Italia*	Black-winged stilt		lakes, wetlands, rivers & streams	insects, crustaceans	predominantly long-distance migrant
179	*Ghiandaia marina*	Roller		various open habitats	insects	long distance migrant
180	*Martin pescatore*	Kingfisher		lakes, wetlands, rivers & streams	fish	resident to short-distance migrant
195	*Falco pellegrino*	Peregrine Falcon		various open living spaces, rocks	fish	mostly sedentary

Threats and conservation measurements:

The last step proposes a detailed analysis of the threats and conservation measurements for each of the selected species. The following sheet focuses on all the threats ranked as H (high importance) by the Birds Directive, categorizing them by frequency: red is high, and yellow is medium. The available data reveals that **the main issue is represented by the conversion of wetlands and the drainage of the land for agricultural use**. Hence the need to reclaim water features in the landscape and to bring back a meadow landscape formerly characterizing the Po Valley.

	NAME		threats								
55	*Tarabusino*	Little bittern	CJ03	CF10	CG02	CL01	CA02	CF04	CF05	CG03	CG12	CJ02
56	*Nitticora*	Black-crowned night heron	CF10	CF03	CA01	CA15	CB06	CB08	CB15	CC06	CG02	CJ03
57	*Sgarza ciuffetto*	Greater Squacco herongoose	CF03	CA01	CA02	CA09	CA15	CB06	CB15	CC06	CG02	
60	*Airone rosso*	Purple heron	CF10	CA05	CA09	CA15	CB15	CG06	CF03	CG02	CJ03	
61	*Airone bianco maggiore*	Great egret	CA09	CB05	CJ03							
62	*Garzetta*	Little egret	CF03	CF10	CA01	CA02	CA15	CB05	CB06	CB15	CC06	CJ03
66	*Marangone minore*	Pygmy cormorant	CB06	CF03	CA15							
78	*Falco di palude*	Western marsh harrier	CL01	CA01	CJ03	CC06	CF10	CG04	CJ02	CA15	CG02	CI01
81	*Albanella minore*	Montagu's harrier	CA05	CA09	CG02	CA03	CB01	CI06	CL01			
97	*Cavaliere d'Italia*	Black-winged stilt	CA15	CF10	CA09	CF01	CF03	CG02	CG09	CI05	CN01	CA02
179	*Ghiandaia marina*	Roller	CB05	CA01	CA02	CA09	CB02	CG02	CS03			
180	*Martin pescatore*	Kingfisher	CJ02	CF10	CG02	CJ03	CA10	CA15	CL01			
195	*Falco pellegrino*	Peregrine Falcon	CF03	CC06	CA09	CC03	CG04	CA03	CG02			
175	*Succiacapre*	European nightjar	CA03	CA01	CA09	CA05	CB05	CF03	CA02	CA04	CA06	CB01

CG02	Management of hunting, recreational fishing and recreational or commercial harvesting or collection of plants
CA15	Manage drainage and irrigation operations and infrastructures in agriculture
CF03	Reduce impact of outdoor sports, leisure and recreational activities
CA09	Manage the use of natural fertilisers and chemicals in agricultural (plant and animal) production
CJ03	Restore habitats impacted by multi-purpose hydrological changes
CF10	Manage changes in hydrological and coastal systems and regimes for construction and development
CC06	Reduce impact of service corridors and networks
CA02	Restore small landscape features on agricultural land
CA01	Prevent conversion of natural and semi-natural habitats, and habitats of species into agricultural land
CL01	Management of habitats (others than agriculture and forest) to slow, stop or reverse natural processes
CB06	Stop forest management and exploitation practices
CB15	Other measures related to forestry practices
CB05	Adapt/change forest management and exploitation practices
CJ02	Reduce impact of multi-purpose hydrological changes
CA05	Adapt mowing, grazing and other equivalent agricultural activities
CA03	Maintain existing extensive agricultural practices and agricultural landscape features
CG04	Control/eradication of illegal killing, fishing and harvesting
CB01	Prevent conversion of (semi-) natural habitats into forests and of (semi-)natural forests into intensive forest plantation
CF04	Reduce/eliminate point source pollution to surface or ground waters from industrial, commercial, residential and recreational areas and activities
CF05	Reduce/eliminate point source pollution to surface or ground waters from industrial, commercial, residential and recreational areas and activities
CG03	Reducing the impact of (re-) stocking for fishing and hunting, of artificial feeding and predator control
CG12	Reduce/eliminate diffuse pollution to surface waters from freshwater aquaculture

