MINISTÈRE
CHARGÉ
DES TRANSPORTS

Liberté
Égalité
Fraternité

dgac direction générale de l'Aviation civile

GRASS MANAGEMENT AT AIRPORTS

FROM WILDLIFE RISK MANAGEMENT TO BIODIVERSITY ENHANCEMENT

TECHNICAL GUIDE

MINISTÈRE
CHARGÉ
DES TRANSPORTS
Liberté
Égalité
Fraternité

dgac direction générale de l'Aviation civile

GRASS MANAGEMENT AT AIRPORTS

FROM WILDLIFE RISK MANAGEMENT TO BIODIVERSITY ENHANCEMENT

TECHNICAL GUIDE

Civil Aviation Technical Service (STAC)

Environment, Safety of Systems and Operations Department, Planning

Warning : this English version for non-French readers has been automatically generated using a translation software. Some graphic elements have not been translated.

Please refer to the original French version for further details.

EDITORS

Constance **ANELLI**

Maxime **LEFÈVRE**

Constance **ANELLI**, a Civil Aviation engineer, began her career at the DSAC as a surveillance inspector for flight operations. At the end of 2021 she joined the STAC to be in charge of issues related to wildlife hazard management and biodiversity. As part of her function within the Environment Division, she is also in charge of the work related to the adaptation of airports to climate change.

Maxime **LEFÈVRE**, a senior technician in Civil Aviation studies and operations, began his career at the Gironde Chamber of Agriculture after graduating from the École Nationale des Ingénieurs des Travaux Agricoles de Bordeaux (now Bordeaux Sciences Agro) as an engineer in agriculture specializing in vine diseases. He then moved to the aeronautical industry in 2008, as a surveillance inspector in charge of air cargo security. After 13 years of inspections in the airport environment, he naturally joined the STAC as a biodiversity project manager at airports, making the most of his dual skills in agronomy and airport management.


AIRFRANCE

TABLE OF CONTENTS

SOMMAIRE

EXECUTIVE SUMMARY - KEYWORDS

EXECUTIVE SUMMARY

Airport operators are responsible for the maintenance of their grassed areas, with the primary objective of ensuring operational safety. Given the global decline in biodiversity, everyone's commitment is essential, and airport grasslands have great potential for improvement. Therefore, in the context of the maintenance of green areas, which is carried out by mowing them more or less regularly, it is possible to implement some best practices to improve biodiversity while maintaining the level of safety at the airport.

To help all operators combine these two objectives, this technical guide, based on an analysis of existing literature and interviews with around 40 airports*, provides information and recommendations on grass management at airports.

KEYWORDS

Hay, Meadow, Airport, Wildlife hazard, Biodiversity, Mowing, Grassland, Grass management, Cutting.

* For more information on collaboration with platforms: https://www.stac.aviation-civile.gouv.fr/fr/fauche

INTRODUCTION

French airport sites cover a total surface area of approximately 500 km^2, of which more than 70% is grassland, mainly meadows. Airport operators are responsible for maintaining these green areas, with the main objective of ensuring operational safety.

However, with the global decline in biodiversity, the intrinsic value of airport grasslands is increasing. Grasslands, a habitat in sharp decline at national level, are environments capable of supporting a wide variety of taxa. These buffer zones represent multiple interests: biological corridors, pollinator forage, water purification, etc. Airport green areas represent an important land reserve with a high development potential, sometimes in the midst of a dense and largely impermeable urban fabric.

The management of the vegetation is a decisive factor in the potential to host a rich and varied flora and fauna. On an airport infrastructure, maintenance is carried out by means of more or less regular grass management, which allows the environment to be maintained in a grassy state. Within the framework of turf management, it is possible to implement certain practices favourable to biodiversity, while maintaining the level of safety at the airport.

Although some airport infrastructure managers have already implemented measures to protect and enhance biodiversity, not all have the same resources to implement this type of approach. For the services responsible for the management of wildlife and airport green areas and, more generally, for the technical teams of airport operators, this technical guide, based on an analysis of the existing bibliography and interviews with a large number of airports, centralises a great deal of information on the maintenance of airport green areas and, in particular, on the management of grassed areas, from both a technical and an organisational point of view. This information represents good practice, a way of thinking for operators that needs to be adapted locally, as each airport has its own specificities in terms of local flora and fauna and the constraints that this imposes. Although the methodology for drawing up a management plan can be applied to any aerodrome, most of the information in this guide relates to environments in metropolitan/mainland France.

Figure 1 - Rooks near an aircraft taxiway.

1. BACKGROUND

Airports are ambivalent places. On the one hand, they are industrial sites where air operations and a large number of related activities take place, and on the other hand, they have the peculiarity of being largely non-artificialised spaces (mainly meadows).

Airport managers, whose task is to ensure the safety of operations, must therefore deal with a site that is both highly anthropised and has certain characteristics of a natural environment, with fauna and flora that must be taken into account in daily management.

Figure 2 - Hare on an airport taxiway.

1. BACKGROUND

1.1. WILDLIFE HAZARD MANAGEMENT

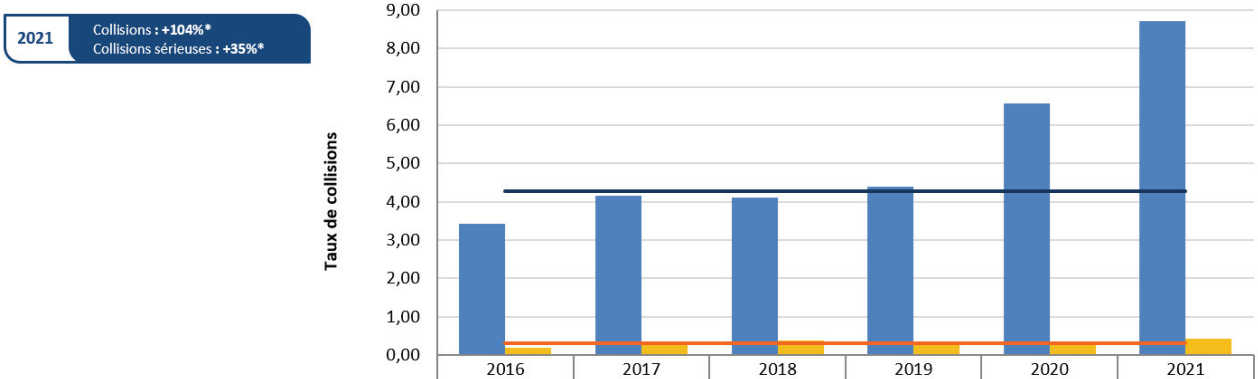
The management of wildlife hazards at airports is subject to a specific regulatory framework involving all stakeholders.

The presence of animals on and around airports can pose a risk to air traffic. The standards of the International Civil Aviation Organisation (ICAO) make airport operators responsible for this risk. As such, airport operators covered by Regulation (EU) 139/2014 or Arrêté du 10 avril 2007 are required to:

- Assess the wildlife risk on and around the aerodrome,
- implement means and develop procedures to minimise the risk of collision, and
- inform the competent authority if a wildlife risk assessment identifies conditions in the aerodrome vicinity that may result in wildlife hazards.

The wildlife risk assessment will allow the identification of the species of concern for aviation safety at each aerodrome. The methods, including the one proposed by the STAC, for carrying out this risk assessment take into account the frequency and severity of collisions involving the species on the one hand, and the presence of the species on the aerodrome through observations made by airport staff on the other. The means and procedures used to limit the risk of collision with animals are many and varied and can be active (scaring, sampling, etc.) or passive. The management of airport green areas is the main means of passive risk management, through the composition of the vegetation cover or the grass management strategy.

The recent evolution of the rate of animal collisions in France between 2016 and 2021 (Figure 3) suggests that a good consideration of this risk by airport operators is necessary, given the observed increase combined with the decrease in traffic during the pandemic period.



	2016	2017	2018	2019	2020	2021
Taux de collisions	3,43	4,15	4,10	4,38	6,56	8,71
Taux de collisions sérieuses	0,20	0,28	0,38	0,36	0,30	0,42
Taux moyen de collisions 2016-2020	4,27					
Taux moyen de collisions sérieuses 2016-2020	0,31					

Figure 3 – Evolution of the collision rate for commercial flights in France between 2016 and 2021.

1.2. BIODIVERSITY, A RICHNESS IN SHARP DECLINE

Biodiversity refers to all living things and the ecosystems in which they live. It is assessed using a variety of indicators along several dimensions:

- Specific diversity, which takes into account both the specific richness (i.e. the number of species) and the relative abundance of species in a given environment;
- Genetic diversity, which refers to the degree of genetic variety within a given species;
- Ecosystem diversity, which characterises the diversity of biotopes (environments) and biocenoses (all the species in an environment).

There is now a scientific consensus that the Earth is experiencing a rapid collapse of biodiversity. This observation is illustrated in the latest report published by IPBES in 2019 [1] through the three dimensions mentioned above.

1.2.1. SPECIFIC DIVERSITY

IPBES reports that species have been declining rapidly worldwide since 1970:

- -40% for terrestrial species;
- -84% for freshwater species;
- -35 % for marine species.

It should be noted that the rate of biodiversity decline varies from one region of the world to another. Birds in metropolitan France are no exception to this observation, as shown by the 1989-2019 report published in 2021 by the French League for the Protection of Birds (LPO), the National Museum of Natural History (MNHN) and the French Office for Biodiversity (OFB) [2]. In fact, 43 species are in decline, such as the house martin, the skylark and the European goldfinch. Figure 4 shows the evolution since 1989 of the relative abundance of birds according to their specialisation. In particular, there has been a decline of almost 30% in 30 years in French towns and countryside (built and agricultural environments).

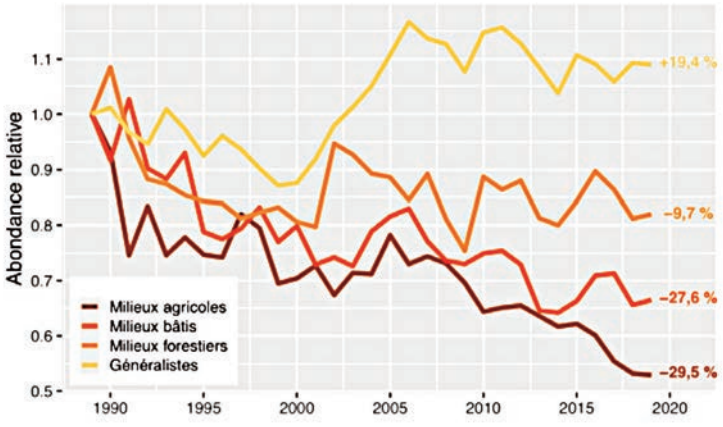


Figure 4
Evolution of indicators by group of birds' specializations.

1. BACKGROUND

The decline in biodiversity alerts us to the increased risk of species extinction. The risk of extinction of plant and animal species in France can be assessed by means of the National Red List, which provides an objective assessment of the level of threat ("Critically Endangered", "Endangered", "Vulnerable", "Near Threatened", etc.) to these species. It is available on the IUCN (International Union for Conservation of Nature) website. On average, 25% of the world's species assessed by IPBES are threatened with extinction [1].

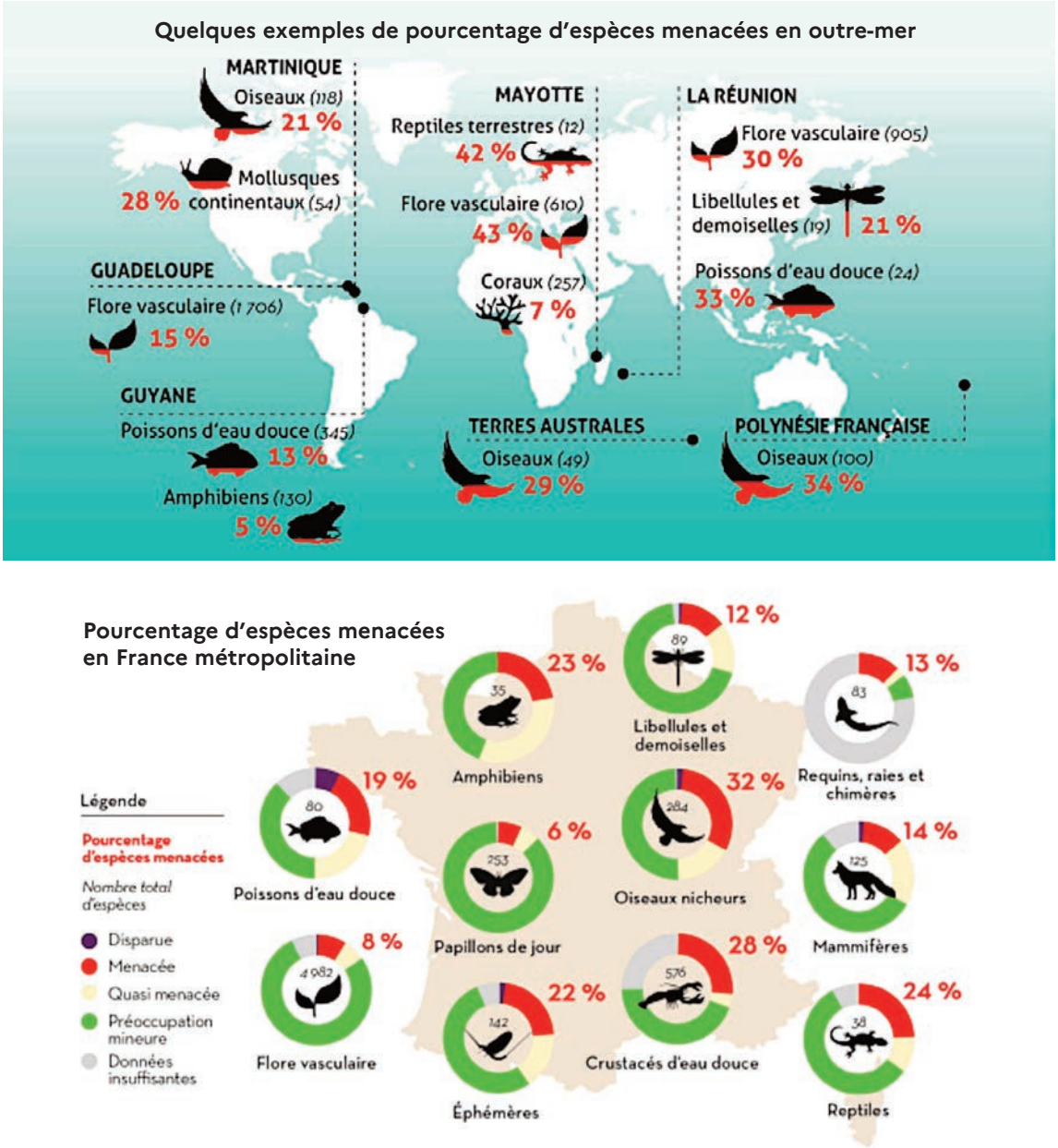


Figure 5 – Threatened species in metropolitan and overseas France.

In metropolitan and overseas France, 2430 of the 13842 species assessed are now threatened (i.e. 17.6%). In addition, 187 species have disappeared from France or are already extinct worldwide [3].

1.2.2. GENETIC DIVERSITY

The number of local varieties and breeds of domesticated plants and animals, and their wild relatives, has declined significantly worldwide. As a result, the number of genetic variations that provide resilience to future climate change, pests or pathogens has declined. [1]

1.2.3. ECOSYSTEMIC DIVERSITY

On a global scale, natural ecosystems have been reduced by an average of 47% compared to their originally estimated state [1], replaced by anthropised environments (urban and agricultural). This standardisation of habitats has very significant negative consequences for a large number of species that depend on specific environments that are being destroyed. Only the number of certain species adapted to different types of environment (so-called "generalists") is increasing. In the latest LPO report [2], 32 bird species have increased in number, such as the wood pigeon, the rock dove and the kestrel, which are present throughout France. These birds may pose an increased risk to aviation due to their gregarious nature, their proliferation around platforms or their size.

Another threat to local ecosystems is the spread of invasive alien species (IAS) (species introduced by humans into an area outside their natural range), which compete with local species. Their numbers have increased by about 70% since 1970 in 21 countries analysed [1].

In its report, IPBES groups the main causes of global biodiversity loss into different direct drivers (also called "pressures"):

- Land/sea use change: expansion of intensive agriculture, use of pesticides, expansion of aquaculture and urbanisation leading to landscape homogenisation, decline of food resources and destruction of specific environments;
- Direct exploitation: overexploitation of natural resources and species.
- Climate change : frequency and magnitude of extreme weather events and their consequences (fires, floods, droughts, sea-level rise, etc.), affecting, among other things, the distribution of species, population dynamics and the functioning of ecosystems.
- Pollution: affects species and the quality of soil, water and atmosphere (e.g. plastics in water, illegal dumping of toxic waste on land).
- Invasive alien species: Harmful to endemic species, ecosystem functions, nature's contribution to people, the economy and human health.

1. BACKGROUND

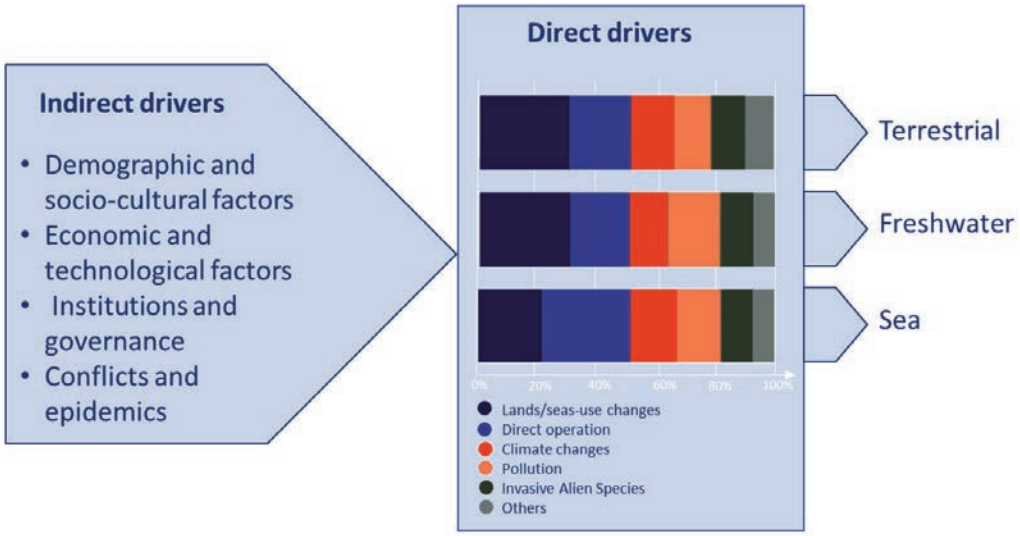


Figure 6 – Direct and indirect drivers of biodiversity decline.

More than 500,000 terrestrial species worldwide do not have sufficient habitat to ensure their long-term survival [1]. Habitat conservation would therefore be one way of ensuring the survival of certain species. For example, the situation of forest birds in France is less unfavourable than that of urban or agricultural birds, and has remained fairly stable since 2000. Indeed, the MNHN [4] points out that this positive balance could be explained by the regular increase in forest area in France, with an increase of about 80 000 ha per year over the last thirty years.

1.3. AVIATION SAFETY AND BIODIVERSITY

Airports are spread throughout the metropolitan area and overseas and are exposed to a wide range of weather conditions. On average, more than 75% of their surface area consists of 'semi-natural', non-impermeable areas, and they are often located close to areas of increasing urban and agricultural pressure. They therefore have the potential to be reservoirs of biodiversity and are likely to be home to heritage species. Naturalist inventories carried out at a large number of airports in recent years have identified more than 9,000 invertebrate species, more than 1,400 plant species, more than 260 bird species, nearly 30 chiropteran species with certainty, and around 20 reptile and 15 amphibian species [5].

