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Methodological support to the analysis of pressures in and around Natura 2000 sites selected for the Copernicus Local Component on Grasslands

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1 Introduction

The ETC task 1.7.5.A foresees the support of the EU Biodiversity Strategy via a range of activities. One of them is the exploration of Copernicus data in the context of biodiversity related information needs.

During the Copernicus Initial Operations 2011 – 2013 the European service industry produced a land cover / land use mapping of a selection of Natura 2000 (N2000) sites as part of the "local component[1]" of the European land monitoring service.

A selection of N2000 grassland-rich sites (5 grassland habitats types 6210, 6240, 6250, 6510 and 6520, including a 2km buffer and covering approx. 160.000 km^2) was mapped using a 55 class MAES nomenclature in order to assess their spatial extent, their condition and their development over time.

In February 2017, a second round of N2000 grassland related production was started, extending the number of sites and covering 300.000 km^2. The further analysis of this updated layer has been agreed as part of the 2018 ETC BD action plan. The full extent of mapped sites will be made available from May 2019 onwards and will cover approx. 630.000 km^2.

The present task is a continuation of the 2017 change analysis carried out by space4environement© which focused on a comparison of changes within the N2000 sites directly and within the associated 2km buffer radius which is not part of the actual protection network.

Due to the circumstance that the Copernicus Service Provider mapping the Grassland layer has also been contracted to provide a change analysis the aim of the current activities is focused on exploring methods to integrate and link native N2000 pressure data with the land cover (LC) mapping in order to establish a closer link of the on-ground information with remotely sensed mapping. The developed knowledge may then be integrated within the change analysis of the final product.

Pressures within the N2000 network are recorded by local experts on the basis of an established reference list[2]. Pressure assessments for sites are provided with a specific code characterising the pressure, its intensity provided on a three-level ordinal scale (low, medium, high) as well as location (inside / outside of site boundary) and type, which may be positive or negative (e.g. mowing can be both positive and negative depending on conservation goals of site).

Potential links between ordinal scaled pressures from the native N2000 database with physical on-ground changes, could serve to compare recorded and mapped pressures and ultimately add a spatial dimension in terms of amount of affected area and location towards these expert judgements.

This knowledge could then be used to address specific environmental impact developments in grassland rich sites or simply to provide a more fact-based grounds for discussion revolving around grassland pressures.

Although the combination of the native N2000 data and the ongoing mapping of grassland rich sites bears a large potential there are many pitfalls to consider. This report conceptualises a methodology to combine both datasets and moreover proposes some concrete suggestions for the planned change analysis which is based on the product.

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[1] Now referred to as "Hot spot monitoring"

[2] Reference list for threats, pressures, activities: https://bd.eionet.europa.eu/activities/Natura_2000/Folder_Reference_Portal/Ref_threats_pressures_FINAL_20110330.xls

2 Objectives

The current report addressed three main goals. The report is structured accordingly.

1. Mapped versus recorded pressures within selected grassland sites: Comparative assessment of pressures defined on the basis of remotely sensed grassland mapping and those recorded within the database.
2. Creation of N2000 pressure /MAES nomenclature linkages database: Collection of identified links between mapped and native N2000 pressure information to construct a database which connects changes of land cover classes to those pressures recorded within the N2000 database.
3. Provide suggestions for upcoming change analysis methodology.

3 Input datasets

Table 3.1 lists the input datasets which were processed within the present analysis. Thereinafter, the pressures database are more closely described.

Table 3.1 List of input datasets

Dataset	Description	Link
Natura 2000 database	The Natura 2000 2012 database IMPACT table. This table contains the ordinal scaled. pressure assessments	https://www.eea.europa.eu/data-and-maps/data/natura-3#tab-gis-data
Natura 2000 GIS Data	Spatial representation of Natura 2000 2012 site polygons.	https://www.eea.europa.eu/data-and-maps/data/natura-3#tab-gis-data
Ref_threats_pressures_FINAL_20110330.xls	Reference list of threats, pressures and activities within N2000 sites.	https://bd.eionet.europa.eu/activities/Natura_2000/Folder_Reference_Portal/Ref_threats_pressures_FINAL_20110330.xls
Natura 2000 Grasslands	Copernicus Natura 2000 local components.	https://land.copernicus.eu/local/natura/natura-2000-2012