The analysis of the conservation measurements proposed by the directive was lastly a useful tool to develop a series of concrete actions that could be implemented within the Oasis park. The dossier gives us a picture of the best practices to implement better living conditions for the 14 selected bird species. The proposed actions were categorized into 4 groups:

- red, for the preeminent interventions that will be implemented within the park
- yellow, for the secondary action
- green, for the supporting measurements
- out of purpose, for relevant actions that cannot be addressed by the park itself.

The most frequent and preeminent interventions that guided the development of the Oasis park include the reduction of recreational activities in natural landscape features, the restoration of habitats within the agricultural land, and the management of the biodiversity-rich habitats.

	NAME		threats			
55	*Tarabusino*	Little bittern	F27	F26	A31	A33
56	*Nitticora*	Black-crowned night heron	F28	A02		
57	*Sgarza ciuffetto*	Greater Squacco herongoose	A02			
60	*Airone rosso*	Purple heron	F26	A31		
61	*Airone bianco maggiore*	Great egret				
62	*Garzetta*	Little egret				
66	*Marangone minore*	Pygmy cormorant				
78	*Falco di palude*	Western marsh harrier	A31			
81	*Albanella minore*	Montagu's harrier				
97	*Cavaliere d'Italia*	Black-winged stilt	F26	I04	F27	A31
179	*Ghiandaia marina*	Roller	A05	A06	A03	G10
180	*Martin pescatore*	Kingfisher	K05	F28		
195	*Falco pellegrino*	Peregrine Falcon				
175	*Succiacapre*	European nightjar				

A31	4	Drainage for use as agricultural land
F26	3	Drainage, land reclamation and conversion of wetlands, marshes, bogs, etc. to settlement or recreational areas
F27	2	Drainage, land reclamation or conversion of wetlands, marshes, bogs, etc. to industrial/commercial areas
F28	2	Modification of flooding regimes, flood protection for residential or recreational development
A02	2	Conversion from one type of agricultural land use to another (excluding drainage and burning)
I04	1	Problematic native species
A05	1	Removal of small landscape features for agricultural land parcel consolidation
A06	1	Abandonment of grassland management
A03	1	Conversion from mixed farming and agroforestry systems to specialised (e.g. single crop) production
G10	1	Illegal shooting/killing
K05	1	Physical alteration of water bodies
A33	1	Modification of hydrological flow or physical alteration of water bodies for agriculture