In view of the decline in biodiversity, airports can take measures to preserve and enhance biodiversity, compatible with their safety requirements, through the management of their green areas, and in particular their grasslands.

1. BACKGROUND

Figure 7
Airport meadow with poor soil, rich in Asphodel and Orchids.

Figure 8
Oak spider in an airport meadow.

Although these objectives of reconciling environmental protection and safety requirements may seem contradictory, it should be noted that:

- Only some of the animal and plant species present on an aerodrome pose a threat to flight operations. The wildlife risk assessment carried out by the operators is the reference tool for identifying the species that pose a risk to operations.
- Some species, if their numbers are controlled, can provide services at airports and thus contribute to the control of other species that pose a greater threat within the framework of wildlife risk management.

It is therefore possible to implement measures to enhance some form of biodiversity at the airport without compromising aviation safety, using a risk management approach rather than hazard elimination.

Airports are not the only types of infrastructure with this type of constraint that are questioning their impact on biodiversity and the means they can implement to reduce their negative externalities on the environment while maintaining a high level of safety on their networks. The considerations of managers of other types of infrastructure (roads, railways, waterways, etc.) naturally overlap with those of airport operators on a number of issues, including:

- The transition from uniform maintenance of green areas to a differentiated approach that is more conducive to biodiversity;
- The fight against invasive alien species;
- The search for alternatives to the use of chemical products.

In the rest of the guide, the reader will find a set of information and best practices for grass management at airports, allowing the promotion of normal biodiversity compatible with the requirements of operational safety. The elements presented here are guidelines for airport operators, which should be adapted locally, as each airport has its own specific characteristics in terms of local flora and fauna and the constraints that this imposes.

2. GRASSLANDS/HAY MEADOWS

Grasslands are defined according to various criteria, in particular their composition, the type of soil or the way in which they are managed. The work carried out by the INPN (Institut National de Protection de la Nature) and the MNHN (National Museum of Natural History) within the framework of the CORINE (COordination and Research of Environmental INformation) biotope programme provides a reference for classifying the main types of environments in Europe and the world.

Airport operators are required to maintain their airport meadows. This maintenance is carried out taking into account various safety objectives (visibility, access, security, wildlife risk, Aircraft Rescue and Firefighting Service (ARFS) intervention) and essentially consists of regular grass management operations.

In this guide, the term 'grass management' includes all operations that reduce the height of grass (cutting, mowing, shredding). It does not include livestock grazing.

Figure 9 – Airport meadow.

2. GRASSLANDS/HAY MEADOWS

2.1. INTEREST AND EVOLUTION OF GRASSLANDS

A grassland is a natural area made up of many plant species, with few woody plants, and consisting mainly of grasses and annual dicotyledonous plants. In France, the natural grasslands (i.e. those covered exclusively by wild animals without human intervention) have disappeared due to the disappearance of the large wild herbivores that ensured their maintenance. In order to maintain themselves and not become forests (see below), grasslands require human intervention in the form of grazing by domestic herbivores or mechanical mowing.

With the disappearance of natural grasslands, it is now necessary to distinguish, on the one hand, permanent grasslands (which have been established for many years and have not been sown with non-native seeds or ploughed) and, on the other hand, temporary grasslands (or hay meadows), which are used for fodder production or which have been established on fallow land.

Grasslands are areas of multiple interest:

- Agronomic: at the scale of the territory, permanent grassland reduces run-off and infiltration, thus playing an important role in the protection of soils (combating erosion) and water quality (through filtration).
- Biological: In addition to their botanical richness, the meadows, and especially the permanent meadows, host a very rich biodiversity, with many species adapted to this type of environment. Depending on how they are managed, they can be favourable to various invertebrates:
    - Mown meadows: among others, for orthopterans, pollinating insects, which are the subject of a national action plan (see annex "FOCUS ON... Conservation of wild pollinating insects"),
    - Grazing: for coprophagous insects attracted by droppings.

Grasslands are therefore very important food resources for both birds and mammals. In France, the surface area of grassland in the metropolitan area has declined sharply over the course of the century with the specialisation of farms and mechanisation. The area of permanent grassland (STH, Permanent Grassland Areas, see map below) fell from 9.9 million hectares in 1961 to 7.6 million hectares in 2010 (Figure 11). The biodiversity associated with this habitat is therefore threatened (see § 1.2).

From an airport operations point of view, the presence of herbaceous vegetation along the runway edge plays an important technical role. Grass greatly reduces the effects of rain erosion when water droplets hit the ground at speeds of 15 to 20 miles per hour. Without grass, they would have a destructive effect on the soil surface, creating fine particles which, once dry, would be carried away by the wind.

Vegetation also limits wind erosion and prevents dust from being blown onto the runway. Dust can also be a problem if it is ingested by the reactors.

When a layer of herbaceous vegetation covers the ground, the bearing capacity of the soil is increased. The denser the vegetation, the greater the bearing capacity. This uplift is important in the event of an aircraft overrunning the runway, both for the aircraft and for the emergency vehicles involved.

FOCUS ON... THE CONSERVATION OF WILD POLLINATING INSECTS

Four main orders of pollinating insects can be distinguished in metropolitan France: Hymenoptera (bumblebees, bees, wasps), which make up the majority, Lepidoptera, Diptera and Coleoptera. In total, 20,000 species of insects in metropolitan France are essential for the sexual reproduction of flowering plants and the agricultural production of fruit and vegetables.

The populations of wild pollinating insects and honeybee colonies have been declining worldwide for several decades. Nearly 8 out of 10 insects (78%) and more than a third of species were considered extinct by 31 December 2021. At the time of writing, 1 in 10 bee and butterfly species are threatened, according to the IUCN. Several factors are contributing to this:

- The availability and quality of food resources and pollinator habitats: invasive and/or ornamental plant species replacing endemic species, availability of nectar;
- Agricultural practices, land engineering and landscape management;
- Crop rotations and use of pesticides;
- Climate change;
- Biological hazards: pathogens, predators (invasive alien animal species);
- Light pollution.

Pollinators are the subject of a new National Action Plan (PNA): "France land of pollinators for the conservation of bees and wild pollinating insects" 2021-2026 [8] to accelerate the implementation of actions to combat their decline.

Flowers and pollinating insects are interdependent: flowers provide food for pollinators and pollinators, by transporting pollen, allow flowers to be fertilised. To ensure the life cycle of wild pollinators, a diversity of local plant species (pollinating insects prefer native flowers) and a diversity of habitats should be provided, in all seasons and in the diversity of green spaces. Favourable and connected habitats are needed to ensure the movement of pollinators between foraging and nesting sites.

Figure 10 –Wild bee in a mallow flower on an airport

FOCUS ON... THE CONSERVATION OF WILD POLLINATING INSECTS

The work carried out by CEREMA (Centre d'Études et d'Expertise sur les Risques, l'Environnement, la Mobilisation) shows that it may be necessary to modify, adapt or even change the way green areas are managed in order to provide wild pollinators with floral resources and nesting sites throughout the season. These proposals are developed in a technical guide entitled "Adapting roadside management to preserve wild pollinating insects".

The following actions are covered in several detailed "action sheets":

- Assess the attractiveness of green spaces to pollinating insects;
- Draw up a management plan that defines the types of maintenance to be carried out;
- Choose equipment adapted to the management of green spaces;
- Organise differentiated management of spaces;
- Manage grasslands with different levers (mowing and frequency and height to be respected, late mowing and refuge zones, export of plant biomass, eco-grazing);
- Management of wooded and shrubby areas: maintain to perpetuate;
- Manage ditches and drainage systems: maintain their function;
- Managing bare areas: technical surfaces and bare soil to be maintained;
- Structure grassed areas to suit pollinators;
- Develop attractive tree and shrub areas;
- Increase the proportion of beneficial species.

These "action sheets" for linear transport infrastructure (LTI) can to some extent be used in a similar way for airport green spaces, due to the diversity of environments found there (natural grasslands, hedges, copses, retention basins, etc.). Airport green areas, like those of the ILT, form a potentially important corridor (green and blue corridor) for the conservation of ecosystems, biodiversity, pollinator populations and pollinated flowers.

Local wild pollinators are adapted to local plant species that need to be fully developed. These local plant species are abundant in airport ecosystems. In addition, most pollinators occupy several habitats and alternate between them, nesting in one and foraging in another, either on or off the apron, depending on the size of the apron. The large surface area of airport landscaping ensures that their movements (between nesting, resting and feeding sites) are not hindered, and in fact are encouraged, as the range of pollinators can vary from 300 feet to 2 miles depending on the species.

2. GRASSLANDS/HAY MEADOWS

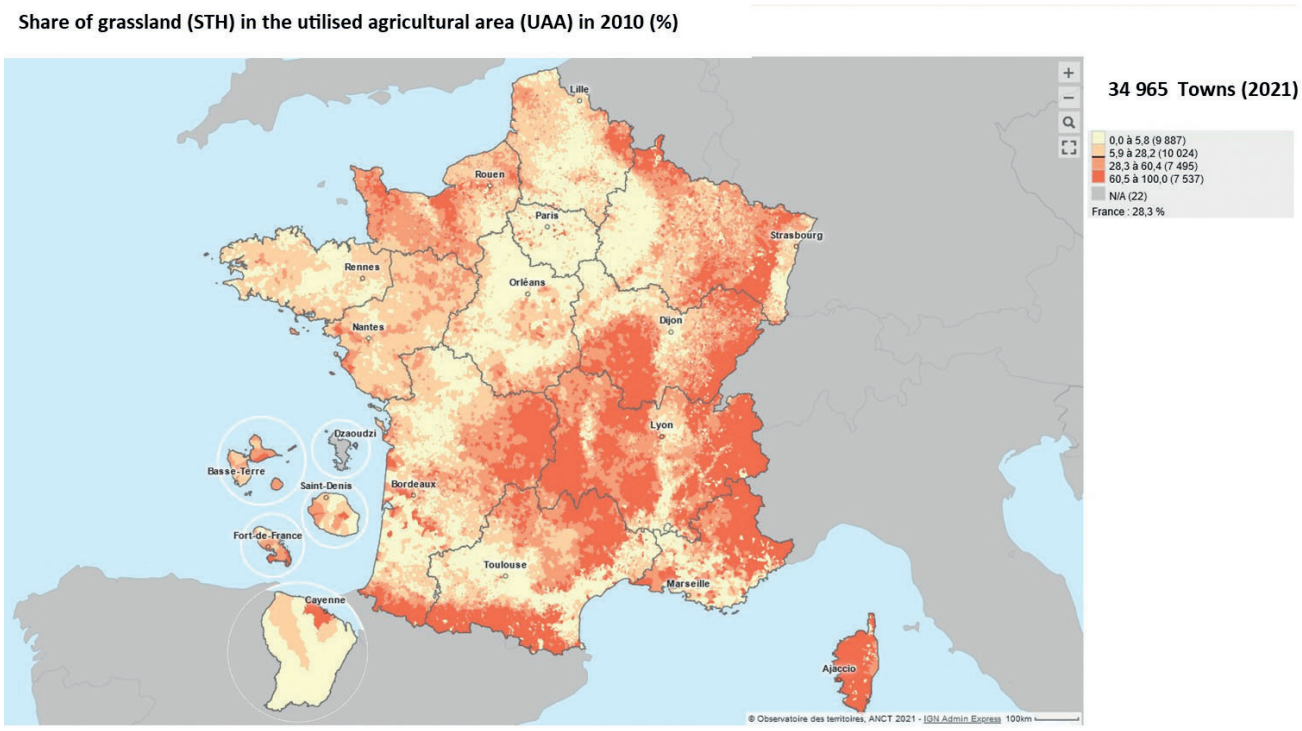


Figure 11 – Part of grassland (STH) in relation to Utilised Agricultural Area (UAA) in 2010 in France.

Without maintenance ("natural" or "anthropogenic"), grasslands resume the natural evolutionary dynamics characterised by ecological successions [9, 10, 11]. An ecological succession is a natural process of evolution and development of an ecosystem from its initial stage to a climax stage. The climax stage is the final state of an ecological succession. It is a stable state characterised by a dynamic equilibrium in which energy and resources are used only to maintain the ecosystem. Each ecosystem has its own assemblage of climax species, which are the best-adapted organisms that persist beyond the final stage of succession.

Mechanisms for ecological succession can be:

- Facilitation: the first colonisers facilitate the arrival of subsequent colonisers by modifying the environment (e.g. creating a soil);
- Inhibition: the first colonisers make the arrival of subsequent colonisers more difficult by modifying the environment. Late colonisers must therefore eliminate them (e.g. shade intolerant plants);
- Tolerance: early colonisers have no positive or negative effect on the arrival of later colonisers (e.g. shade-tolerant plants).

Thus, without maintenance or disturbance, most grasslands in mainland France will change from grasses to scrub, then to shrubs, then to trees to reach a climax stage.

Figure 12 – Example of the recovery of natural dynamics after clearing for cultivation.

In order to maintain safety levels, airport operators are therefore required to carry out regular maintenance of their grassed areas.

2.2. TYPES OF AIRPORT GRASSLANDS IN METROPOLITAN AND OVERSEAS FRANCE

In metropolitan France, airport grasslands consist mainly of:

- Mesophilic grassland (fertile and well-drained soil);
- Wet grassland (poorly drained soil);
- Lawns (nutrient-poor and dry soils, referred to as 'xerophytic' (dry) or 'mesophytic' (less dry)).

Overseas airport grasslands do not necessarily fit into these categories due to their specific climate or soils: Peaty heaths and dry Kalmia heaths at Saint-Pierre Pointe Blanche airport, dry calcareous grasslands on volcanic soil at Lifou (New Caledonia), Niaoulis savannah at Koumac (NC), wet savannah at Moué-île des Pins (NC), southern subtropical grassland at Dzaoudzi (Mayotte), etc.

Only the main types of airport grasslands in mainland France are described below.

2. GRASSLANDS/HAY MEADOWS

2.2.1. MESOPHILIC GRASSLANDS

Mesophilic grasslands are herbaceous plant formations on relatively fertile, well-drained soils under average climatic conditions (humidity and temperature). They are traditionally mown in early summer for hay production. The regrowth (regain) is either grazed by livestock or mown in late summer. Their plant composition includes a wide variety of grasses and broad-leaved weeds, especially in the low fertiliser variants (see Appendix 2). Depending on the altitude at which they develop, there are two variants:

- The first, at low altitudes (< 300m), generally occupies fairly deep silty soils that are naturally well supplied with mineral elements;
- The second, mainly found at medium altitudes (between 300 and 550 m), occupies soils that are often more shallow or rocky and poorer in mineral elements.

Figure 13
Goat orchid (Himantoglossum hircinum) in a mesophilic airport meadow.

Above 550 m, the grassland is enriched by species with a submontane distribution. We no longer speak of mesophilic grasslands/meadows, but of subalpine mountain haymeadows (between 550 m and 1,700 m) and alpine pastures (above 1,700 m), which are mainly maintained by pastoral activities. These areas, which are often communal, recover their function as conservatories of plant and animal biodiversity thanks to practices that are renewed every year.

Mesophilous grasslands are threatened by changes in management (replacement of mowing by intensive grazing or cultivation).

The French airports affected by this type of grassland are mainly lowland airports in the modified oceanic and semi-continental zones (see Appendix 1 for biogeographical zones), which are not subject to regular summer droughts in France, as well as medium altitude airports (<550 m) throughout France.

2.2.2. WET GRASSLANDS

Wet grasslands consist of large herbaceous plants. They are found in boreal, nemoral, warm humid and temperate zones. Their common characteristic is that they are wet for much or all of the year. They are dominated by heliophilous species, mainly grasses in the case of grasslands and broad-leaved dicotyledons in the case of Megaphorbia. They are mostly semi-natural vegetation, maintained at the grassland stage by human intervention. With their great diversity of flora and fauna (see Appendix 2), wet grasslands play an important role in the conservation of endangered bird and insect species.

Two types of wet grassland can be distinguished:

- Called "eutrophic", they are characterised by nutrient-rich soils. These meadows, with their rich flora, are generally found on areas that are regularly flooded (by the proximity of a watercourse or by rainfall in the case of areas located on topographical depressions). The French airports affected by eutrophic wet meadows are mainly lowland airports on the Atlantic coast.
- Known as "oligotrophic", characterised by nutrient-poor soils, generally corresponding to peat bogs, moors or wet steppes. These environments are often home to rare species with slow growth and metabolism. There are few grasslands of this type in mainland France, and even fewer on aerodromes. The Saint-Pierre Pointe-Blanche airport, located in the territory of Saint-Pierre and Miquelon, is one of the few affected in French overseas departments and territories.

2.2.3. MOUNTAIN HAY MEADOWS

The hay meadows of the montane and subalpine levels (from 550 m to 1700 m), which are now in decline everywhere, have for a long time occupied large areas for forage production in the French mountains (Alps, Pyrenees, Jura, Vosges, Massif Central). They are established under mesophilic conditions on moderately fertile and neutrophilic soils of varying depth, or even tending towards calcareous or acidophilic soils after increased fertilisation.

Mixed mowing and grazing treatments modify the floristic composition of grasslands to a greater or lesser extent, depending on the combination of treatments, loading and duration of grazing. These variations can lead to intermediate situations, difficult to interpret, between mountain hay meadows and mesophilic mountain grasslands. The permanent fertilisation of these meadows leads to a significant loss of floristic diversity and to a strong dominance of grasses.

The floristic diversity of these meadows therefore depends on the maintenance of regular and delayed grass management practices, with or without spring grazing or autumn regrowth, and limited fertilisation.

2.2.4. XEROPHILIC, MESO-XEROPHILIC AND MESOPHILOUS LAWNS

Xerophilic (or xerophilous) (= dry) meso-xerophilic and mesophilic (less dry) lawns occur on calcareous or calcareous-siliceous soils that are shallow, well drained or dry, generally poor in nutrients available to plant species and exposed to harsh weather conditions. They are found in Mediterranean regions with low rainfall, in mountainous regions known as "alpine" (above 1,700 m), and also in sub-Atlantic areas with well-drained, well-exposed calcareous soils in mainland France.

They consist of short herbaceous vegetation, the height of which can vary according to soil depth and exposure. The plant species are dominated by grasses or forbs (see Appendix 2) with low forage productivity. When the shrub cover increases (>10%), it is preferentially referred to as scrubland in the Mediterranean area.

Often considered as wastelands, these environments are home to a rich diversity of flora and fauna with Mediterranean or Alpine affinities and play an important landscape role. They are home to many original and remarkable species, including orchids, insects, reptiles and birds. Xerophilous and mesophilous grasslands are home to 26% of the protected plants in France and around 30% of the known plants in mainland France.

Figure 14 – Field of pyramidal orchids (Anacamptis pyramidalis) in a mesophilic lawn.

The vast majority of lawns are either natural (so-called "primary" lawns), resulting from the progressive colonisation by plants of new mineral environments under constraining conditions (naturally blocked dynamics), or maintained by human action (deforestation, grazing). These are known as "secondary" grasslands. With the sharp decline in pastoralism during the 20th century, these low-productivity meadows were gradually abandoned, which naturally led to a gradual closure of the environment through the establishment of agricultural areas (see Figure 11). In 50 years, about 50% of these environments have disappeared in France. Xerophilous and mesophilous lawns still exist in airport areas, thanks to the need to maintain the environment at the grassland level for safety reasons.

2.3. COMPOSITION OF GRASS COVER ON AIRFIELDS

The interviews conducted with airports as part of the preparation of this technical guide illustrated the diversity of habitats present in metropolitan France and overseas. While the four main types of environment described above were strongly represented, some operators also mentioned the presence of other more specific ecosystems, such as mangroves in the French overseas territories. Airport operators also reported that they sometimes have to carry out operations on their grasslands in order to change their composition. The two main operations are seeding and the removal of targeted species.