3.1 The Natura 2000 pressure database

The reference list for the pressures and threats recorded within the Natura 2000 IMPACT table (hereinafter referred to as N2000-DB) is available online and contains over 400 different pressures organised into 16 different categories. These categories will be hereinafter referred to as "pressure groups". Figure 3.1 Example of the pressure data contained within the IMPACT table of the N2000 dataset. Pressures are categorised using a reference list (IMPACTCODE). An assessment of their intensity, their location and nature (negative/positive) are also provided shows an excerpt of the N2000-DB.

IMPACT

SITECODE	IMPACTCODE	DESCRIPTION	INTENSITY	POLLUTIONCODE	OCCURRENCE	IMPACT_TYPE
AT1101112	B01	forest planting on open ground	HIGH		OUT	N
AT1101112	A04	grazing	HIGH		IN	P
AT1101112	A03	mowing / cutting of grassland	HIGH		IN	P
AT1102112	F06	Hunting, fishing or collecting activities not referred to above	MEDIUM		IN	N
AT1102112	B	Sylviculture, forestry	MEDIUM		IN	N
AT1102112	A07	use of biocides, hormones and chemicals	MEDIUM		IN	N
AT1102112	A08	Fertilisation	MEDIUM		IN	N
AT1102112	A04	grazing	MEDIUM		IN	P
AT1102112	A03	mowing / cutting of grassland	MEDIUM		IN	P
AT1103112	E02	Industrial or commercial areas	MEDIUM		OUT	N
AT1103112	A03	mowing / cutting of grassland	HIGH		IN	P
AT1103112	G05	Other human intrusions and disturbances	HIGH		-	N
AT1103112	C01.01	Sand and gravel extraction	MEDIUM		OUT	N
AT1104212	J02.02	Removal of sediments (mud...)	HIGH		IN	N

Figure 3.1 Example of the pressure data contained within the IMPACT table of the N2000 dataset. Pressures are categorised using a reference list (IMPACTCODE). An assessment of their intensity, their location and nature (negative/positive) are also provided

Further details on the description of these can be found within the Art17 Guidelines[3] which makes use the identical pressure and threat nomenclature. In accordance with these guidelines

"[…] *Pressures are considered to be factors which are acting now or have been acting during the reporting period, while threats are factors expected to be acting in the future. It is possible for the same impact to be both a pressure and a threat if it is has an impact now and this impact is likely to continue.*"

Because there is no direct differentiation between pressure and threat in the N2000-DB within the reference list these are not further differentiated and treated as interchangeable terms in this report.

The listed changes, activities and/or objects within the pressure nomenclature are chiefly related to anthropogenic actions in and around N2000 sites, but also include natural pressures and threats.

The range of pressures and threats listed within the database also contain pressures which stem from static objects in the landscape (e.g. port areas, airports or factories). These pressures can be identified easily within land cover mapping frameworks.

Threats and pressures listed within the database are provided with a ranking concerning their relative importance (Table 3.2). No specific spatial extent has been set for these. Likely with good reason - as several activities entail diffuse pollution or disruption their quantification is complex and difficult to establish in metric terms. However, member states have the option to specify the

[3] https://circabc.europa.eu/sd/a/2c12cea2-f827-4bdb-bb56-3731c9fd8b40/Art17-Guidelines-final.pdf

percentage of affected site area. This unfortunately has not been included in the final N2000-DB. The temporal coverage of the data is, in theory, the reporting period i.e. one year.

Table 3.2 Description of ranking for pressure intensity in native N2000 database[3]

Code	Meaning	Comment
H	High importance/ impact	Important direct or immediate influence and/or acting over large areas.
M	Medium importance/ impact	Medium direct or immediate influence, mainly indirect influence and/or acting over moderate part of the area/acting only regionally.
L	Low importance/ impact	Low direct or immediate influence, indirect influence and/or acting over small part of the area/ acting only regionally

The list of different pressures is restricted to 20 entries to avoid accounting for minor pressures. In addition, the number of entries with the highest rank is limited to five. A check of the N2000 2012 DB however revealed that this is requirement is not strictly adhered to. An additional attribute designates whether the pressure occurs **within**, **outside** or in **both** locations in and/or around the site. Again, a specific spatial range for what is designated as outside is not provided.