05.3. Diverting the birds

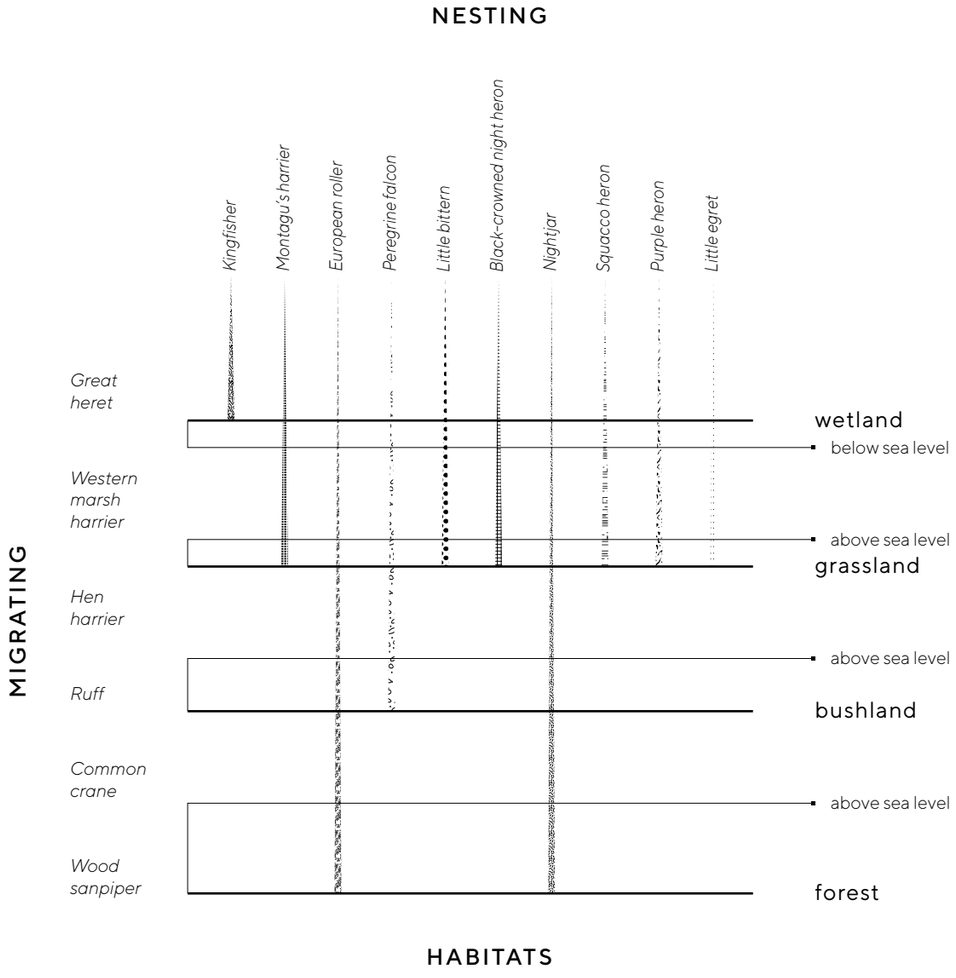
The problem of birds death at solar farms is complex, and the amount of published and peer-reviewed information regarding large-scale solar plants and birds is scarce. Furthermore, the impact on the bird population largely depends on the location and size of the PV park, as well as the threatened, endangered, and sensitive birds present in the area. As a result, the assessment of causes and applicable measurements to address bird fatality needs to be carried out on a project-specific basis.[30]

For Canaro SP we will focus our attention on water-dependent species since they constitute the majority of the local protected avifauna. (*see birds selection). These specimens have been postulated to be most vulnerable because of the potential to confuse arrays for bodies of water, what is known as the "water lake effect hypothesis" [31].

30. Walston et al., 2015, A Review of Avian Monitoring and Mitigation Information at Existing Utility-Scale Solar Facilities
31. Kagan et al. 2014; WEST 2014

According to the literature[32], effective mitigation actions include: "(1) Avoiding areas of high bird use (e.g., regularly used flight paths, migration corridors, and aggregation areas); (2) Avoiding areas inhabited by sensitive species or those of conservation concern; (3) Avoiding topographical features that promote foraging or that are used by migrating birds for uplift (e.g., the tops of slopes)[33]; (4) Avoiding areas of high biodiversity, endemism, and ecological sensitivity; (5) Developing conservation buffers for vulnerable species based on thresholds determined through empirical research; (6) Carefully selecting or modifying infrastructure to minimise collision risk or indirect effects".

32. Kerlinger et al. 2010, Martin 201228. Kagan et al. 2014; WEST 2014
33. Kitano and Shiraki 2013


NESTING
Kingfisher
Montagu's harrier
European roller
Peregrine falcon
Little bittern
Black-crowned night heron
Nightjar
Squacco heron
Purple heron
Little egret
MIGRATING
Great heret
Western marsh harrier
Hen harrier
Ruff
Common crane
Wood sanpiper
wetland
below sea level
above sea level
grassland
above sea level
bushland
above sea level
forest
HABITATS

06

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