2.3.1. SOWING GRASSLAND IN AERONAUTICAL AREAS

2.3.1.1. SOWING CONDITIONS

Some airports reported that they had modified the grass cover for different purposes:

- Better drought resistance
- Better wind resistance
- Reduced maximum vegetation height to reduce grass management
- Creation of a hostile cover for certain animal species.

During the 2010s, two airport operators experimented with replacing the vegetation cover with a specific seedling. These experiments revealed a number of difficulties:

- In one case, it was found that about 18 months after sowing, a significant proportion (more than 70%) of the vegetation on the plots in question did not come from the seeds sown, but from the seeds of the surrounding local species.
- In the second case, the sown grass also gradually disappeared from the meadows as the sown plots were completely colonised by local species. This is explained by the cereal potential of the soil, which gradually takes over.

This experience illustrates the difficulties of controlling vegetation in an open environment using exotic varieties.

Moreover, uniformity of vegetation cover is not recommended in the context of measures to enhance local biodiversity.

In certain circumstances (particularly in the case of site works) it may be necessary to carry out a seeding operation to avoid a surface remaining bare for too long. In such cases, it may be preferable to use grasses and/or flower meadows of local species rather than large-scale selected turf. Operators can find out more about the "Végétal Local" label from the French Biodiversity Office [12].

2. GRASSLANDS/HAY MEADOWS

The recent focus on developing practices that promote biodiversity has highlighted the collection of local seeds for use in creating adapted and resistant herbaceous plants as part of a development project. This operation can be performed by using seeds on another site or by spreading the residues of mowing after the seeds have matured (known as the 'hay flower' technique).

This method is both economical and effective as the hay acts as a mulch over the seeds, retaining moisture and encouraging germination.

It is strongly encouraged to create or develop locally-sourced indigenous seeds in Europe. Some airports are already involved in the process of seed conservation, supported by the conservatoires d'espaces naturels (CEN), which then use these seeds on other sites. Airports could use these techniques to create their own seeds, which could then be used on other parts of the airport site. For more information, refer to the section titled 'Harvesting seeds from airport meadows' (see insert 'ZOOM ON...').

2.3.1.2. SOWING METHODS

The method of sowing at an airport must be adapted to safety requirements, and in particular to the constraints associated with bird hazards. Ploughing the ground before sowing is therefore strongly discouraged, if not prohibited, because of the attraction it creates for birds.

In an airport environment, it is therefore advisable to favour surface sowing methods (carried out by hand or using specific machinery), which consist of spreading the seeds on the surface without prior tillage or with limited harrowing. These techniques make it possible to reinforce and supplement the existing flora without destroying any vegetation that may be present and while limiting the attraction of birds associated with the turning of the soil. Light burial of the seeds limits bird feeding and the risk to wildlife.

A mixture of local seeds should be preferred in order to diversify the floral species and maximise germination success (see previous paragraph). In all cases, it is advisable to roll the seed on loose soil immediately after sowing to maximise soil-seed contact and thus ensure a good germination rate.

There are agricultural machines that prepare the soil, sow directly and roll the soil (= pass the packer roller) in a single pass. This technique is very interesting to limit the presence of birds after the work.

Figure 15 – Quivogne disc harrow.

2.3.1.3. SOWING TIME

Spring (April-May) is preferable because:

- On the one hand, the risk of drought in summer is high;
- On the other hand, the risk of winter losses is high, especially for non-grass crops.

As an example, one airport interviewed cited the case of an area that was filled in 2020, where ryegrass was sown at the end of the work in the summer of 2021. The following months were particularly dry and the seeds had difficulty germinating. They remained in the soil and emerged with losses in the spring of 2022.

There are also possibilities for autumn sowing (October) with some mixtures whose seeds stratify with the cold and give good soil cover results in the spring.

2.3.2. REMOVAL OF TARGETED PLANT SPECIES

2.3.2.1. ELIMINATING SPECIES ATTRACTIVE TO BIRDS

Botanical species have been identified as attractive to certain birds. Eliminating or minimising the presence of these species can be an effective risk management tool if their presence on the site reduces the level of wildlife risk.

For example, plants such as some clovers, alfalfa and vetches attract pigeons, although not all species in the genera Trifolium, Medicago and Vicia attract these birds. The platforms interviewed shared their experiences of removing these species:

- To control alfalfa, one farmer changed the mowing height of the affected areas. He switched from a multi-year low cut to an annual cut at a height of 20 cm, early enough in the year to be done before the alfalfa flowers. This experiment worked well and significantly reduced the amount of alfalfa on the platform.
- A similar approach to vetch control did not work on another field surveyed. The farmer had to revert to low mowing combined with harrowing of the area invaded by this species.

Figure 19
Cultivated common vetch (vicia sativa).

FOCUS ON... SEED HARVESTING ON AIRPORT GRASSLANDS

The Chambéry Mont-Blanc and Poitiers-Biard airports have been collecting seeds from the meadows around the airport since 2021 and 2018 respectively. This operation was initiated and is managed by the Conservatoire des Espaces Naturels (CEN) of their respective regions.

Certain strips of grassland around the airport that are considered to be protected from urban development are harvested between May and September, depending on the estimated maturity of the target plants, which depends mainly on the weather, before mowing. In 2021, CEN Nouvelle Aquitaine carried out seed collection in two periods: one in April-May and the other in June-July.

This makes it possible to diversify the species harvested. The seeds are harvested under conditions of low humidity, as the seeds must be as dry as possible, and then stored before being sown in the spring or autumn.

Harvesting is carried out by farmers using a brush harvester or combine harvester:

- The brush seed harvester consists of a special tractor-mounted tool that is driven over the grassland at an adjustable height of between 2 inches and 3 feet above the ground, brushing the inflorescences and dropping the seeds and debris into a tank. If the seeds are not dry enough, the brush is ineffective. At harvest, the seeds are dried on a tarpaulin for an hour or two and then placed in 10kg bags for easy storage and distribution.
- The combine cuts the stalks, threshes the ears and separates the stalks from the seeds. At the exit, some of the stalks are ejected and some remain with the seeds (70% stalks to 30% seeds in the harvested mixture). The seed/stalk mixture is stored in a tank before being transferred to a dump truck. To ensure drying before bagging, the seeds are dried for a week (in a barn or in drying containers) to a thickness of 2-4 cm and mixed with a rake.

Figure 16
Pictagraine brush mounted on a tractor in the airport area.

Figure 17
Combine harvester in airport area.

In terms of productivity, the brush technique is roughly equivalent to the combine harvester (which is highly dependent on the vegetation, around 24 kg of seed/ha - data from CEN Nouvelle Aquitaine 2021). Professional recommendations for sowing natural grassland are 25 kg of seed/ha to be sown, so a brusher such as a combine harvester can sow up to 1 ha of land for 1 ha of harvested area.

FOCUS ON... SEED HARVESTING ON AIRPORT GRASSLANDS

While the combine is faster and can easily handle large fields, it is more difficult to set up to harvest grass seed as it is basically designed for uniform fields of crops such as wheat. The brush harvester crushes the soil less and reduces the quality of the grass, which can then be cut for forage. The brush seed harvester is suitable for donor areas that are sloping or flooded. It is also more respectful of the fauna of natural meadows than the combine harvester: insects and other animals caught by the brush can easily escape when the contents of the tank are regularly deposited on the tarpaulin, as they have not been crushed and are less traumatised. This is not the case with the combine.

Figure 18 – Brush and wax cloth where the seeds are deposited and the stems are separated from the seeds with a fork.

In Savoie, these seed banks are used in green space projects in the city of Chambéry and throughout the department. In the Poitiers region, the CEN makes them available free of charge to farmers and local authorities for replanting natural areas and managing green spaces in order to diversify biodiversity. On the other hand, the "Pictagraine" service (the name given to the CEN's brushing machine) is not free and includes botanical expertise (necessary to know the meadow, the species present, an estimate of the coming harvest, the optimum date for harvesting with a maximum number of species and a maximum number of seeds), the harvest, the post-harvest expertise (determining the seeds harvested with a binocular magnifying glass), the sowing (need for a suitable sowing machine, as conventional agricultural seeders do not work) and the botanical expertise after sowing.

However, technical studies, in particular those carried out by the Tarn Chamber of Agriculture [13] and the Alp'Grain project [14], show a significant difference between the total cost per hectare of establishing natural grassland from local seeds (higher cost) and the cost of establishing grassland from traditional commercial seeds (lower cost).

The genetic heritage of local seeds also makes them naturally more resilient than imported seeds, which improves the efficiency of sowing and the symbiosis with local biodiversity (e.g. matching the plant's nectar secretion to the passage time of the pollinator specific to that plant).

In addition, seed recovery could also be a way of reducing the food resources of granivorous bird species. granivorous bird species and therefore limit their presence on airfields, in the same way as mowing before sowing.

Apart from naturally occurring species, crops are generally not recommended on airport grasslands, as the crops themselves can be attractive and the cultivation practices can also increase the risk to birds (e.g. ploughing). However, replacing crops with mown grassland is not always sufficient to reduce bird attractiveness, as the species attracted by the two environments are not necessarily the same. On one platform studied, the removal of wheat (a decision taken to reduce the attractiveness of certain bird species) and its replacement by a forage meadow would have led to an increase in the number of birds of prey on the platform. Therefore, if the avian risk associated with certain species has been negatively affected, it is likely that the local context of this airport (wheat cultivation and related agricultural practices) has had a regulating effect on the presence of raptors.

Finally, it should be noted that the level of risk is assessed according to the level of traffic. For example, at airports with low traffic, operators can implement specific practices that are not possible at airports with more regular and higher traffic. At one of the low-traffic airports interviewed, part of the airport's green areas (around 30%) is cultivated by partner farmers (cabbage, artichokes). With these practices, the risk to birds remains low, with a very limited number of collisions. However, the farmers are obliged to respect certain instructions given by the operator (e.g. no ploughing on both sides of the runway at the same time).

2.3.2.2. ELIMINATING INVASIVE AND ALIEN INVASIVE SPECIES

Some botanical species are not particularly attractive to birds, but are identified as "invasive species" or "invasive alien species" because:

- They pose risks to other aspects of airport operations (visual disturbance, damage to sensitive infrastructure, etc.). They are generally not eliminated by mowing alone and require targeted intervention.
- Others, introduced by humans to an area outside their natural range, compete with native species. They have a major impact on local biodiversity. These are known as Invasive Alien Species (IAS) (see Appendix 3).

In both cases, it is necessary to limit their spread, either for safety reasons or to enhance the normal biodiversity of the airport site. The main invasive species found on aerodromes are certain species of thistle, pyracantha, bloodroot, prickly pear, Provençal cane and numerous invasive alien species (see Appendix 3).

2.3.2.2.1. INVASIVE SPECIES

It is possible to implement appropriate measures for effective control of invasive plants, in parallel with information measures (to facilitate their detection) and training in their recognition, with a view to treatment and prevention. Precautions should be taken at the design stage by choosing non-invasive local species for planting (particularly in urban greening projects), rather than biologically invasive species that impoverish the biodiversity of an area. Subsequently, an inventory of "contaminated" areas can be made on a regular basis in order to implement specific control measures. Pre-planting intervention is generally recommended to prevent seed dispersal and to avoid the export of soil containing fragments of these plants (contamination by vegetative propagation).

The invasion of thistles and dogwoods is often caused by management practices that favour them: management by shredding for bloodroot and other small woody plants, soil preparation for thistles, which tend to colonise ruderal environments first.

Below are some tips for specific control of the above species.

Invasive thistles

Some thistles, such as the creeping thistle (Cirsium arvense), which is subject to prefectoral decrees, or Silybum marianum, commonly known as the holy thistle or milk thistle, two species found on many airport platforms, grow rapidly, very tall and in clumps. They are a source of visual obstruction and a problem for airport security. They require regular uprooting, crushing or cutting before flowering to prevent seed production. Seeds can remain in the soil for over 15 years. Thistles can form walls up to 7 metres high that are difficult to break through. They produce a lot of biomass and reduce biodiversity.

Figure 20 – Milk thistle (Sylibum marianum) in fruiting stage invading an airport area.

Many of the airports interviewed are experimenting with different solutions to limit the spread of thistles:

- Mowing before flowering (disc/drum mower);
- Surface harrowing to a depth of 15-20 cm (disc harrow), followed by root export and surface levelling, followed by a second harrowing a year later when the thistle seeds in the soil from the first harrowing have germinated;
- Hand pulling before the seeds ripen in June.

One of the platforms interviewed decided to voluntarily allow clover to grow on the overgrown areas of its platform after the thistle had been pulled up and/or mown. The aim was to quickly recolonise the areas left bare after the removal of the thistle, thus preventing the thistle from recolonising. These trials seem to have had positive results, with clover tending to naturally take over from the thistle.

Some centres have also tried sowing fescue, or a suitable mixture bought from a turf specialist, after harrowing to get rid of invasive plants such as thistles. The results were not very successful, as the turf did not prevent the thistle from regrowing from the long-lived seeds left behind.

Pyracantha and Dogwood

These are species whose proliferation at airports sometimes makes them invasive. One of the most effective proven techniques to get rid of them is to remove the foot after crushing the aerial part. This technique has its limitations for large areas of airport grassland, especially if the removal is outsourced (high cost of intervention).

Provencal Cane

It is also a French endemic species with a high rate of vegetative reproduction by roots and very rapid growth. It is on the list of the hundred most harmful invasive species in the world. As its name suggests, it is particularly common in airports around the Mediterranean. Particular attention should be paid to the transport of soil contaminated with remnants/fragments of cane and to stalks left on wet ground, which are important factors in its spread. In fact, even the smallest piece of reed can give rise to new shoots.

2.3.2.2.2. INVASIVE ALIEN SPECIES (IAS)

Prevention, and therefore learning to recognise invasive alien species, is the basis of the fight against IAS. In order to prioritise actions, lists have been drawn up in most regions of France according to the potential risks posed by IAS. These lists are available on the websites of the regional botanical conservatories. Below are some suggestions for the control of two species present on several platforms in France. Advice on other botanical species that are less common on platforms but whose presence should be monitored as IAS is given in Appendix 3.

2. GRASSLANDS/HAY MEADOWS

Asian Knotweed

Knotweed is an invasive alien species (IAS) native to the Asian continent. There are several types of knotweed:

- Japanese knotweed (Fallopia japonica);
- Sakhalin knotweed (Fallopia sachalinensis);
- Bohemian knotweed (Fallopia bohemica).

No single technique is completely effective in controlling knotweed. Current recommendations in the literature are:

- Repeated mowing before flowering, if sexual reproduction is suspected (which is not the main source of reproduction in France, where the plant reproduces mainly by cuttings and the spread of rhizomes).
- Put up geotextiles or waterproof and lightproof tarpaulins and pull them up regularly.
- Replant with woody competitors, which are not suitable for all areas of airport grassland.

Particular attention should be paid to the transport of soil contaminated with knotweed remnants/fragments and stems left on wet land, which are important factors in the spread of knotweed. Two platforms surveyed reported the presence of this invasive alien species. One of them opted for systematic removal and export of the grass cuttings. Tarps/geotextiles are also used. These techniques limit the spread but do not completely eradicate the species.

Figure 21 – Airport platform partially invaded by Japanese knotweed (Fallopia japonica).

The American Grape

The American grape (Phytolacca americana) is also an invasive alien species (IAS) in France. It is spread exclusively by its seeds (from person to person or by fruit-eating birds). Treatment is quick: a short cut at the base or mowing before flowering is enough to eliminate it. It is best to remove it early so that it does not grow back. This is more of an environmental problem (exotic species replacing local species) than a security problem, although some platforms on the outskirts of the airport have been invaded. The solution adopted by one of these platforms is to periodically crush the flowers before they ripen, in order to limit the spread of the seeds by the birds that feed on them.

3. GRASS MANAGEMENT – METHODS AND PRACTICES

A meadow can be maintained (kept in its meadow state) by two main techniques: by animals or by mechanical means. Depending on the needs, other operations can also be carried out (mowing, levelling, aeration, reseeding, etc.).

This chapter only deals with mechanical tools, which are the main technique used in airports. However, grazing is still possible in some areas of the airport where operational constraints are compatible with this technique (see insert "FOCUS ON... Grazing on Airports").

Previous studies of airport grasslands and similar areas such as roadsides, as well as the responses of airport operators in metropolitan France and overseas interviewed for this guide, allow the identification of practical methods of grass management according to the objectives to be achieved. The following topics are addressed here from the point of view of aviation safety and biodiversity:

- Grass management equipment according to the objective of grass cuttings recovery;
- Amount, frequency and duration of grass management.

Grass maintenance can be carried out by internal means or by an external service provider (farmer or grounds maintenance company). Of the airports surveyed, 76% use an external service provider for some or all of their turf management. This gives them access to professional equipment that the airports would not necessarily be able to invest in.

Figure 22 – Chipper in action on a platform.

FOCUS ON... GRAZING ON AIRPORTS

From a safety point of view, grazing must be controlled as it can present risks.

According to article 6 of the decree of 10 April 2007 on the management of wildlife hazards on aerodromes, "the grazing of animals on aerodromes is not allowed unless the grazing area is equipped with a fence adapted to the species of animal concerned or the animals are guarded during the opening hours of the aerodrome". These measures prevent any encroachment on the runways and taxiways.

In addition

- Site selection is important because the presence of animals and their droppings can attract certain bird species (corvids, cattle egrets). Animals should be kept away from manoeuvring areas.
- Grazing by sheep should be controlled as they may not eat all the grass and leave it in clumps.
- Airport operational constraints must be compatible with this technique.

From an environmental point of view, grazing has a negligible impact as it is a fuel-free maintenance activity. However, the level of fertilisation of the plots (caused by the deposition of urine and faeces) and the grazing pressure (trampling of the animals on the plot) must be controlled, as they influence the selection of plant species present in the environment. In fact, a soil that is too rich will have an unfavourable effect on the ability of remarkable species to express themselves. Defoliation and trampling by too many livestock (number of livestock units per hectare to be controlled) will tend to favour fast-growing and aggressive runners. Regarding the number of livestock, it should be noted that rotational grazing (moving animals through several small plots in rotation) has a positive impact on biodiversity, as it gives plants time to rebuild their reserves (no grass depletion).

Of the airports surveyed, two have established an airside grazing area more than 150m from the runway. The area is mainly used by sheep between April and June. In addition to the provision of natural fertiliser and the fact that it is an ecological grass management system, one of the platforms indicated that it uses this as a measure to protect Little Bustard nests in certain targeted areas, as grazing is a less aggressive technique than mechanical methods (possible displacement of female Little Bustards during grazing periods, little damage to nests, relatively rapid regrowth of vegetation cover). On another platform, sheep have recently replaced machines for the annual maintenance of wasteland to prevent overgrowth and reduce the risk of summer fires.

Both airports and farmers can therefore find an economic interest in this practice, as long as the impact on the level of wildlife risk is well understood.

Grazing is also a way of managing the grass on photovoltaic farms, where the passage of mechanical tools is difficult (low height under the panels, see "FOCUS ON... Photovoltaic parks on airports").

3. GRASS MANAGEMENT – METHODS AND PRACTICES

3.1. GRASS MANAGEMENT EQUIPMENT BY OBJECTIVE OF GRASS CLIPPINGS RECYCLING

Grass management refers to all operations that reduce the height of grass: cutting, mowing or shredding, with possible disposal of the cuttings.