Some activities can have both a positive and negative environmental impact. This is also captured within the database with a designated attribute.

3.2 Pressures derived from N2000-grassland mapping

The following description of the grassland mapping was cited from the nomenclature guidelines of the product[4]:

The *[…] "Natura2000 product offers a detailed LC/LU dataset for a selection of Natura2000 sites and a surrounding 2 km buffer zone. The sites cover endangered semi-natural grassland habitats rich in species which will be assessed in order to investigate the effectiveness of the N2000 network in halting the decline of certain grassland habitats.*

The Area of Interest (AoI) comprises a selection of grassland-dominated, covered Natura 2000 sites and a surrounding 2 km buffer zone, which could be covered simultaneously by EO data for both reference years 2006 and 2012. The N2000 component contains 2 complementary service elements: a) LC/LU status maps over a selection of N2000 sites for the reference years 2006 and 2012; b) LC/LU change layer 2006-2012 derived from and fully consistent with a) to characterise the N2000 site evolution over time. The N2000 status layer differentiates 55 thematic LC/LU classes specified according to the MAES (Mapping and Assessment of Ecosystems and their Services) 1 ecosystem types. The layers are based on satellite image classification to derive the 2006 and 2012 LC/LU situation. A key element is a visual interpretation and delineation of LC/LU from VHR satellite imagery for the reference years 2012 and 2006."

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[4] https://land.copernicus.eu/user-corner/technical-library/N2000_Nomenclature_Guidelines.pdf - last accessed 06.12.2018)

The Copernicus service provider developed a change matrix which aggregates specific changes to groups which can be proxy for landscape pressures. This change matrix is produced both for all occurring changes at level three the MAES nomenclature and specifically for changes within grassland. Please refer to the annex for the latest version of the change matrices.

4 Mapped versus recorded pressures within selected grassland sites

This chapter provides a first comparison of recorded pressures from the N2000–DB and those which have been derived from changes in land cover. This comparison is conducted to determine whether pressures within the mapping are similar to those identified through in the mapping. In other words, the objective is to check if mapping and database convey the same “message” in terms of importance of certain pressures.

In a first step an overview of the composition of pressures from the N2000–DB is provided. Then land cover change statistics and therefrom derived pressures based on the mapping are displayed. Finally the actual comparison of pressures from the mapping and database in relation to the development of grassland habitats is provided.

4.1 Descriptive statistics for the N2000-database pressures

The subsequent results are compiled for sites which have been mapped within the N2000–GRA mapping product and for which a pressure assessment has been provided within the IMPACTS table of the N2000–dataset.

The database for the year 2012 was used for temporal consistency with the mapping product. Only those activities which are designated to be detrimental (i.e. those which are negative) were included in the analysis.

A total of 14 pressure main pressures have been identified within the mapped sites. Figure 4.1 provides the absolute number of affected sites per designated pressure group within the N2000–DB.

The most frequently mentioned pressure inside of N2000 sites was Agriculture in high and medium pressure intensity (776 / 468 records). This was followed by medium intensity human intrusions and disturbances (464 records) and medium pressure from forestry with a total of 452. Evidently, the most recordings of pressures are located within site boundaries. In comparison to this, pressures located both in- and outside of site boundaries appear negligible. The only exemption from this is the pressure assessment “No threat” which was designated for 79 sites.

Natural system modification also appears to be highly frequent recorded with a high pressure for 340 and high for 282 sites.

Urbanisation, which denotes the conversion of agricultural and natural areas towards more sealed land cover, is listed with medium and high pressure at almost equal frequency (290 /289). In terms of quantity it appears it ranks in the mid-range.

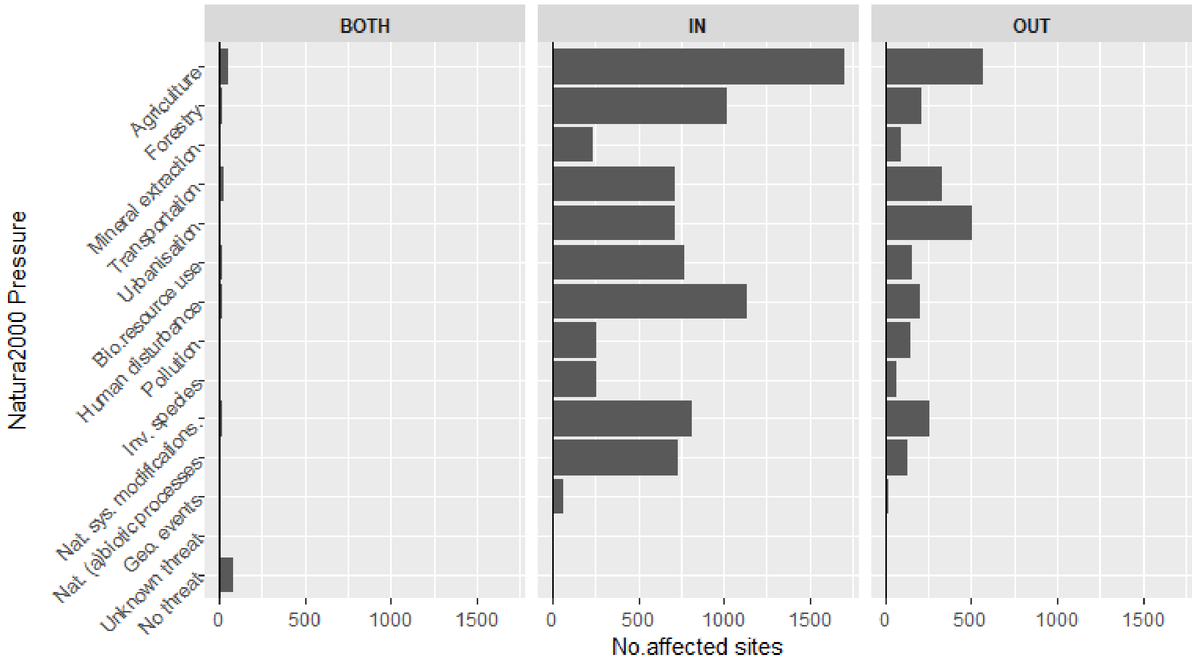

Figure 4.1 Sum of recordings for N2000 designated pressure groups by location (Inside, Outside, Both) of occurrence

Figure 4.2 provides a comparison between the relative proportions of pressure intensity recordings per site divided by the location of their occurrence (Inside / Outside / Both). The proportions of pressure intensity indicate that pressures with high intensity are encountered at slightly higher frequency within sites in comparison to outside. This also applies to the most dominating pressures agriculture, forestry and human disturbance. For these specific pressures the intensity recording of low is also of higher proportion outside of sites.

Although the threat from invasive species is substantially higher within site boundaries they feature quite similar proportions in terms of pressure intensity.

The pressure groups: Geological events as well as “unknown” and “no” threats appear negligible in terms of their amount of recordings.

The circumstance that for most pressures only slight differences between their designations towards specific locations was observed indicates that the “location” attribute may not be as relevant to pressure analysis as presumed. However, this may be site-specific and also dependent on which pressure and region is assessed.