At the end of a grass management operation, the disposal of bio-waste is a key management step, as it has an impact on flight safety and biodiversity. Leaving grass clippings on the ground has several effects:

- Risk of grass clippings being blown into the manoeuvring area by the engines or propellers. The risk would be the ingestion of these cuttings by the engines of the aircraft or their projection towards another element.
- Risk of creating voids. If the grass clippings are compacted and left on the ground for a long period of time, they can cause cavities by smothering the vegetation.
- Enriching the soil with organic matter and nitrogen. The risk is that once a certain level of soil enrichment has been reached, fast-growing nitrophilous plants that are more difficult to control will become established. The poorer (or "leaner") the soil is in nutrients, the more diverse the flora will be ([16]).
- Wildlife risk. The decomposition of plants attracts many insects that serve as food, especially for birds. The presence of this "compost" becomes an attractive factor for fauna.
- Fire hazard. Grass clippings, especially if they are dense, reach high temperatures during the fermentation process. There is a risk of self-ignition in the case of dry grass, but also in the case of a runway excursion and subsequent kerosene loss.

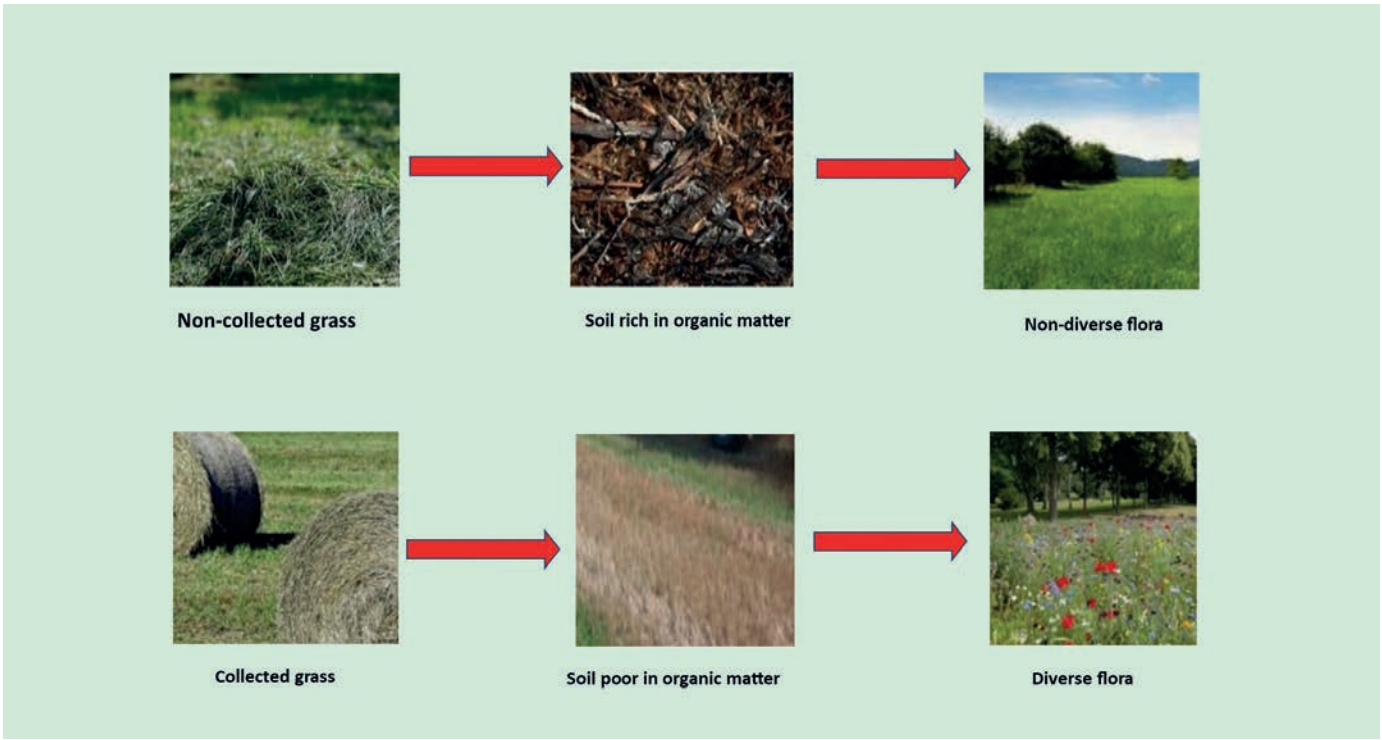


Figure 23 – The richness of biodiversity lies in the nutrient poverty of the soil.

3. GRASS MANAGEMENT – METHODS AND PRACTICES

In addition to creating a less diverse prairie, a rich soil (enriched by grass clippings left on site) leads to faster vegetation growth, which in turn increases the frequency of mowing to maintain vegetation at a target height and therefore the cost of grass management. Conversely, an airport that exports the clippings will reduce the rate of grass regrowth on its platform. This reduces the number of times the grass needs to be cut in a year and therefore the cost.

The choice between cutting, mowing and shredding depends on the objectives of the grass clippings recycling and the species present on the ground.

3.1.1. CUTTING: RECYCLING AS FODDER, LITTER OR MULCH

Grass management by mowing is suitable for herbaceous plants or possibly small woody plants that are not very developed, but can be difficult if the site does not allow access to the equipment (too rugged terrain, etc.) or if woody plants or small shrubs are present on the turf and make the equipment unsuitable.

In order to obtain a good height of the whole stem, mowing is the operation of choice if the airport wishes to recycle the cut grass as fodder, litter or mulch. For example, 49% of the airports that responded to the questionnaire value the grass clippings as fodder for the farmer who owns the airport grassland. The vast majority of these are small and medium sized airports (<30,000 movements/year). In some cases, the recycling of grass clippings enables the turf management to be self-financing.

Figure 24 – Hay collection on an airport meadow.

In addition, because the cut is made at a single point and the stalk falls to the ground at the same cutting height, the risk of killing small fauna by cutting is lower than by shredding and mowing. Fauna can escape from the fallen grass before it is collected.

In fact, many animals live, feed or nest in the grass and can be affected by grass management. The figure below illustrates some of these animals.

1: Eurasian Skylark: nests on the ground in flower-rich meadows from spring to autumn. 2: Ladybird: larva and adult feed on aphids. 3: Oak spider: lives in woods and meadows, overwinters as an egg. 4: Grass eggar caterpillar: hatches between October and March depending on the region, feeds on fabaceae and grasses until its transformation in July-August. 5 and 5bis: Marble white (*Melanargia galathea*) and Common blue butterfly (*Polyommatus icarus*): caterpillar feeds on grasses for the former, on herbaceous legumes for the latter. Adults suck nectar from flowers. 6 and 6bis: Solitary bee and Bumblebee: nest on the ground or in a wall or hollow stems, collect nectar and pollen from flowers to feed their larvae, and pollinate pistils. 7: Myriapoda (*Ommatoiulus moreleti*): preferably in tall grass or vegetation piles. 8: False-oil beetle: in flowering meadows, larva on the ground in decaying wood or stems, adult from April to August, feeds on pollen. 9: Flower crab spider attacking a beetle: both live in meadows as adults from spring to autumn. 10 and 10bis: Southern wartbiter and Bush cricket: Eggs on the ground, larvae in spring, adults from June. 11: Green leafhopper: larva develops in a cuckoo spittle clinging to grassland plants.

Figure 25 – Sample of wildlife potentially impacted by grass management.

3. GRASS MANAGEMENT – METHODS AND PRACTICES

The materials available are classified below by type of cutting:

- Cutting by shearing: cutting machines with cutter bar or section.

Motorised mowers or cutter bars mounted on a vehicle allow high and low grass to be cut by shearing, while preserving the stalks, and are particularly suitable for low-density forage. Its light weight protects the soil and requires little power. Its capacity is approximately 0.5 ha/h, but can go up to 2 ha/h depending on the type. The cutter bar is equipped with one movable knife (or two, depending on the model) and a fixed support. On single-blade models, only the upper blade moves back and forth. Below the blade, a fixed support bar is fitted with fingers that divide the crop, act as counter-knives for shearing and guide the blade.

Figure 26 – Cutter bar with knives s 165/240.

In double blade models, the two blades are driven in opposite directions and kept in contact by oscillating guides.

- Impact cutting: rotary disc machines, drum machines.

Allows very tall grass to be cut with a higher output than those with cutter bars: about 4 ha/h. The power requirement is higher and the weight and robustness are greater.

This is the most common system used on farms. It consists of knives mounted on discs (also called plates) or drums that rotate at high speed. For the same cutting height, rotary mowers are more destructive to wildlife than the motor mower or cutter bar attached to a tractor.

Figure 27 – 2-drum x 4-blade machine attachment, folded.

The cutting device of the drum machines is based on knives that are spread by the rotating movement of the suspended drums, a movement that is transmitted from above. The most commonly used machines have between 4 and 6 drums.

- Laceration cutting : flail machines.

They are effective in grasslands where the toughest types of plants and grasses are present, including low thickets. Their capacity is about 2 ha/hour. The cutting of the stems is not straight and is therefore more damaging to the grass regrowth and causes a lot of leaf removal, especially in leguminous plants.

Figure 28 – Gaspardo flail machine.

Figure 29 – Flail knives.

It should be noted that it is possible to add a conditioner to a cutting machine (often rotary) so that the forage is pressed after cutting to speed up drying. However, the conditioner increases the risk of death or inability to fly of bees (58% with conditioner vs 8% without conditioner) and decreases the survival rate of orthopterans (after 42% with conditioner vs 80% without conditioner) [17].

3.1.2. MOWING, SHREDDING: RECYCLING THROUGH COMPOSTING OR METHANIZATION

Mowing and shredding produce small amounts of grass clippings (on average half the volume of mowed grass) and should therefore be used for composting or methanisation.

None of the airports surveyed currently use methanisation for their grass clippings. The airports could contact professionals to assess the methanisation potential of their grass clippings. Methanisation is a natural biological process of decomposition of organic matter in the absence of oxygen, resulting in the production of biogas:

- Biogas, the combustion of which produces heat and electricity (cogeneration) or even cold (trigeneration);
- Digestate, which is used as a natural fertiliser and soil conditioner.

Grass clippings have a significant methanisation potential, depending on their composition. It is estimated that a mown meadow produces between 6 and 9 tonnes/ha/year of grass clippings [18]. One tonne of methanised grass can produce the energy equivalent of 75 litres of heating oil [19], i.e. a total of 450 to 675 litres of fuel per hectare per year.

It should be noted that:

- For the process to be cost effective, the methanisation farm must be located close to the airport;
- Wet methanisation at 37°C for 30 days destroys any invasive plants that may be present in the grass clippings and therefore does not pose a risk of spreading when the digestate is spread [19].

Of the airports surveyed, 13% compost either directly on their platform (dedicated composting area) or by exporting their green waste to a landfill. Although the compost produced in-house could be sold at a profit, none of the operators practising in-house composting sell their compost. It should be noted that the sanitary conditions for selling the compost are relatively strict. In practice, the compost is used internally to improve the quality of the land used for animal feed. Nevertheless, the airport has calculated that it is financially more interesting to compost on site than to send it to a landfill.

Figure 30 – Composting area for grass clippings on a platform.

Mowing is used when the operator needs to cut a short length of grass. Mowing is usually done with a ride-on mower or a strimmer (a portable tool with a wire that rotates around an axis). The strimmer is mainly used in areas that cannot be reached by agricultural machinery (small spaces, finishing touches).

Figure 31 – Tractor-mounted mower.

3.1.3. SPECIFIC EQUIPMENT AND INFRASTRUCTURE

A flail mower (or shredder) and a vacuum cleaner, with a waste collection bucket at the rear, are combined to create specific equipment for airport meadows. The unit is coupled to a tractor and can mow and recover mowing residues in a single pass. For instance, a commercially available machine has a working width of 6.9 m and a green waste carrying capacity of 30 m3, which optimizes operations.

In all cases, it is recommended to fit machines and equipment with low-pressure tires to limit wheel marking on the ground. This is because tracks or ruts created by the passage of machinery are rapidly colonized by wildlife.

It is important to work in good soil moisture conditions to avoid soil destructuring, regardless of the equipment used.

Additionally, there is specific equipment available for mowing airport fences, which is a permanent challenge for operators (see insert 'ZOOM ON... Maintenance of airport fences').

The installation of photovoltaic panels on the airport right-of-way may require a review of the equipment used to maintain green spaces and all mowing methods. Please refer to the 'ZOOM ON... Photovoltaic parks on airports' section for more information. This will ensure that the necessary infrastructure is in place.

FOCUS ON MAINTENANCE OF FENCES AIRPORT

Airfield fence maintenance is a complex issue for managers due to the length of the lines (especially at large airports), security constraints, relationships with landowners along the right of way and the recent ban on phytosanitary products, which may require changes in practice.

While chemical alternatives can be considered through the use of biocontrol products, mechanical solutions are preferable. The techniques used by airports are the strimmer, the ride-on mower and/or the knife mower for fences, protected by a rubber-edged disc that sticks as close as possible to the fences, either on a hitch with pneumatic tyres or suspended by a hydraulic cylinder.

Figure 32 – Knife mower for fences, mounted on hydraulic cylinder.

The main problem is the amount of human labour required for this task, especially on large platforms with an important fence line. In addition, the manual cutting and uprooting solutions, which are the most respectful of biodiversity, are also the most expensive. The solutions adopted by operators are therefore a compromise between respect for biodiversity and management of human and financial resources.

Among the possibilities mentioned during the airport survey, one French airport wanted to obtain seeds of sedum or orpine, a lichen that remains less than 10 cm high all year round, from a supplier along its fences in 2021. However, the project was put on hold because the linear area was considered too large.

Concreting all or part of the fence base is an expensive but very durable solution. Although this practice contributes to the artificiality of the ground, it strengthens the fence and prevents the feet of the fence from being damaged by burrowing mammals (boars, rabbits...) that dig and pass under the fences. This is the solution adopted by one of the managers interviewed to combat boar intrusion at the airport.

Thermal weeding, either with a flame or by spraying boiling water, is another technique that has been mentioned. However, the time required and the controversial effectiveness raise questions about the relevance of this solution for this application.

A document entitled "ZERO PHYTO AIRPORTS: how to make the transition to zero phyto in the airport context?" [20] written by UAF & FA is available on the UAF website.

Figure 33
Fence with shutter and burying the fence in concrete.

Figure 34
Chemically weeded fence.

FOCUS ON... PHOTOVOLTAIC PARKS ON AIRPORTS

As part of the energy transition, many projects are being developed in France to install photovoltaic parks. In the vicinity of airports, these parks have mainly been installed on the roofs of car parks. Today, several airports are considering installing them on grassy areas, either airside or landside.

In addition to the regulatory issues associated with the installation of such infrastructure in terms of operational safety and environmental constraints, this will lead to changes in the maintenance of the areas concerned. In fact, the management of a photovoltaic park consists of mowing the grass under the panels to prevent them from being damaged by vegetation, and between the panels to maximise the amount of sunlight received and therefore their energy yield. The importance of avoiding any projection of material when working on the panels and the reduced height of the passage under the installations may require different grass management techniques (height and frequency of cutting, equipment used, etc.) from those normally used on the airfield.

In addition, the installation of photovoltaic panels can also have an impact on the management of wildlife hazards. For example:

- Bird nesting under the panels: The pleasant temperature under the solar panels is likely to attract birds during the nesting period. However, as summer approaches and the temperature under the panels reaches 70 degrees, it is possible that the birds will abandon their nests and the eggs will not survive this temperature.
- Creation/modification of wildlife corridors. As PV parks are fenced, animals may have to walk along the fences. The location of wildlife passages on the platform could be changed.

The operator will therefore need to anticipate the impact of grass and wildlife hazard management on the platform from the start of the project.

Figure 35 – Photovoltaic parks on Aurillac airport, sheep grazing from May to November.

3.2. GRASS MANAGEMENT HEIGHT, FREQUENCY AND PERIOD

Frequency, timing and height of cutting are factors that have a direct impact on both safety and biodiversity. Safety (visibility, wildlife risk), biodiversity conservation, operational constraints, cost and weather are the main criteria used by the farmers surveyed to determine the height, frequency and duration of grass cutting.

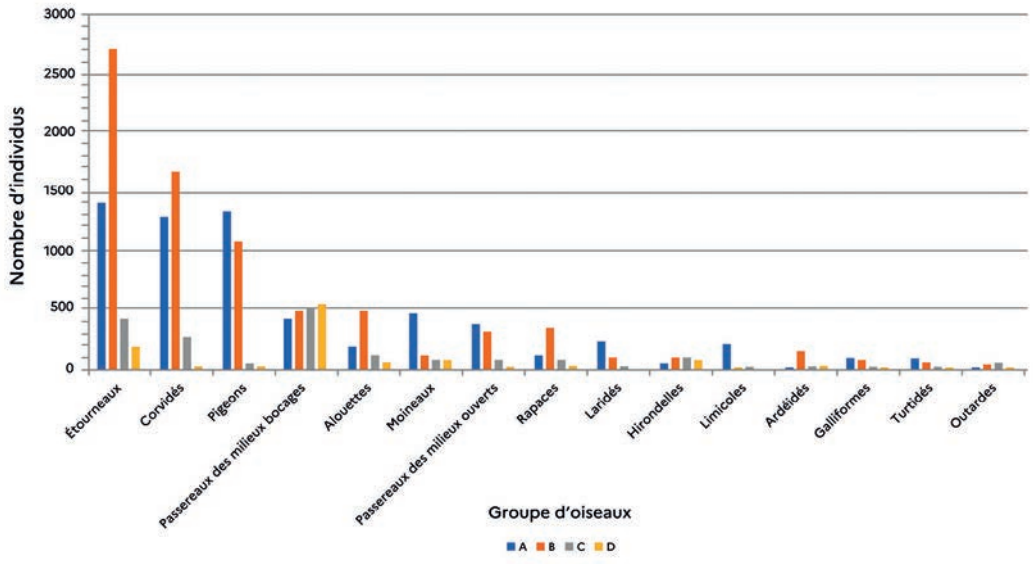
3.2.1. GRASS MANAGEMENT HEIGHT

It is generally recommended to mow at a height of about 20 cm or more, where the composition of the cover allows, in order to reduce the attractiveness of the area to birds and to limit the destruction of biodiversity caused by the passage of equipment.

Indeed, recommendations for the maintenance of grasslands in areas other than airports [21] identify several problems associated with mowing the grass cover:

- A strong impact on biodiversity (destruction of flora by overly aggressive cutting and destruction of small fauna);
- Increased risk of soil erosion (soil degradation);
- Accelerated establishment of invasive plants.

In addition, the results of the protocol "Height of vegetation and presence of birds" carried out by the association Aero Biodiversity [5] show an increased presence of birds when the height of the vegetation is less than 20 cm. Abundance is highest below 5 cm of vegetation, because the most gregarious birds are concentrated in the most bare areas. Figure 36 below details the results of the protocol by species group and vegetation height.



Bird numbers by species group and vegetation height category. A: 0-5 cm; B: 5-20 cm; C: 20-50 cm; D: >50 cm. (2018 and 2019 data)

Figure 36 – Bird numbers by species groups and vegetation height.

However, for safety reasons, it is sometimes necessary to cut grass in certain areas of the airport. This is particularly the case around lighting and signage elements and radio navigation instruments (see insert "FOCUS ON... Grass management around beacons and radio navigation instruments"). Similarly, the ICAO Technical Specifications [23] recommend that grass be maintained at a height of 10 cm on the so-called "runway strip" (a surface graded and prepared to accommodate the accidental rolling of an aircraft). These safety requirements impose certain measures on the operator.

Operators should therefore adapt the height to the areas to be mowed. This practice of differentiated grass management is used by 66% of the airports surveyed (with varying numbers of areas). The remaining 33% have chosen a low height regardless of the area. Although these practices are all unique, being adapted to the local context, some similarities could be identified:

- Some airports chose a higher height at the edge of the runway (10-20 cm) than in some areas away from the runway (5-10 cm) in order to attract birds, especially raptors, to these remote areas (13% of the airports surveyed). In fact, most species, especially birds of prey, prefer areas with shorter grass because it is easier to find food and keep an eye out for predators due to the good visibility in all directions. One platform in the French Overseas Territories has chosen to cut the grass away from the runways to attract cattle herons, which were regularly involved in bird strikes.
- Others, on the other hand, have opted for short grass at the edge of the runway, leaving a height of 30, 40 or even 50 cm away from the runway (54% of the airports surveyed). While one airport explained that short grass or no grass at all on the runway edge was a way of managing the risk of little bustards, the others justified this choice on the basis of legal requirements [23].

Figure 37 – Female Little bustard hidden in the high meadow on an airport.

In the case of the use of a farmer, some airports have also expressed difficulties in imposing a high height for reasons of yield (not enough grass harvested).

FOCUS ON... GRASS MANAGEMENT AROUND BEACONING AND RADIO NAVIGATION INSTRUMENTS

On an airport, some areas are sensitive to too much grass:

- Around lighting and signage points, as the vegetation should not obstruct their visibility;
- Around certain radio navigation equipment, because radio waves do not reverberate well on uneven ground.

Like signposts, lighted markers at the edge of the runway are obstacles that must be carefully avoided during grass management operations. The grass around these markers is usually cut with a ride-on mower or shredded with a strimmer (finishing work).

As far as radio navigation devices are concerned, some are more sensitive than others to the homogeneity of the surrounding terrain (reverberation of the radio signal) on the one hand, and to the presence of metal objects (tractors, etc.) on the other. For this last reason, the radio navigation instruments that require special attention must be switched off during grass cutting. The instruments in question are:

- The glide (downhill line): must be cut regularly in a rectangular area 300 m long and wide from the edge of the runway to 55 m beyond the glide.
- The localiser (centre line): must be cut regularly in front of the antennas in a rectangular area 300m long and 60m wide on either side of the antenna centre line (behind the antennas: 10m deep rectangle, 60m on either side of the antenna centre line).
- The VOR-DME (axis and distance): must be cut regularly within 50m around the antenna, for the good functioning of the sensors necessary to monitor the VHF signal located at about 35m from the antenna.

Figure 38

Short grass in the area of radio navigation instruments (here ILS localizer), and high grass further away.

Figure 39

Mowing the grass around a beacon sign with a mower.

With regard to other means of radio navigation (NDB or locator beacon, direction finder, DME implanted alone), no particular treatment is recommended in terms of grass management, the grass can remain high.

3.2.2. GRASS MANAGEMENT FREQUENCY

From the point of view of wildlife hazard, the grass management action creates a punctual increase in risk, as birds are attracted to freshly cut areas because of easier access to food. Also, by reducing the number of annual grass management operations, these periods of punctual increased risk are mechanically less frequent. In addition, a reduction in the frequency of operations will allow a higher level of cover to be maintained (see previous paragraph).

From the point of view of biodiversity, an extensively managed meadow (0 to 2 treatments per year) has a better diversity of flora and fauna than an intensively managed meadow. Studies ([15], [23], [24]) have shown that this is particularly the case for entomofauna, with the presence of insects being up to twice as high in extensively managed grasslands. The relationship between the frequency and timing of grass management is also essential to maximise the value of biodiversity; the reduction in the number of treatments must be accompanied by a delay in the timing of the first treatment to maximise its positive impact.

In addition, as mentioned above for height, too high a frequency of grass management will favour stolon plants, slow growing grasses or fast growing invasive plants.

Extensive management also reduces the cost of turf management by reducing the time and wear and tear on equipment. According to one estimate ([25]), mowing represents a cost per intervention that is about two times higher than mowing for an equivalent area, but represents a significant gain over the year (2 interventions against more than a dozen to maintain the cover with mowing).

In practice, several platforms interviewed do not have a predefined intervention frequency and intervene as soon as the height of the grass does not allow sufficient visibility for the wildlife hazard unit or the RFFS. Others, on the other hand, have a maintenance contract with a fixed number of grass management operations per year, which can lead to problems in the event of accelerated growth of the vegetation cover.

Outside of airport runways, discussions with airports revealed that almost half of the platforms surveyed (46%) generally only intervene once a year, 27% indicated that they intervene twice a year and 27% intervene at least 3 times or more. There seems to be no correlation between the biogeographical location of the airport (dry or wet, cold or hot - see Annex 1) and the number of interventions per year in areas away from the runway. However, some airports mentioned specific constraints::

- The frequency and intensity of tropical rains at the New Caledonian airports surveyed require managers to take action very regularly (once a month in the wet season) due to the high growth rate.
- The balance between crop yield and the cost of grass management can lead to a second intervention by the partner farmer at the end of the summer, when the grass has grown sufficiently.

Some platforms go further in the extensive management of their pastures and in the differentiation of the management methods by creating "refuges" (see insert "FOCUS ON... The choice of refuges").

FOCUS ON... THE CHOICE OF REFUGE AREAS

A refuge zone or strip is an area that is not managed at the same time as the rest of the site: intervention later in the year or intervention every second or third year, depending on the dynamics of the vegetation, and in particular the dynamics of the appearance and growth of small woody plants.

The aim is to protect the existing flora and fauna by providing them with an alternative site. Grass management can have a negative impact on insect, bird and small mammal populations. Some insects have complex life cycles, such as butterflies and solitary bees, whose caterpillars and pupae often overwinter in wilted grass or on the ground. The refuges will provide them with shelter during the winter. For birds, these areas will allow them to carry out different stages of their lives, such as nesting, feeding or resting before migration. For plant species, these areas allow them to complete their life cycle. It is important that these refuges are free from IAS.

It is recommended that at least 10% of the grassland should be refuge areas (the smaller the plot, the larger the refuge area should be) [26]. If different environmental types coexist on the site (e.g. wet grassland and dry grassland), it may be important to define refugia for each of these environments.

In the case of airport grasslands, 28% of the platforms surveyed have chosen to leave areas 'fallow' for one or even two years. Others have chosen areas that they manage later in the year. These are always areas away from the runways.

While some operators have done this for biodiversity reasons, others have initially done so for safety reasons, as it attracts small wildlife away from the runways.

It is important to regularly monitor these areas and their impact on the airport, both from a wildlife risk management perspective and from a biodiversity perspective to avoid the establishment of undesirable plant species. Improving staff skills in identifying plant species is important for the management of fallow land.

In particular, the airport operators agreed on the need to intervene at least every two years, to change the vegetation on a regular basis and, if necessary, to carry out selective cutting of shoots and semi-woody plants:

- On the one hand, to avoid excessive overgrowth of the area, which would make it more difficult to access and therefore maintain;
- On the other hand, to avoid the long-term establishment of too many animals (wild boars, birds, roe deer, foxes, etc.), which could lead to a change in the level of risk for wildlife on the platforms.

FOCUS ON... THE CHOICE OF REFUGE AREAS

Continued vigilance has led one operator to decide to remove refuges from its airport. Difficulties with lapwings led him to make this decision in order to provide a potential site away from the infrastructure for lapwings, which prefer shorter cover.

Figure 40 – Fox on the edge of a wasteland at an airport.

Figure 41 – Refuge area below the runway threshold and localizer at an airport..

3.2.3. GRASS MANAGEMENT PERIOD

By delaying the first treatment, the number of treatments per year is automatically reduced. In addition, late turf management allows the biological cycle of flora and fauna to be better completed. Depending on local biodiversity concerns, specific periods should be taken into account when planning grass management.

In particular, two studies [27, 28] have clearly demonstrated the positive effect of postponing the date of action until after 15 July on the reproductive success of grassland passerines and the increase in the proportion of their territories.

Other recent studies [29, 30], focusing on the entomofauna, have shown that species richness and abundance of some species were significantly higher on grasslands managed later.

Finally, the SETRA note [15] points out that grass growth is slower when the cobs are cut. It is therefore necessary to wait until the cobs have developed. Therefore, acting too early will not limit the regrowth and final height of the grass and will require a second cut during the year. It is therefore necessary to take grass regrowth factors into account when planning grass management.

In the case of forage use, an intervention between the end of June and mid-July seems to be the best compromise between biodiversity and forage quality.

Figure 42 – Reasoned management of roadside, Walloon region.

From a safety point of view, the timing of turf management must also take into account the level of traffic over time. It is advisable to avoid, as far as possible, periods of heavy traffic to carry out grass management, as this action is generally particularly attractive to the avifauna. In the event of problems with raptors on the airfield, it is advisable to intervene early enough to allow the grass to grow back before July-August, when migrating raptors and young birds are on the airfield in search of food.

3. GRASS MANAGEMENT – METHODS AND PRACTICES

During the discussions with the operators, several of them spoke of the need to implement various measures related to this issue:

- In one case, the operator indicated that he does not intervene from 15 June to 15 September, because this is the season with the highest local traffic and also because it is the period of the year with the highest presence of birds.
- In a second case, the operator stated that it prefers to intervene at night. This practice is particularly relevant at airports where the level of traffic does not allow much grass management during the day, but this remains a constraint (availability of agents, higher costs of night work, reduced visibility, risk of damage to infrastructure).

Where this is not possible, additional wildlife risk management measures may be implemented. For example, one operator implements several specific risk management measures during daytime operations:

- Systematically adding a wildlife hazard officer to the field,
- Increasing the number of rounds,
- Increasing the wildlife hazard level on the platform broadcast to users.

Finally, it should be noted that the duration of grass management is influenced by various external factors such as the weather or the nutritional quality of the grass (if the grass clippings are used as fodder). It is important to take all these aspects into account when determining the optimum grass cutting period.

Figure 43 – Attractiveness of cattle herons during mowing at an airport.

3.2.4. DIFFERENTIATED GRASS MANAGEMENT: PLANNING OF HEIGHT, FREQUENCY AND AND PERIOD

Differentiated management, also known as "adapted" or "reasoned" management, is a way of managing grasslands by adapting methods to different areas in order to carry out the right maintenance, in the right place and at the right time.

This type of grassland management is based on a preliminary work of sectorisation of the green areas according to the problems and objectives to be achieved locally (safety, biodiversity, forage yield, etc.). Maintenance methods can then be adapted in terms of duration, frequency, height and technique. This planning is reflected in a management plan specific to each aerodrome (see section 4 "Grass management plan").

Differentiated management also makes it possible to limit over-treatment of certain areas, which generally results in savings that can be reinvested in the completion of maintenance work.

Figure 44 – Differentiated management: short on the airport strip and long further away.

4. THE DESIGN OF A GRASS MANAGEMENT PLAN

A grass management plan (sometimes called a "mowing plan") is a document in which the airport operator plans its actions in relation to the maintenance of grassed areas. It must include in particular:

- The sectorisation of the airport's green areas;
- The maintenance objectives associated with each sector;
- Maintenance methods for each sector (frequency of intervention, height, target period, means of intervention).

It is recommended that each airport has such a plan. This document makes it possible to formalise the operations carried out and to trace the actions taken, thus enabling a history to be drawn up and analysed, as well as facilitating the coordination of operations with all the parties involved. It is also the ideal tool for achieving sustainable development objectives by guaranteeing safety, developing biodiversity and limiting maintenance costs.

A detailed greenspace management plan can be part of the habitat management plan according to ICAO [31, 32] and EASA standards for certified aerodromes [33].

The previous chapters have shown that many factors influence the management of airport green areas (type of vegetation and surrounding environment, climatic conditions, type and layout of airport infrastructure, objectives of the manager, etc.). Each management plan is therefore unique and reflects all these factors. Nevertheless, it is possible to follow a methodology based on the principle of maintenance management by objectives.

Figure 45 – Mower in action at an airport.

4. THE DESIGN OF A GRASS MANAGEMENT PLAN

4.1. METHODOLOGY

The first step in this process is to bring together all the airport stakeholders involved in the maintenance of the airport's green areas (Wildlife Hazard Management Unit, Rescue and Fire Fighting Service (RFFS), Aeronautical Area Managers, Green Area Managers, Air Traffic Control, etc.). Indeed, as we have seen in the previous paragraphs, the links are close and this coordination plays a key role in the results obtained.

The operator's management teams can also be involved, particularly in defining the maintenance objectives for each sector, if there is a proactive local policy for preserving and improving the environment.

The following three steps appear to be essential to arrive at a well-designed management plan:

- 4.1.1 Analyse terrain and platform constraints;
- 4.1.2 Sectorise the land and define objectives per sector; and
- 4.1.3 Define and formalise maintenance arrangements by sector/objective.

4.1.1. ANALYZE THE TERRAIN AND THE CONSTRAINTS OF THE PLATFORM - KNOW TO ACT !

Knowledge of the local ecosystem (on and around the airport right of way) is necessary. The better the knowledge of fauna, flora and habitats, the more effective the management plan can be as a means of managing wildlife hazards and enhancing biodiversity. Knowledge of topography can also play a role in defining areas and objectives.

Operators generally have a good knowledge of the avifauna and mammals present on their platform in the context of wildlife hazard prevention. In addition to information on their presence on the right of way, it is useful to map their geolocation within the airport. This additional information allows a better understanding of their behaviour, the type of environment that attracts them, etc.

For small fauna (invertebrates, pollinators, butterflies, amphibians, reptiles, etc.), comprehensive inventory data are less often available locally. However, data on these species are also very informative, both in terms of wildlife risk management and biodiversity. For example, insects, which represent more than 2/3 of the living organisms on earth, play an important role in both areas, as they are both an important source of food for many bird species and play an essential role in the organic richness of a meadow.

As far as fauna is concerned, a detailed knowledge of the habitats present in and around the airport right of way, as well as the flora that makes up these habitats, is also very important data. Some of this information is generally known to the wildlife control personnel as part of the regular surveillance of the perimeter of the airport. To obtain this information, most operators use external service providers specialising in biodiversity, usually consulting firms or naturalist associations. The figure below is an example of habitat mapping at Bastia-Poretta airport.

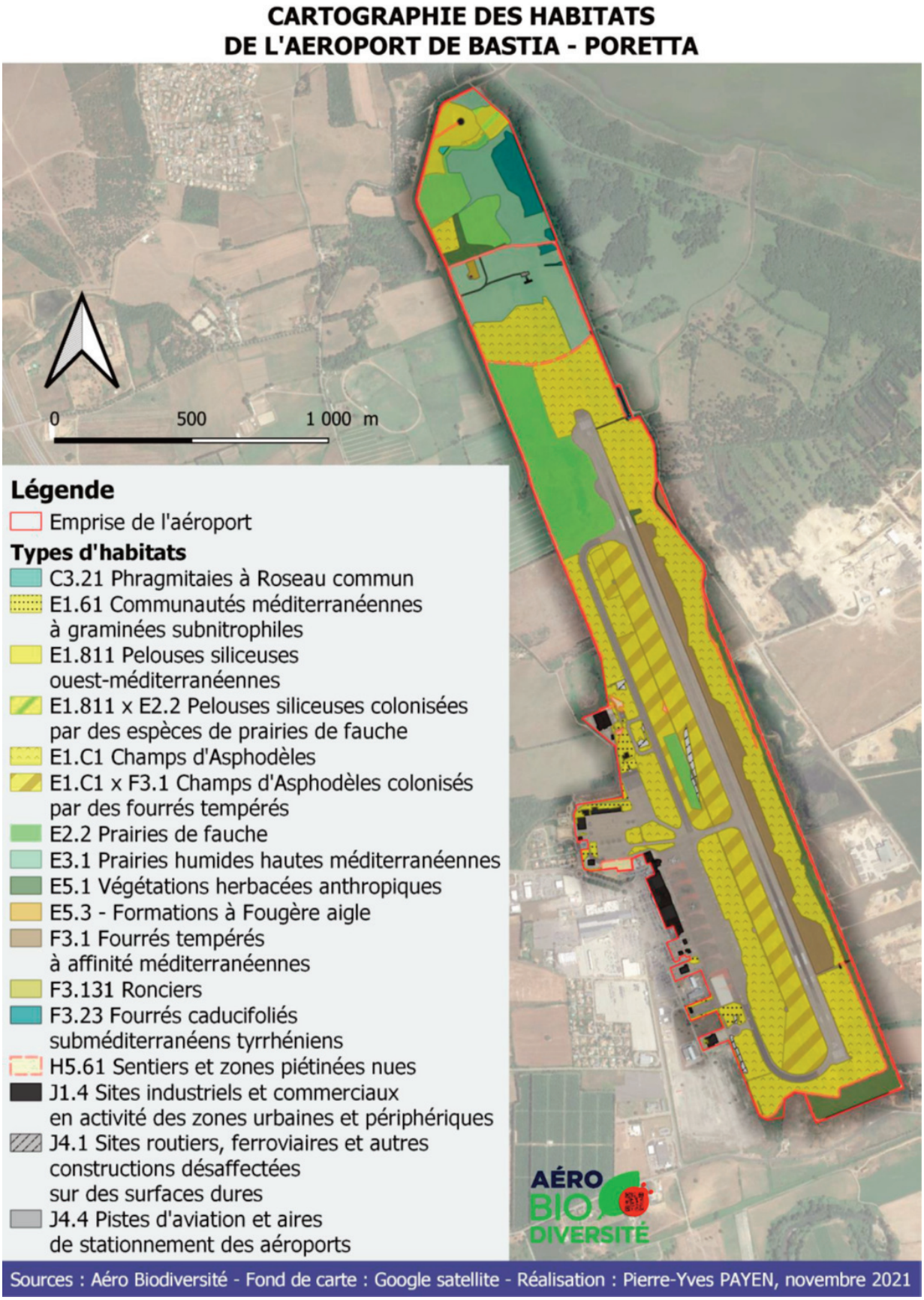


Figure 46 – Cartography of the habitats of Bastia-Poretta airport.

Rigorous monitoring of fauna and flora is essential in order to be able to compare the evolution of a situation over time. A number of scientific protocols exist and are available on the MNHN or Vigie Nature websites (e.g. PROPAGE for monitoring butterflies, FLORILEGES for monitoring urban flora, etc.).

For a successful and usable analysis, it is necessary that these inventories are carried out by agents with a solid knowledge of ecology. If the airport services agents are not able to carry out these inventories and ensure a rigorous follow-up, the operator can call on associations or companies to carry them out.

Nevertheless, the participation of airport agents is encouraged, both to improve their level of knowledge and to be able to carry out monitoring activities throughout the year. If this is done internally, it is recommended that the monitoring of floral biodiversity and animal species that do not pose a threat to aviation safety be carried out outside the agents' operational shifts, so as not to undermine the wildlife risk prevention service.

In addition to the naturalistic inventory of the species present in the right of way, an inventory of the infrastructure and, in particular, the associated operational constraints is essential. This work will provide input for the next step (sectorisation and definition of objectives). This technical inventory will cover all the different components (linear fencing, typology and area of This technical inventory will cover all the different components (linear fencing, typology and area of impervious surfaces, navigation aids, marking and signage, etc.).

4.1.2. SECTORING THE LAND AND DEFINING OBJECTIVES BY SECTOR

The land sectorisation is derived from:

- Analysis of the terrain and the airport infrastructure; then
- The definition of objectives in relation to the characteristics identified.

The number of sectors will vary according to the characteristics identified during the terrain and infrastructure analysis.

To define the objectives, the operator should list all the factors that are important for environmental management. As the primary mission of airport operators is to ensure the safety of operations, safety will always be the first factor to be considered when managing the area. However, without compromising safety, biodiversity objectives can be set for certain areas where safety constraints do not impose overly strict maintenance procedures.

In general, the operator may therefore consider the following two factors (the objectives of which will need to be adapted):

- Safety risks: wildlife hazards to be controlled, lighting visibility to be maintained, radio navigation systems to be cleared and maintained in good working order, fire hazards to be prevented, etc.
- Ecological factors: heritage plant species to be preserved, invasive alien species to be eliminated, plant diversity to be improved, etc.

In terms of wildlife risk to be managed, targets should be based on the platform's wildlife risk assessment. Efforts should be focused on high risk species. It would be appropriate to identify these species in the targets for each sector.