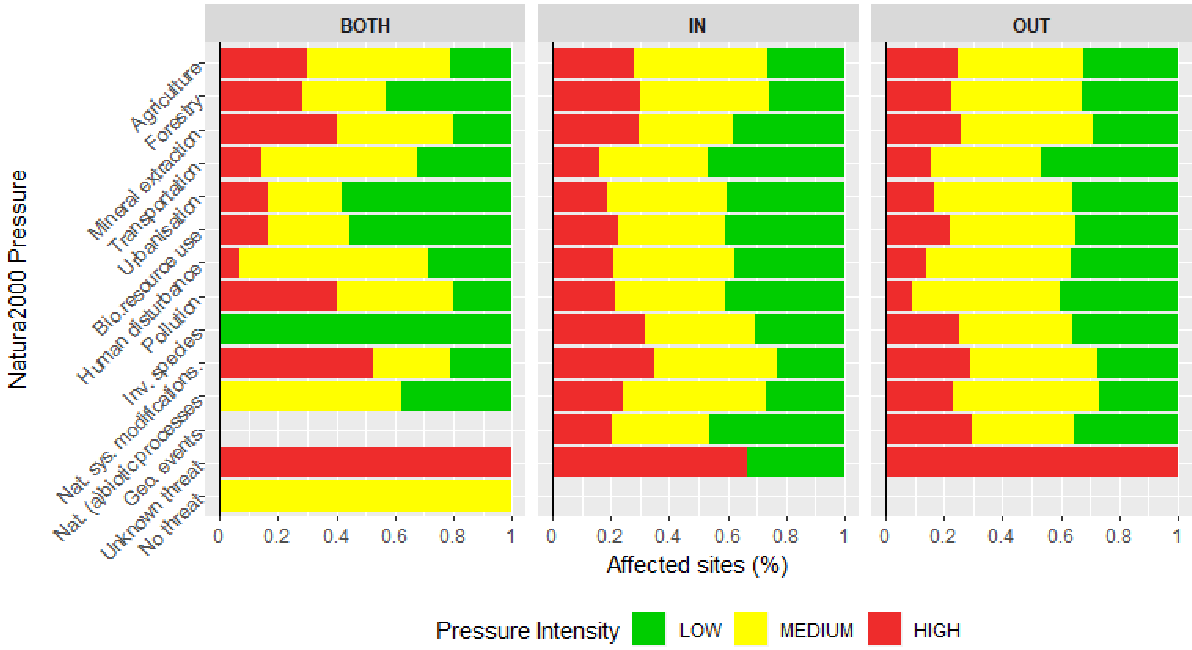

Figure 4.2 Proportion of pressure intensity by location (Inside, Outside, Both) and designated pressure group. Data has been extracted from 2012 N2000-DB to correspond to change period of N2000 grassland mapping

4.2 Land cover changes based on Natura 2000 grassland mapping

The current approach utilizes the pressure matrix provided by the Copernicus service provider for the aggregation of individual land cover changes into groups indicating an increase and decrease of pressure in the period from 2006 to 2012. The pressure matrix is included within the annex.

The terminology which was applied in the matrix has been modified. There are 9 land cover change groups (LCG) which either positive or negative changes of land cover with regard to conservation goals. A brief description of these is provided within Table 4.1.

Table 4.1 Description of land cover change groups (LCG) addressed in the present report. LCG´s are grouped by target area and are paired to reflect environmentally negative and positive processes

Target area	Negative LCG	LCG description	Positive LCG	LCG description
Artificial surfaces	**Urbanisation (UR)**	Increase of urban sprawl and population growth, reflected in increase of pervious and impervious urban LC classes.	**De-urbanisation (DU)**	This LCG is the inverse of urban sprawl and aggregates processes relating to de-urbanisation and demolition, and environmental restoration. Despite fundamental differences concerning underlying motivation, their common denominator is the increase of permeable surface.
Agricultural areas	**Agricultural intensification (AI)**	Conversion of natural into agriculturally utilized land.	**Agricultural extensification (AE)**	Agricultural extensification includes all changes from intensively used agricultural grassland, arable land and plantation to non-cultivated LC classes via natural succession, change of land-use intensity or abandonment.
			Agricultural Land abandonment (ALA)	Abandonment of extensive pastures and discontinuation of traditional mowing and grazing practices resulting in shrub encroachment. This represents a specific case of agricultural extensification.
Forest & semi-natural areas	**Deforestation (DF)**	Reduction of closed woodland into open grassy vegetation either due to logging or natural processes (fire).	**Afforestation (AF)**	Conversion or natural succession of agricultural and open natural landscapes into woodland and forest.
Wetlands & Water Bodies	**Drainage (DR)**	Removal of wetlands. Lowering of water table to facilitate or increase agricultural productivity as well as forest growth.	**Hydrological Restoration (HR)**	Wetland and natural water body restoration. Includes conversion of open and closed natural terrestrial landscapes to semi-aquatic and aquatic counterparts.

4.2.1 Data preparation

Figure 4.3 provides an overview of the general processing workflow. The reason for performing a geometric union (c.f. Figure 4.4) of the N2000-GRA and N2000-GIS is explained further below.