In general, the more detailed the objectives, the more tailored the management plan can be.

4.1.3. DEFINE THE GRASS MANAGEMENT PLAN

The purpose of this step is to produce a document that includes a map showing the different sectors to be managed and the associated turf management conditions. Each sector could be identified on the map by a number or colour.

The turf management conditions are defined on the basis of the previously defined objectives.

To determine the best actions to take, the operator may wish to consider implementing the ideas discussed in the previous chapters and summarised in section 4.2 of this chapter. It is important to note that there is no default solution and that the operator will certainly carry out experiments, the results of which, whether successful or not, will be used to refine his management plan in the future. This approach must be part of a logic of continuous improvement.

For each area, the following mowing conditions can be defined :

- The height/frequency/period of operations;
- The equipment used and the type of grass management carried out;
- The arrangements for collecting the cut grass;
- The service or service provider responsible for the grass management operation.

Any other element, such as instructions on how to carry out the grass management (e.g. start in a particular area, etc.) or any agreement with the service provider, may also be included in the management plan.

If a service provider is used, it is important for the operator to draw up a management agreement to limit the risk of litigation and to secure the relationship with the provider. Ideally, the agreement should be for one year, so that each year the manager can clearly define what is expected of the farmer, particularly in the case of differentiated management (reminder of mapped intervention sectors), as well as the agreed price (if the service is remunerated). Feedback from some operators has shown the need to include obligations and guarantees from the service provider in the agreement, in particular obligations to achieve results rather than obligations to provide resources.

The management plan can be built up over several years, as some plots may not be maintained annually (see Chapter 3), but on a less regular basis. A long-term vision for the management of green spaces can therefore be included in the management plan.

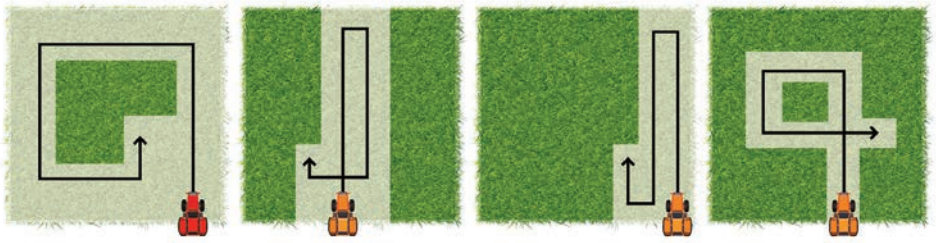
In addition, the plan will need to be reviewed periodically, depending on the evolution of the fauna and flora present. This requires regular ecological monitoring and analysis of changes in biodiversity and safety, facilitated by the use of the scientific protocols mentioned above. The frequency of updating must be determined by the operator according to the nature and speed of the developments.

It is recommended that a number of indicators be established to facilitate monitoring (number of different species (specific diversity), quantity/area occupied by a particular species, frequency of observation of a species, number of wildlife collisions, etc.). The organisation of an annual meeting with all stakeholders is recommended as an opportunity to evaluate the actions taken.

In addition to an annual review, the operator must define time milestones in the management plan to allow "real time" management of elements that may need to be revised during the year. Indeed, although the management plan is essentially a strategic planning document for maintenance operations, it is important not to neglect the tactical vision in order to be able to react in time to changing conditions (weather conditions, unexpected presence of certain species, etc.). The operator can therefore set targets for certain indicators (e.g. canopy height), specific alerts (observations of species at risk) or fixed time milestones.

4.2. SUMMARY OF IDEAS BY THEME

4.2.1. GRASS MANAGEMENT PATTERN

Practices \ Impacts	Safety	Biodiversity
Non-centripetal grass management On large areas to be managed, avoid centripetal grass management, which traps birds and mammals in the centre of the field. Below are three methods of grass management that allow birds and mammals to escape.  Figure 47 – Favorable grass management..	Neutral	Positive
Start grass management away from the runway and do not work both sides of the runway at the same time. Starting management on areas away from the runway avoids concentrating birds on the runway edge. Treating areas on both sides of the runway at the same time may cause birds to cross the runway.	Positive	Neutral
Reduce the working speed To give the animals time to escape, reduce the working speed to 5-10km/h.	To be assessed	Positive

4.2.2. MATERIAL

Practices \ Impacts	Safety	Biodiversity
Cutting instead of mowing and shredding Whenever possible, use a mower that, for the same cutting height, will kill insects, amphibians, small mammals and birds on the ground more than a mower or shredder. Cutting also makes better use of the grass clippings.	Neutral	Positive
Installing a scare bar Install a scare bar on the equipment to scare away birds and small wildlife.	Neutral	Positive
Do not use conditioner	Neutral	Positive

4.2.3. GRASS MANAGEMENT PERIOD, FREQUENCY AND HEIGHT

Practices \ Impacts	Safety	Biodiversity
Manage grass before the period of least air traffic Grass management should be carried out before the period of lowest traffic on the airfield, as the risk of wildlife is higher during and immediately after mowing. At busy aerodromes, grass management can therefore be carried out at night, the only time when traffic levels are low enough to ensure safety. Nevertheless, night-time grass management has a major impact on biodiversity. Indeed, nocturnal pollinators and insects are more numerous than diurnal ones (64% of invertebrates are partially or exclusively nocturnal [35]), and diurnal fauna sleeping at night would be even more disturbed.	Positive	To be assessed
High cut Short grass attracts many animals: good visibility to spot prey/food and avoid predators, easy resting. A short canopy limits the number of insects and small animals. Tall grass (more than 20 cm) provides shelter for some ground-nesting animals, many mammals, birds, reptiles and insects, but is less attractive to birds of prey who cannot see their prey, and to social birds who do not feel safe or have difficulty finding food (gulls), due to the lack of visibility. Depending on requirements, the timing of grass cutting may be more important than the height of the grass: cut at a time that allows the grass to grow back quickly (e.g. mid-September).	To be assessed	Positive
Cut grass less often The fewer times the grass is cut in a year, the lower the risk of bird strikes. Experience also shows that reducing the number of cuts has a positive effect on biodiversity.	Positive	Positive
Managing grass late in the year This respects the natural cycle (completion of the development of certain species of fauna/flora). Cutting the grass late in the year reduces the number of cuttings per year and therefore the costs involved.	To be assessed	Positive
Creating refugia Whether created for a few months of the year (e.g. late grass management) or over a longer period (wild land), refugia protect plant and animal species by providing them with a habitat that is protected from any interruption in their evolutionary cycle. Maintenance may be required to control the growth of woody plants and small shrubs, and a regular rotation of areas is necessary to allow as many species as possible to express themselves. As they attract some animals (see high cut), refuge areas away from the runways can be used to control wildlife hazards at some airports.	To be assessed	Positive

4.2.4. HERBACEOUS COVER

Practices \ Impacts	Safety	Biodiversity
Give preference to local seed when planting or overseeding Local seed should be preferred when seedling or overseeding. This enables: ▸ Regenerate local ecosystems, ▸ Increase efficiency (better resistance, symbiosis with local biodiversity).	Neutral	Positive
Limiting/eliminating invasive alien species Invasive alien species threaten biodiversity, especially native species, through their rapid spread. Identifying, limiting and even eliminating them will have a positive impact on local biodiversity. Eliminating them improves the visibility of the platform and reduces the need for maintenance in the long term.	Positive	Positive

4.2.5. TREATMENT OF GRASS CLIPINGS

Practices \ Impacts	Safety	Biodiversity
Valorising grass clippings Exporting grass clippings for animal feed, bedding, composting, methanisation, etc., is: ▸ Reduce the risk of grass clippings blowing away and being sucked up by aircraft engines. ▸ Deplete the soil of nutrients, thereby encouraging the diversification of flora. ▸ Reduce the risk of creating voids in the soil. ▸ Limit the risk to wildlife by removing the attraction of leftover grass. ▸ Avoid the risk of fire due to self-ignition.	Positive	Positive

CONCLUSION

The information gathered during the preparation of this technical guide tends to show that there is a point of balance in turf management on airport sites. In fact, it is possible to implement measures that are beneficial to biodiversity while ensuring a high level of operational safety, particularly with regard to wildlife hazards. The rational management of airport grasslands, adapted to a detailed analysis of the terrain and recorded in a management plan, is an undeniable lever for the promotion of certain species of fauna and flora, while contributing to the management of wildlife risks.

Bearing in mind that adaptations are necessary due to the unique composition of the environment (fauna and flora), the layout of infrastructures, the location of the aerodrome, traffic, etc., the ideas and methodology presented in this guide can help all operators to make this change.

In addition to the management of grassed areas at airports, which is the subject of this technical guide, airport operators are invited to multiply initiatives that favour the enhancement of their natural heritage and its integration into their environment. This can be done by developing exchanges with neighbouring communities or other relevant actors (CEN, DREAL, CEREMA) to improve the integration of the airport into its environment, by implementing a labelling process for management practices, or by making contractual commitments to preserve the environment through a Real Environmental Commitment (ORE), a legal instrument created in France by the 2016 Biodiversity Recovery Act [36].

APPENDIX

APPENDIX 1 – CLIMATE ZONES IN FRANCE AND EUROPE

In biogeography, a biogeographical zone is a geographical area that is relatively homogeneous in terms of climate and ecology, in terms of plant formations and temperatures. It is an ecological unit in ecological land classification systems. The biogeographical zones of a region are a consequence of the climatic zone (precipitation + temperature) and latitude of that region, as well as the composition of the soils and bedrock.

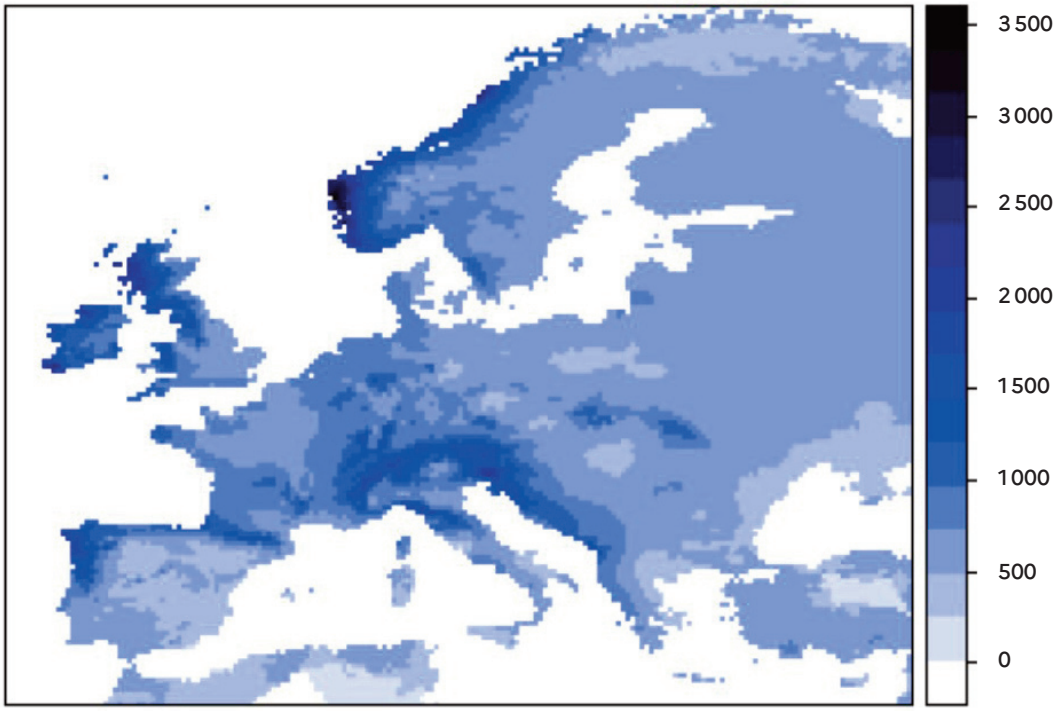


Figure 48 – Average annual precipitation in Europe. Data on a 17-year average (between 6 and 63 years depending on the station).

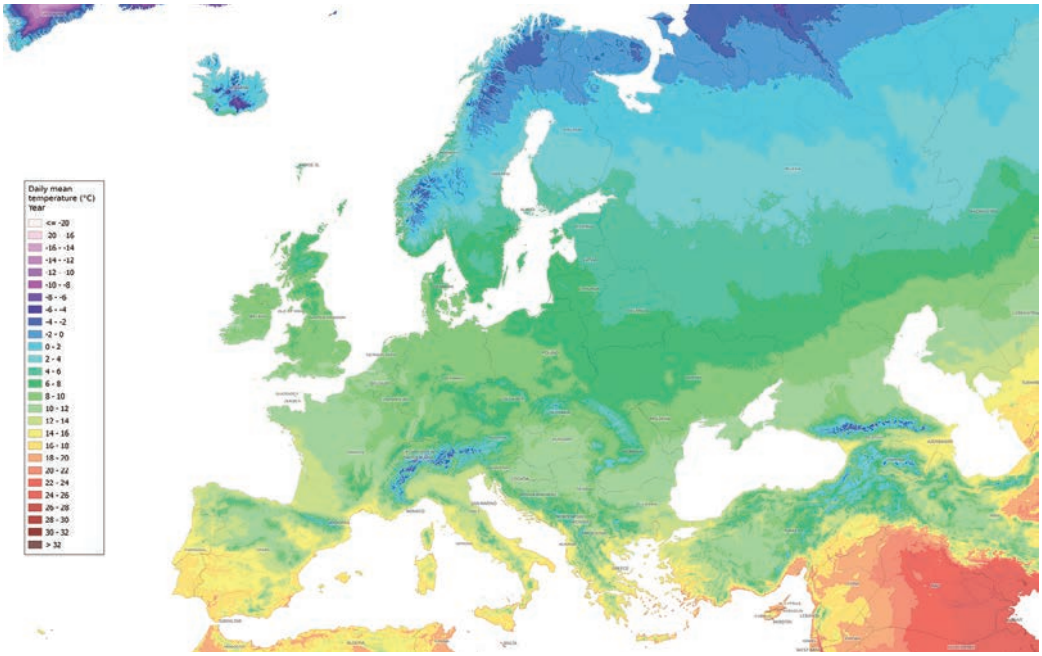


Figure 49 – Average temperatures over the year 2020 in Europe..

By combining precipitation and temperature zones, and other parameters such as the chemical composition of a soil, homogeneous biogeographical zones can be established:

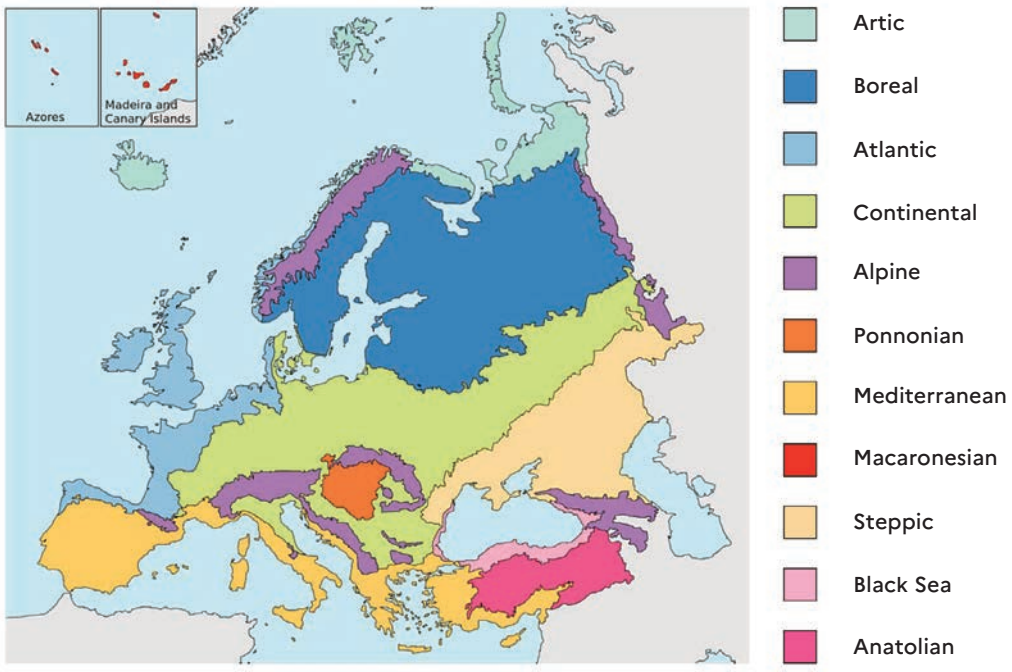


Figure 50 – Biogeographical regions of Europe.

APPENDIX

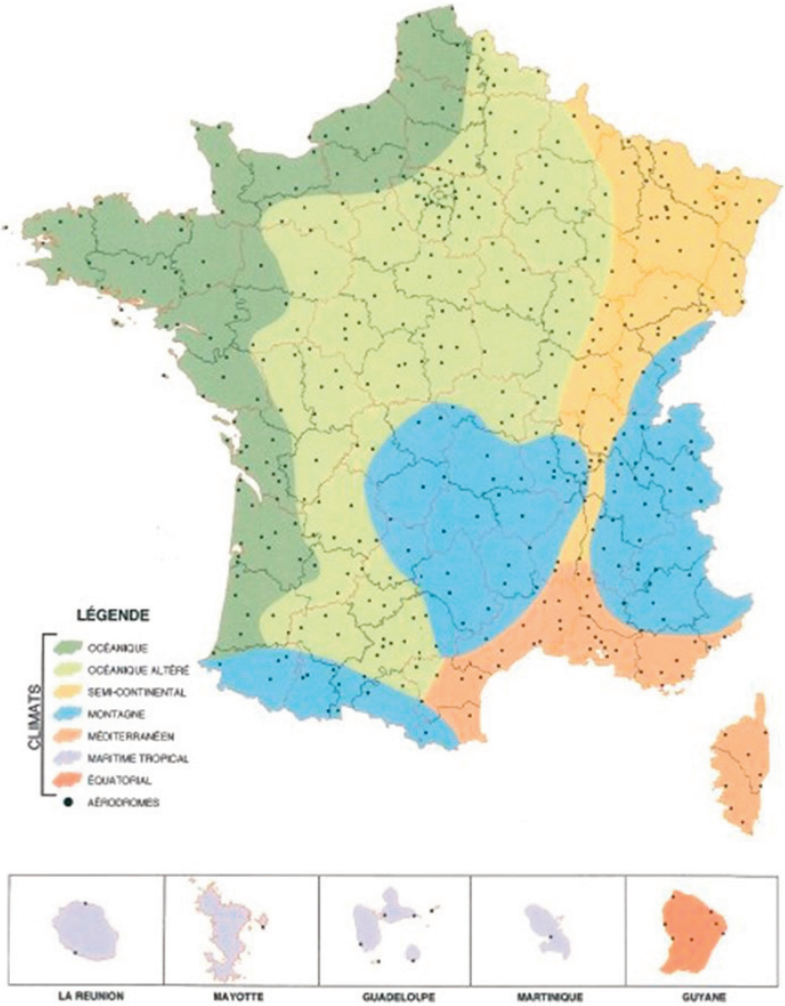


Figure 51 – Biogeographical regions of France and overseas.

The types of natural grassland correspond to the biogeographical regions of an area. Thus in metropolitan France:

- Dry grasslands correspond to Mediterranean or mountain environments above 5600 ft. altitude, or to sub-oceanic calcicole or acidicline environments
- Mountain hay meadows also correspond to mountain environments, but below 5600 ft.;
- Wet hay meadows are more suited to oceanic climates and poorly drained areas (amount of clay in the soil above a certain value, see table);
- Mesophilic hay meadows can be found almost everywhere, as soon as the conditions of heat and humidity and the conditions of soil nitrification are not exacerbated in either direction, or soil drainage is effective (amount of clay in the soil below a certain value, see table).

Average permeability of soils of different textures (cm/hour):	
Sand	5,0
Sandy loam	2,5
Silt	1,3
Clay loam	0,8
Silty clay	0,25
Clay	0,05

APPENDIX 2: TYPES OF AIRPORT GRASSLANDS IN METROPOLITAN FRANCE AND CHARACTERISTIC BOTANICAL SPECIES

APPENDIX 2.1 MESOPHILIC HAY MEADOWS OF THE PLAINS AND SUBALPINE MOUNTAINS

The composition of the plant cover of mesophilic hay meadows is mainly dictated by the mineral richness of the soil, its capacity to retain water from precipitation and the maintenance regime.

Low altitude grasslands (known as "planitiary") are, under a biennial mowing regime, normally dominated by fromental or tall oats (Arrhenatherum elatius). It is accompanied by good forage grasses such as:

- Orchard grass (Dactylis glomerata)
- Meadow fescue (Festuca pratensis)
- Kentucky bluegrass (Poa pratensis)
- Timothy (Phleum pratensis)
- Meadow foxtail (Alopecurus pratensis)
- Golden oatgrass (Trisetum flavescens)
- Downy oatgrass (Avenula pubescens)

Figure 52 – Fromental.

Figure 53 – Orchard grass.

Figure 54 – Timothy (foreground) and meadow fescue (background).

and dicotyledons which can, especially in low-fertilised grassland variants, be abundant, such as:

- Meadow knapweed (Centaurea jacea)
- Daisy (Chrysanthemum leucanthemum)
- Rough hawksbeard (Crepis biennis)
- Meadow salsify (Tragopogon pratensis)
- Musk mallow (Malva moschata)
- Ribwort plantain (Plantago lanceolata)
- Meadow buttercup (Ranunculus acris)
- Yarrow (Achillea millefolium)
- Wild carrot (Daucus carota)
- Field scabious (Knautia arvensis)
- Greater burnet-saxifrage (Pimpinella major)

Figure 56 – Yarrow.

Figure 55 – Meadow knapweed.

Figure 57 – Field scabious.

Grasslands where the regrowth is grazed also include:

- Perennial ryegrass (Lolium perenne)
- White clover (Trifolium repens)
- Crested dog's-tail (Cynosurus cristatus)
- Catsear/flatweed (Hypochaeris radicata)

On heavily amended soils, these are mainly:

- Wild chervil (Anthriscus sylvestris)
- Hogweed (Heracleum spp)

that dominate among the dicotyledons.

Figure 58 – Ray Grass anglais.

Figure 59 – Cow parsley.

APPENDIX 2.2 : WET HAY MEADOWS

The vegetation of eutrophic wet hay meadows is often composed of large dicotyledons such as:

- Narrow-leaved water-dropwort (Oenanthe silaifolia)
- Ragged-robin (Silene flos-cuculi)
- Mayflower (Cardamine pratensis)
- Snake's head fritillary (Fritillaria meleagris)

Figure 60 – Ragged-robin.

or in even wetter areas:

- Marsh spike-rush (Eleocharis palustris)
- Tubular water-dropwort (Oenanthe fistulosa)
- Jointleaf rush (Juncus articulatus)
- Creeping Bentgrass (Agrostis stolonifera)
- Marsh bedstraw (Galium palustre)

Figure 61 – Snake's head fritillary.

Figure 62 – Jointedleaf rush.

The level of hydromorphy can be assessed with the presence of certain grassland ranunculus.

For example:

- Flammulated buttercup/Lesser spearwort (Ranunculus flammula) indicates the wettest soils.

This is followed by:

- Creeping Buttercup (Ranunculus repens)
- Prickly Buttercup (Ranunculus acris)
- Bulbous buttercup (Ranunculus bulbosus)

on drier soils.

However, the absence of these plants does not allow us to conclude whether the grassland is wet or not.

Figure 63 – Flammulated buttercup.

APPENDIX 2.3 : XEROPHILOUS AND MESOPHILOUS LAWNS

Plants characteristic of dry/calcareous or acidic environments are found here.

In alpine lawns, we can observe:

- Seguier's spurge (Euphorbia seguieriana)
- Deptford pink (Dianthus armeria)
- Autumn lady's-tresses (Spiranthes spiralis)
- Sage-leaved rockrose (Cistus salviifolius)
- Field fescue (Festuca arvernensis)
- Eternal flower (Helichrysum stoechas)
- Venus navel (Umbilicus rupestris)
- Sand timothy (Phleum arenarium)

Figure 64 – Deptford pink.

Figure 65 – Autumn lady's-tresses.

In Mediterranean environments (xerophilous or mesophilous lawns), one will find rather:

- Pyramidal orchid (Anacamptis pyramidalis)
- Long-lipped orchid (Serapias vomeracea)
- Monkey orchid (Orchis simia)
- European Michaelmas daisy (Aster amellus)
- Closed xeranthemum (Xeranthemum inapertum)
- Reclining fumana (Fumana procumbens)
- White Asphodel (Asphodelus albus)

Figure 66 – Pyramidal orchis.

Figure 67 – Long-lipped orchid.

In the sub-oceanic environment, dry calcicole and acidicline grasslands can be found:

- Red fescue (Festuca rubra)
- Common bent (Agrostis capillaris)
- Kentucky bluegrass (Poa pratensis)
- Heath bedstraw (Galium saxatile)
- Bristly hawkbit (Leontodon hispidus)
- Small Burnet (Sanguisorba minor)
- Field eryngo (Eryngium campestre)
- Maiden pink (Dianthus deltoides)
- Red sorrel (Rumex acetosella)
- Bird's-foot trefoil (Lotus corniculatus)

Figure 68 – Field eryngo and Alpine argus butterfly in a xerophilous calcareous sub-oceanic lawn.

APPENDIX 3 - INVASIVE ALIEN SPECIES
(SOURCE : [38], [39], [40], [41])

The following is a non-exhaustive list of the main invasive alien plant species (IAS) in France area, to watch out for in grasslands such as airport grasslands, and some management advice to follow to eliminate them or limit their spread.

- Tree of heaven (Ailanthus altissima)
- Redroot pigweed (Amaranthus retroflexus)
- Common ragweed (Ambrosia artemisiifolia)

How to get rid of/limit its spread: uproot before August, when the plant is pollinated. Mowing or shredding is preferable in case of large quantities. Composting plants, even with seeds, is not a problem. Beware of transporting soil from contaminated areas.

- Butterfly bush/summer lilac (Buddleja davidii)
- Himalayan balsam (Impatiens glandulifera) and orange balsam/orange jewelweed (Impatiens capensis)

How to get rid of/limit its spread: manual removal of the whole plant for reduced populations. Mowing with a brush cutter in case of invasion. Be careful to cut short under the first node and not to cut in several sections to avoid the risk of cuttings.

- Giant Hogweed (Heracleum mantegazzianum)

How to get rid of/limit its spread: Hand-pulling on young plants (the plant has a life span of 3 years), otherwise on large populations, mowing before flowering (April of the 3rd year), and reducing the soil around the collar to dry out the plant. Wear gloves and clean cutting tools (sap is irritating to the skin in the presence of ultraviolet light).

- Spottet spurge (Euphorbia maculata)
- Prickly pear/fig opuntia (Opuntia Ficus indica)

How to get rid of/limit its spread: Mechanical control of Opuntia can be considered. This is done with a mechanical shovel and allows the whole plant to be pulled out and to avoid re-growth. Manual treatment is carried out with forks. The aerial part is first cut, then the roots are pulled out.

- Pampas grass (Cortaderia selloana)

How to get rid of/limit its spread: As this plant spreads the numerous seeds from its feathers with the wind, it is advisable to cut the feathers before seeds maturing.

Figure 69 – Pampas grass.

- Dallisgrass/sticky heads (Paspalum dilatatum) and water fingergrass/Thompson grass (Paspalum distichum)

How to get rid of/limit its spread: this is a grass that spreads its seeds with the wind. Eliminating it is tedious and of little use in airport grassland, as it only likes very wet environments (edges of watercourses or ponds).

- American pokeweed (Phytolacca americana)

How to get rid of/limit its spread: cut at the base or mow before flowering. Early removal is ideal, so that it does not re-grow from the foot; crush flower clusters regularly before fruiting to limit dispersal by seed-feeding birds.

Figure 70 – American pokeweed in flower and beginning of fruiting.

- Japanese knotweed (Reynoutria japonica)

How to get rid of/limit its spread: repeated mowing before fruiting, if sexual reproduction is suspected (which is not the main source of reproduction in France: this plant reproduces there mainly by cuttings and dissemination of rhizomes); laying geotextiles and regular uprooting; replanting with woody competitors, a method that is not suitable for all airport grassland areas. Care should be taken with the transport of soil contaminated with knotweed remains/fragments, and stems left on wet land, which are major factors in the spread of the plant.

Figure 71 – Japanese knotweed in flower.

- Black locust (Robinia pseudoacacia)

- Eastern bacharis (Bacharis halimifolia)

- Narrow-leaved ragwort (Senecio inaequidens)

How to get rid of/limit its spread: manual uprooting for young plants of the year, digging up at the collar of the largest plants to avoid stump sprouting, cutting and gyro-cutting possible in the event of heavy colonization, until the stumps and seed bank are exhausted. If grubbing is not possible, cutting must be done before flowering (February-March).

- Canada goldenrod (Solidago canadensis) and giant goldenrod (Solidago gigantea)

How to get rid of/limit its spread: Manual removal of the plants before flowering and disposal by incineration. Be careful to put the pulled plants directly into a container. If the areas are too large, mow twice a year before the seeds mature and dispose of the mowing waste.

- Tall flatsedge (Cyperus eragrostis)
- Staghorn sumac (Rhus typhina)

How to get rid of/limit its spread: The Staghorn sumac reproduces mainly vegetatively and spreads rapidly by suckering. Root fragments detached from the plant can form a new individual. Rapid intervention is necessary (pruning or uprooting, depending on the means available). Be careful not to cut the roots into several sections to avoid the risk of cuttings.

- Annual fleabane (Erigeron annuus) and Canadian horseweed/Canadian fleabane (Erigeron canadensis)

How to get rid of/limit its spread: Control bare areas, immediately remove new plants, quickly revegetate bare ground with native species. Do not mow the fleabane after the seeds have matured as the wind spread the seeds over miles (flowering June to October).

Figure 72 – Canada fleabane.

BIBLIOGRAPHY

[1] IBPES, « Rapport de l'évaluation mondiale de la biodiversité et des services écosystémiques, résumé à l'intention des décideurs » ;

[2] OFB, Vigie Nature, MNHN, BirdLife, LPO, Agir pour le Biodiversité, « Suivi des oiseaux communs en France - Résultats 2019 des programmes participatifs de suivi des oiseaux communs », https://www.vigienature.fr/sites/vigienature/files/atoms/files/syntheseoiseauxcommuns2020_final.pdf ;

[3] UICN Comité Français, OFB, MNHN, « La liste rouge des espèces menacées en France : 13 ans de résultats », https://uicn.fr/wp-content/uploads/2021/03/bilan-13-ans-liste-rouge-nationale.pdf

[4] Muséum National d'Histoire Naturelle, « Près de 30 espèces d'oiseaux en moins dans 30 ans dans les villes et les campagnes françaises », https://www.mnhn.fr/fr/actualites/pres-de-30-d-oiseaux-en-moins-en-30-ans-dans-les-villes-et-les-campagnes-francaises ;

[5] Aéro Biodiversité, Résultats des relevés, https://aerobiodiversite.org/resultats ;

[6] Cerema, « Adapter la gestion des bords de route pour préserver les insectes pollinisateurs sauvages. », Bron : Cerema, 2021. Collection : Références. ISBN : 978-2-37 180-520-0 (pdf)

[7] H.Mouret, D.Provendier, S.Malaval, J.Millet, « Face au déclin des pollinisateurs sauvages, des clés pour agir localement », OFB, revue Biodiversité des clés pour agir, n° 1, avril-juin 2022 : https://www.ofb.gouv.fr/sites/default/files/Fichiers/Plaquettes%20et%20rapports%20instit/revue-biodiversite1-pollinisateurs.pdf

[8] Ministère de la transition écologique et de la cohésion des territoires, 2022, « Plan National Pollinisateurs 2021-2026 », https://www.ecologie.gouv.fr/lancement-du-nouveau-plan-national-pollinisateurs-2021-2026

9] Kindt A., Institut du Développement Durable et Responsable, « Dix principes et concepts essentiels en écologie, application des principes aux milieux urbains », http://www.biodiversite-positive.fr/succession-ecologique-dynamique-des-milieux/ ;

10] Maire O., cours année 2101-2011, Licence 3 biologie des organismes, « Les successions écologiques, développement et évolution des écosystèmes », https://www.doc-developpement-durable.org/file/Culture/Arbres-Bois-de-Rapport-Reforestation/forets-preservation-restoration/successions-ecologiques/Les-successions-ecologiques.pdf ;

[11] Gloaguen J.-C., Rozé F., Touffet J., Clément B., Forgeard F., « Etude des successions après abandon des pratiques culturales en Bretagne », https://www.tandfonline.com/doi/pdf/10.1080/12538078.1994.10515230 ;

[12] Site de la marque Végétal Local de l'Office Française de la Biodiversité, https://www.vegetal-local.fr/

[13] Chambre d'Agriculture du Tarn, « Méthode de récolte et d'implantation de semences issues de prairies naturelles », guide technique, 22p., https://tarn.chambreagriculture.fr/fileadmin/user_upload/Occitanie/074_Inst-Tarn/1-PRODUCTIONS_TECHNIQUES/Elevage/Prairies_et_fourrages/guide_illustration_YP.pdf ;

[14] Koch E-M., Spiegelberger T., Barrel A., Bassignana M., Curtaz A., « Les semences locales dans la restauration écologique en montagne, Production et utilisation de mélanges pour la préservation », 98 p., https://www.actu-environnement.com/media/pdf/news-28789-semences-locales-montagne.pdf ;

BIBLIOGRAPHY

[15] ADSTD, Noremat, Grand Lyon SETRA, CETE de l'Est, CETE Normandie Centre, Note d'information du Setra – Série Chaussées Dépendances n° 122 « Fauchez mieux, le fauchage raisonné. », septembre 2009, https://dtrf.cerema.fr/pdf/pj/Dtrf/0005/Dtrf-0005639/DT5639.pdf?openerPage=notice ;

[16] Čop, Vidrih & Hacin, 2009, « Influence of cutting regime and fertilizer application on the botanical composition, yield and nutritive value of herbage of wet grassland in Central Europe. », Grass and Forage Science 64, 454-465 ;

[17] AGRIDEA, « Techniques de récolte des prairies et diversité des espèces », https://agridea.abacuscity.ch/abause-rimage/Agridea_2_Free/1440_4_F.pdf ;

[18] CEMAGREF, 1994, « Projet de gestion des déchets verts », 77p., p.7, https://www.hauts-de-france.developpement-durable.gouv.fr/IMG/pdf/projet-gestion-dechets-verts-2001.pdf ;

[19] Fiche Noremat, mai 2019, 6p., « Fauchage avec exportation : produire de l'énergie avec l'herbe de nos routes » https://www.noremat.fr/fr/pages/bonnes_pratiques_pdf/fauchage_avec_collecte.pdf ;

[20] UAF & FA, Groupe AFP, DGAC, Syrphea Conseil, 2022, « Aéroports en zéro phyto : comment mener la transition zéro phyto en contexte aéroportuaire ? », https://xrm.eudonet.com/XRM/at?tok=B68DF156&cs=SEZCpsM48jhJwwZT3ibD4p_cIdIy6I994IDkZhdpk63MS23VcqfkzNl9mhdax0HR&p=26qteH2RHB6-a3FNhtbpT5aIItTif81rYq6kccPVcOcKMQ5P97LuucBf6vdfLP8ralnilmHos4I%3d ;

[21] Collectif du Lac de Créteil, Enfora, EPTB Gardons, « Gérer les espaces enherbés avec la fauche différenciée : intérêts économique, social et écologique », 18 p., https://laccreteil.fr/IMG/pdf/605614.pdf?2061/53444f1412a8925ce9bf0048bfb6d1e866fca8ab ;

[22] Doc 9137 OACI Manuel des services d'aéroport, 9ème partie « Maintenance », 01.03.2011.

[23] Association Nord Nature Chico Mendes, « Qu'est-ce que le projet "Gestion différenciée et biodiversité" ? », https://www.nn-chicomendes.org/nos-actions/la-mission-gestion-differenciee/gestion-differenciee-et-biodiversite ;

[24] BdM, Portail wallonie.be, "Le fauchage en gestion différenciée", guide du Pôle Wallon de fauchage différencié, http://biodiversite.wallonie.be/fr/la-gestion.includehtml?IDC=3655 ;

[25] Fiche Airele, econetwork.eu, 19p., « Gestion différenciée des espaces verts : Une démarche environnementale et paysagère à coût maîtrisé pour les entreprises et parcs d'activités », https://www.finistere.fr/var/finistere/storage/original/application/817ab153420596113f4d5f2ff879a999.pdf ;

[26] NATAGORA, « Prairies de fauche, prairies fleuries. Fiche de gestion – réseau nature. », https://reseaunature.natagora.be/fileadmin/Projet_Reseau_Nature/Fiches_conseils/Gestion_Prairies_Fleuries_Fauches.pdf ;

[27] Belghali S., Le Goff C., Ferrier C., Lacondemine A., Soufflot P., Broyer J., « Fauche retardée en faveur de l'avifaune prairiale : 11 ans d'expérimentation dans le Val de Saône », magazine Faune Sauvage/OFB, n°327 juillet-septembre 2020, pp. 45-50, https://www.researchgate.net/publication/359295105_Fauche_retardee_en_faveur_de_l%27avifaune_prairiale_11_ans_d%27experimentation_dans_le_Val_de_Saone ;

[28] Broyer J., Belghali S., Le Goff C., Ferrier C., Soufflot P., 2020, « Spatial convergence of meadow passerine territory distribution with mowing delay : an experiment in lowland grasslands. », Journal of ornithology 161 : 769-778, http://doi.org/10.1007/s10336-020-01764-x ;

[29] Humbert et al, 2012, « Does delaying the first mowing date benefit biodiversity in meadowland ? », « L'influence de la date de fauche d'une prairie retardée sur la biodiversité », Environmental Evidence, 1-9 ;

BIBLIOGRAPHY

[30] Buri P., Humbert J.-Y., Stańska M., Hajdamovicz I., Tran É., H. Entling M., et al., 2016, « Delayed mowing promotes planthoppers, leafhoppers and spiders in extensively managed meadows. », Insect Conservation and Diversity ; Buri P., Humbert J.-Y., Unternährer D. & Arlettaz R., 2018, « Des régimes de fauche alternatifs pour favoriser la biodiversité des prairies. » Recherche Agronomique Suisse 9, 314-321 ;

[31] Annexe 14 de l'OACI chapitre X « Entretien de l'aérodrome », 9ème édition, 15.11.2022 ;

[32] Doc 9137 OACI Manuel des services d'aéroport, 3ème partie « Prévention et atténuation du risque faunistique », 5ème édition, janvier 2020 ;

[33] Règlement UE n° 139/2014 partie ADR.OPS : AMC1 ADR.OPS.B.020 Réduction des dangers liés aux impacts d'animaux et GM2 ADR.OPS.B020 (d) qui traite du programme de gestion du risque animalier et qui propose un processus de gestion des sols et des habitats sur l'aérodrome, 12.02.2014 ;

[34] Guide technique "Evaluation et suivi de la biodiversité sur un aérodrome", Service Technique de l'Aviation Civile, Septembre 2020 ;

[35] Site Nuit France, article La Nuit Naturelle, http://www.nuitfrance.fr/?page=nuit-naturelle&partie=biodiversite-nocturne ;

[36] Magazine OFB n° 1 avril-juin 2022, « Biodiversité, des clés pour agir », pp.46-48 ;

[37] C. Tapia, S. Guerreiro, M. Mendizabal, C. Kilsby, octobre 2015, « High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU », 123 p., https://www.researchgate.net/publication/293619546_High_level_quantified_assessment_of_key_vulnerabilities_and_priority_risks_for_urban_areas_in_the_EU ;

[38] Haury J., Matrat R., Hudin S., Lambert E., Anras L., Dutartre A., Bottner B., Gentil E., Gressette S., Loriot S. et al. (HAL Open Science), « Manuel de gestion des plantes exotiques envahissant les milieux aquatiques et les berges du bassin Loire-Bretagne », 01/12/2018, 156 p. ;

[39] Centre régional de phytosociologie agréé, conservatoire botanique national de Bailleul, « Plantes exotiques envahissantes du Nord-Ouest de la France, 30 fiches de reconnaissance et d'aide à la gestion », http://cen-normandie.fr/sites/default/files/fichiers/30_fiches_de_reconnaissance_-_plantes_exotiques_envahissantes_du_no_de_la_france_-_cbnbl-.pdf ;

[40] Cornic C., Urien E., Abraham H., Roche H., Monjoin T., « Rapport National Aéro Biodiversité 2021 », 2021, 86 p., https://aerobiodiversite.org/wp-content/uploads/2022/02/Rapport-National-2021.pdf ;

[41] Site des espèces exotiques envahissantes : http://especes-exotiques-envahissantes.fr/ ;

Bosshard A., 1999, Thèse, « Renaturierung artenreicher Wiesen auf nährstoffreichen Böden », en français « Restauration de prairies riches en espèces sur un sol riche en éléments nutritifs », https://biodivers.ch/fr/index.php?title=Milieux_prairiaux/Revalorisation_et_cr%C3%A9ation_de_prairies_riches_en_esp%C3%A8ces_par_enherbement_direct_et_ensemencement&mobileaction=toggle_view_mobile ;

DGARNE, DEMNA, FUSAGx, UCL, ULg, « Catalogue des espèces et habitats des sites Natura 2000 de la région Wallonne », 2 p. http://biodiversite.wallonie.be/fr/liste-des-especes-de-la-directive-habitats-en-wallonie.html?IDD=1671&IDC=832 ;

Amor E., Faverot P., Conservatoire d'Espaces Naturels Rhône-Alpes, Les cahiers techniques, octobre 2017, « Les prairies humides de fauche », 16p., p 4. ;

BIBLIOGRAPHY

Béguin L., Le Mell B., Girard L., Da Silva L., Ferrer M.-L., association Nature Vivante, 2013-2014, « Connaissance et préservation des pelouses sèches – Isère Rhodanienne et Bonnevaux », 136 p., https://www.scot-rivesdurhone.com/wp-content/uploads/2015/07/Inventaire-pelouses-s%C3%A8ches.pdf ;

M. Duru, P. Cruz, J.-P. Theau, C. Jouany, P. Ansquer, R. Al Haj Khaled, O. Therond, 2007, « Typologies de prairies riches en espèces en vue d'évaluer leur valeur d'usage : bases agro-écologiques et exemples d'application », 24 p. ;

Louvel J., Gaudillat V. & Poncet L., 2013. EUNIS, European Nature Information

System, Système d'information européen sur la nature. Classification des habitats. Traduction française. Habitats terrestres et d'eau douce. MNHN-DIREV-SPN, MEDDE, Paris, 289 p., https://inpn.mnhn.fr/docs/ref_habitats/EUNIS_trad_francais.pdf ;

Revue RELIEF n° 13 « Prairies » ;

Fournier F, Sasson A., ORSTOM, UNESCO, « Ecosystèmes forestiers tropicaux d'Afrique », https://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers07/16575.pdf ;

Base de données des produits phytopharmaceutiques utilisables dans le cadre de la loi Labbé : https://www.ecophyto-pro.fr/n/base-de-donnees-des-produits-utilisables-dans-le-cadre-de-la-loi-labbe/n:325 ;

Site Pesweb Canada – fiche de données de sécurité du flazasulfuron : https://pestweb.ca/assets/files/productdocuments/doc_031AB860C95FF1F9D362D739387593D0E1BB18B4.pdf ;

Pruvôt A., Zakeossian M., service Protection de la ressource d'Eau de Paris, Thieblemont E., Julié K., service Communication d'Eau de Paris, « Valoriser la biodiversité à Eau de Paris », guide technique, http://www.eaudeparis.fr/uploads/tx_edpevents/GuideGestionEcologique.pdf ;

Crémer S., extrait de « La gestion des prairies » note de cours 2014-2015, « L'entretien des prairies », http://www.fourragesmieux.be/Documents_telechargeables/Entretien_prairie_Cremer_2015.pdf ;

Luxen P., Knoden D., Crémer S., « L'entretien des prairies permanentes », Fourrages Mieux, Région Wallone, Département d'économie rurale du Luxembourg, https://www.latelierpaysan.org/IMG/pdf/entretien-prairies.pdf ;

Coulombel A., Pierre P., Deleau D., Osson B., « Quel entretien pour les prairies permanentes ? », ITAB, Chambre d'Agriculture de la Mayenne, ARVALIS Institut du végétal, GNIS, https://abiodoc.docressources.fr/doc_num.php?explnum_id=1576 ;

Cornic C., De Chateauvieux K., Guerrier T., Herledan V., Jullien L., Monjoin T., Muller D., Oury Y., Seitre J., Seitre R., Urien E., « Rapport Aéro Biodiversité 2020 », 2020, 79 p., https://aerobiodiversite.org/wp-content/uploads/2021/02/Rapport_National_2020.pdf ;

Schweigert N., Felgines A., Guide technique du STAC, septembre 2020, « Évaluation et suivi de la biodiversité sur un aérodrome », 62 p., p. 14-16. ;

Schiess-Bühler C. (AGRIDEA), Frick R. (ART), Tänikon R., Stäheli B. (AGRIDEA), Furi R. (ALP), « Techniques de récolte des prairies et diversité des espèces », AGRIDEA, 8P., https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjv0JKuzOb3AhVKif0HHYxIAgUQFnoECAcQAQ&url=https%3A%2F%2Fagridea.abacuscity.ch%2Fabauserimage%2FAgridea_2_Free%2F1440_4_F.pdf&usg=AOvVaw3rO0DRJCvqhHY6USlliKqU ;

BIBLIOGRAPHY

Deleau D. (Arvalis-Institut du Végétal), Desmoniere E. (AFPF), Knoden D. (Fourrages-Mieux), Pavie J. (Idele), Pierre P. (Idele), Osson B. (Gnis), Uijttewaal A. (Arvalis- Institut du végétal), Duhaut A.-L. (FrCUMA Bretagne) « Entretien mécanique des prairies : pourquoi ? Comment ? Et pour quels bénéfices ? », AFPF (Association Francophone pour la Prairie et les Fourrages), 16p., https://afpf-asso.fr/_objects/tao_medias/file/guide-entretien-20022020-erratum-3814.pdf?1582190193 ;

Fourrages Mieux ASBL, synthèse 2012, « Le matériel de fauche », 2p., http://www.fourragesmieux.be/Documents_telechargeables/FT_Materiel_de_fauche.pdf ;

Zoneshumides29.fr, « les outils de fauchage », http://www.zoneshumides29.fr/telechargement/GTAGZH_Outils_fauchage_032012.pdf ;

N.H., Le Sillon Belge, article « Quelles questions dois-je me poser avant d'acquérir une nouvelle faucheuse ? », 14/04/2018, https://www.sillonbelge.be/2321/article/2018-04-14/quelles-questions-dois-je-me-poser-avant-dacquerir-une-nouvelle-faucheuse ;

Hauteclair P., février 2018, Fiches de gestion réseau nature, Natagora, « Prairies de fauche, prairies fleuries », 24 p., https://reseaunature.natagora.be/fileadmin/Projet_Reseau_Nature/Fiches_conseils/Gestion_Prairies_Fleuries_Fauches.pdf ;

Vonesch A., Astric A., Brunissen E., Forestier N. & Leroy M.-M., réseau Alsace Nature, 48 p., « 10 principes de gestion des zones herbeuses pour épargner la faune et la flore », https://ftp.alsacenature.org/COM/RESEAUX-THEMA/agri/10Principes-gestion-herbe-WEB.pdf ;

Dumont B., Farruggia A. (INRA, Unité expérimentale de Marcenat), Garel J.P. (INRA, Unité de recherches sur les herbivores), « Pâturage et biodiversité des prairies permanentes », 2007, 8 p., http://www.journees3r.fr/IMG/pdf/2007_01_environnement_01_Dumont.pdf ;

Marion B., « Impact du pâturage sur la structure de la végétation : Interactions biotiques, traits et conséquences fonctionnelles », Université Rennes 1, 2010, 236 p., https://tel.archives-ouvertes.fr/tel-00566651/document ;

V.V., Pôle wallon de gestion différenciée asbl, portail anthropologia.org, « Le fauchage », novembre 2015, 6 p., https://www.arthropologia.org/user/pages/02.association/05.ressources/36.guide-fauchage-gestion-differenciee/Guide%20fauchage%20gestion%20diffe%CC%81renciee.pdf ;

AGRIDEA, « Des bandes de prairie non fauchées pour favoriser la biodiversité », 2007, https://www.agraroekologie.ch/wp-content/uploads/2017/01/1472_4_F.pdf ;

Pillet S., BTEE SA, 2019 : « Biodiversité et compensation écologique sur les aérodromes. Aide à l'exécution. » Office fédéral de l'environnement et Office fédéral de l'aviation civile, Berne. L'environnement pratique n° 1906, 61 p. ;

Besse L., 2011, Service Technique de l'Aviation Civile, « Péril animalier et environnement des aérodromes » ;

Brussolo T., De Julien De Zelicourt S., Printemps A., DGAC, 2013, « Clôtures aéroportuaires dans le cadre de la prévention du péril animalier – Guide à l'attention des gestionnaires de la faune sur les aérodromes », pp. 17-19 ;

Etude commandée par la DGAC en 2016 et réalisée sur l'aéroport de Roissy-CDG par APEX, CREXECO, VertAgroSup et Cart&Cie, « Prévention du risque animalier – développement d'un couvert herbacé destiné à la prévention du risque animalier sur les aérodromes » ;

Etude commandée par la DGAC en 2018 et réalisée sur la plate-forme de la DGA à Fonsorbes (31) par CREXECO. « Prévention du risque animalier – développement d'un couvert herbacé destiné à la prévention du risque animalier sur les aérodromes » ;

Pillet S., BTEE SA, première édition 2015 : « Manuel international de recommandations pour la gestion du risque animalier sur les aéroports », 184 p., ISBN 978-2-9 700 977-0-9 ;

WEBOGRAPHY

Barenbrug trademark site:

- Choix des gazons : https://gazon.barenbrug.fr/professionnel/paroles-dexperts/les-gazons-comment-les-choisir ;
- Culture du Koeleria Macrantha Barkoel - mars 2018 - juillet 2019 : https://gazon.barenbrug.fr/professionnel/paroles-dexperts/culture-du-koeleria-macrantha-barkoel-mars-2018-juillet-2019 ;
- Station de recherche : https://www.youtube.com/watch?v=az9a8MdX61Q ;

Base de données en ligne des variétés de gazon : https://www.choixdugazon.org/ ;

Site de la SEMAE, interprofession des semences et plants : https://www.semae.fr/semences-fourrageres-gazon/ ;

Agriculture84.fr, « Les différentes sortes de faucheuses », 4 décembre 2020, https://agriculture84.fr/faucheuses/ ;

Régions biogéographiques d'Europe : https://www.pngwing.com/en/free-png-dszxp ;

Zones climatiques en France : https://www.researchgate.net/figure/Map-of-European-climate-zones-and-recommended-energy-crops-Source-4FCROPS-Continental_fig4_312591611 ;

Vidéo : « L'entretien des terrains sportifs pour tendre vers le zéro phyto » : https://www.youtube.com/watch?v=KiUxMBrlKm8 ;

Site santé Canada, Projet de décision d'homologation PRD2019-15 de l'acide pélargonique : https://www.canada.ca/fr/sante-canada/services/securite-produits-consommation/pesticides-lutte-antiparasitaire/public/consultations/projets-decision-homologation/2019/acide-pelargonique-herbicide-beloukha/document.html ;

Webmedia L'ADN, article : « La SNCF abandonne le Glyphosate au profit de l'acide pélargonique » : https://business.ladn.eu/news-business/actualites-annonceurs/groupe-sncf-abandonne-glyphosate-pour-desherbant-naturel/ ;

Perméabilité des sols : https://www.fao.org/fishery/docs/CDrom/FAO_Training/FAO_Training/General/x6706f/x6706f09.htm ;

Chambre d'Agriculture du Tarn : https://tarn.chambre-agriculture.fr/agroenvironnement/biodiversite/biodiversite-utile/prairies-naturelles/ ;

GLOSSARY

A

EAESA = ASA
European Union Aviation Safety Agency

ARFS = RFFS
Aircraft rescue and firefighting service

C

CEN
Conservatoire des Espaces Naturels, is responsible for collection of natural grassland seeds on airports

CEREMA
Center for Studies and Expertise on Risk, Environment, Mobility and Development

CUMA
Cooperative for the Use of Agricultural Equipment

D

DREAL
District Direction for Environment, Planning and Housing

E

ERC = ARC
Avoid - Reduce - Compensate sequence

I

IAS
Invasive Alien Species

ICAO = OACI
International Civil Aviation Organization

IPBES
Intergovernmental scientific and Policy platform on Biodiversity and Ecosystem Services

IUCN = UICN
International Union for Conservation of Nature

L

LPO = LPB
League for the Protection of Birds

LTI
Linear Transport Infrastructures

M

NMNH = MNHM
National Museum of Natural History

O

OFB = FOB
French Office for Biodiversity

ORE = REO
Real Environmental Obligations

S

SAU = UAS
Useful Agricultural Surface

SETRA
Transport Research Department

SPPA/SPRA
Wildlife Hazard Management Unit

SSLIA = ARFS=RFFS
Aircraft rescue and firefighting service = Rescue and Fire Fighting Service

STH = PGA
Permanent Grass Areas

U

UGB = LU
Livestock Unit

V

VOR-DME
VHF Omnidirectional Range + Distance Measuring Equipment (2 coupled devices)

DEFINITIONS

A

Acidicline or acidocline
Likes rather acid soils

Adventice
Also called weed, it refers to a plant that grows in a place without having been intentionally installed there

Annelids
Commonly known as worms

Arachnids
A sub-branch of the arthropods. Examples: spiders, mites, scorpions

Arthropods
Invertebrates with a body made up of jointed segments

Asphodel
Perennial plants with flowers grouped in clusters that bloom from the bottom up

Avifauna
All birds

B

Basicline
Grassland Flora developing on rather basic soils

C

Calcicole
Vegetation that likes calcareous soil

Columbidae
A family of birds including doves, pigeons and turtle doves

Conditioner
Added to a mower, this tool accelerates the drying of the forage by breaking up the fibres

D

Dicotyledonous
As opposed to Monocotyledonous, a plant family whose seed has two cotyledons, i.e. two primordial leaves present in the seed before it germinates.

E

Entomofauna
All insects

G

Grass
Any plant with tiny flowers grouped in spikes, with a hollow stem

Green and blue frameworks
A land-use planning policy aimed at preserving ecosystems and combating the loss of biodiversity. To this end, the framework forms a network of natural or semi-natural elements, both terrestrial ("green framework") and aquatic ("blue framework"), the objectives of which include preserving or even restoring the ecological continuities that are essential for the movement of species and the proper functioning of ecosystems, while at the same time allowing the development of human activities.

H

Herbicide
Product that destroys weeds

I

Inflorescence
The arrangement of flowers on the stem of a flowering plant. For example, the spike is a single inflorescence.

Inputs
Products brought to the land that do not come from the farm or its vicinity. They are not naturally present in the soil but are added to improve crop yields.

M

Megaphorbia
A wet wasteland composed of tall plants

Mesophilic
Refers to plants that thrive best under average conditions of the drought-wetness gradient

Meso-xerophytic
Refers to plants that thrive in dry environments but are not resistant to extreme drought

N

Nemoral zone
Between the boreal and Mediterranean zones in Europe

O

Orthoptera
Insects characterised by wings aligned with the body (e.g. locusts)

R

Ruderal environments
Spaces generally linked to gravelly filtering soils colonised by pioneer plant species tolerating very poor and dry soils

S

Silicolous grassland
A grassland that grows well in an acidic siliceous environment

Silt soil
Soil rich in silt. This particular soil has been deposited by alluvial deposits. It is the opposite of sandy soil and clay soil

Stolon plant
A plant that produces creeping aerial stems (e.g. strawberry plant)

T

Transgenic plants
Genetically modified plants

W

Woody
A plant containing sufficient lignified bundles to make its stems strong and wood-like

X

Xerophytic
Grassland that grows well in an acidic siliceous environment

ACKNOWLEDGEMENTS

STAC would like to thank all the airport operators and green space managers in airports who participated in the survey on their grass management practices. The quality of the discussions was essential to the construction of this publication.

STAC would also like to thank the CENs of New Aquitaine and Savoie as well as the company Semence Nature for sharing their practices relating to the harvesting of seeds on airport grasslands.

Finally, the STAC would like to thank the Aéro Biodiversité association and the BTEE SA company for their valuable feedback on the proofreading of the guide.

Design : STAC/Département Administration, Système d'Information et Diffusion

Cover picture © Constance **ANELLI** DGAC/STAC

Picture credits: © Constance **ANELLI** DGAC/STAC, Fig. 12, 25, 27, 38, 41, 69
© Sylvain **CAMBON** DGAC/STAC, Fig. 39
© Yann **DELBORT** Communauté d'Agglomération du Bassin d'Aurillac, Fig. 35
© François **GIANNONE** DGAC/STAC, Fig. 43
© Marta **GIORDANO** DGAC/STAC, Fig. 15, 28 30
© Maxime **LEFÈVRE** DGAC/STAC, Fig. 8, 10, 13, 14, 16, 17, 18, 19, 20, 21, 22, 29, 31, 55, 57, 58, 64, 65, 66, 68, 70, 71, 72
© Benoît **MARS** DGAC/STAC, Fig. 33
© Richard **METZGER** DGAC/STAC, Fig. 1, 2, 7, 9, 24, 34, 37, 40, 44 ,45
© F. **NAVEAU** SPW, Fig. 42
© Roland **SEITRE** Aéro Biodiversité, Fig. 25
©AdobeStock, Fig. 52, 63
© DGAC/STAC, Fig. 67
© https://greentech.eu/fr, Fig. 26
© DGAC/STAC, Fig. 67

Graphics credits: © Constance **ANELLI** DGAC/STAC, Fig. 6
© Maxime **LEFÈVRE** DGAC/STAC, Fig. 12, 23, 25, 32
© DGAC/STAC, Fig. 3, 47, 51
© LPO, MNHM, OFB, Fig. 4
© UICN, Fig. 5
© Ministère de l'Agriculture, IGN, GeoGla, Fig. 11
© Aéro Biodiversité, Fig. 36
© Aéro Biodiversité/Aéroport Bastia-Poretta, Fig. 46

© High level quantified assessment of key vulnerabilities and priority risks for urban areas in the EU [36], Fig. 48
© https://imgur.com/a/wbsFqUG, Fig. 49
© https://www.pngwing.com/en/free-png-dszxp, Fig.50

March 2023

Direction générale de l'Aviation civile
service technique de l'Aviation civile
CS 30012 - 31 avenue du Maréchal Leclerc
94 385 Bonneuil-sur-Marne CEDEX FRANCE
Téléphone : 01 49 56 80 00
www.stac.aviation-civile.gouv.fr
www.ecologie.gouv.fr