Although the N2000-GRA product is based on a buffered N2000-GIS layer there is no exact spatial boundary in the product which determines where a given polygon is located inside and outside of the site.

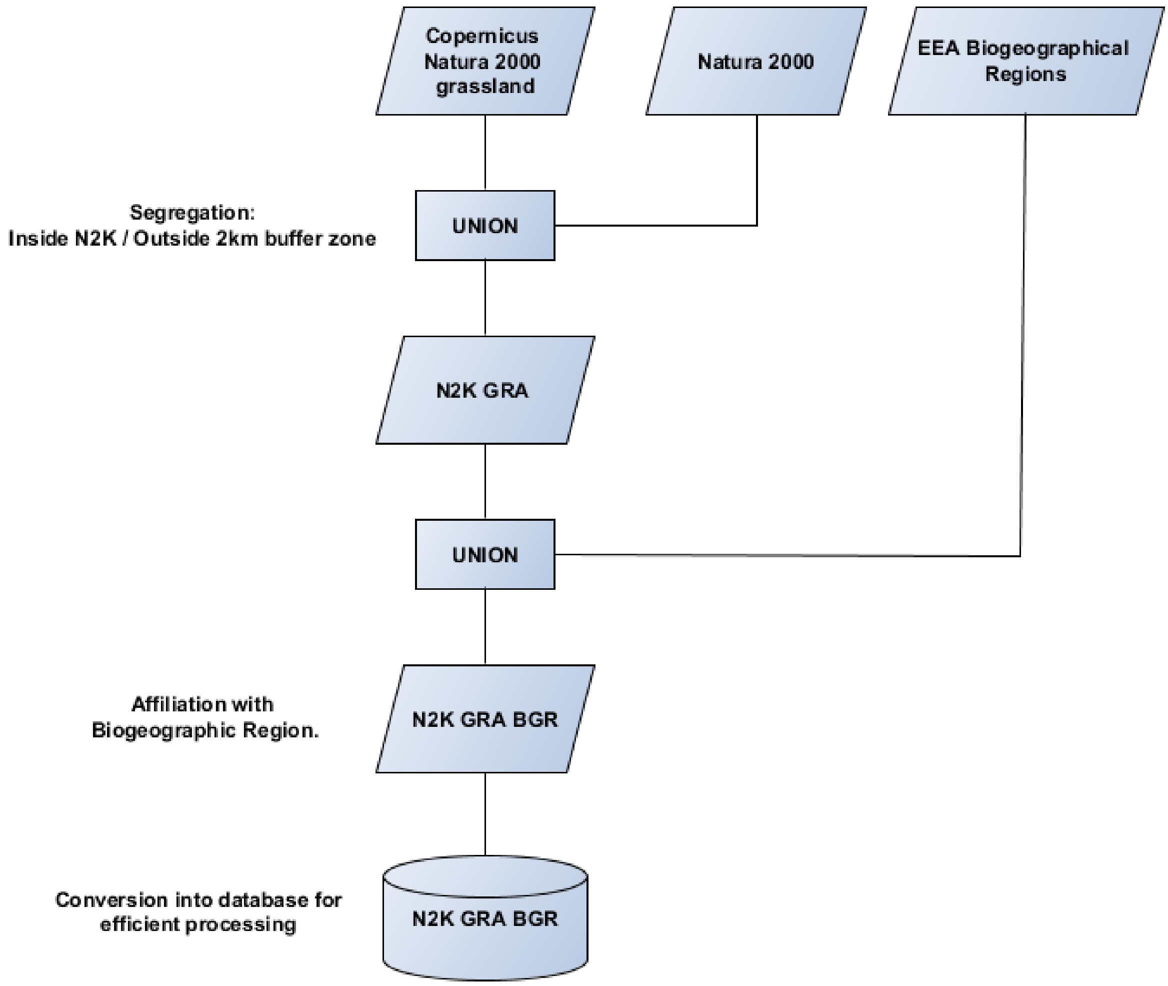

Figure 4.3 Simplified workflow for preparation of database for analysis. (Source: ETCBD- Report 175A 2017)

Of course this is a basic premise for a comparative analysis of changes within and outside of site boundaries. For a visual representation of this issue please refer to Figure 4.4.

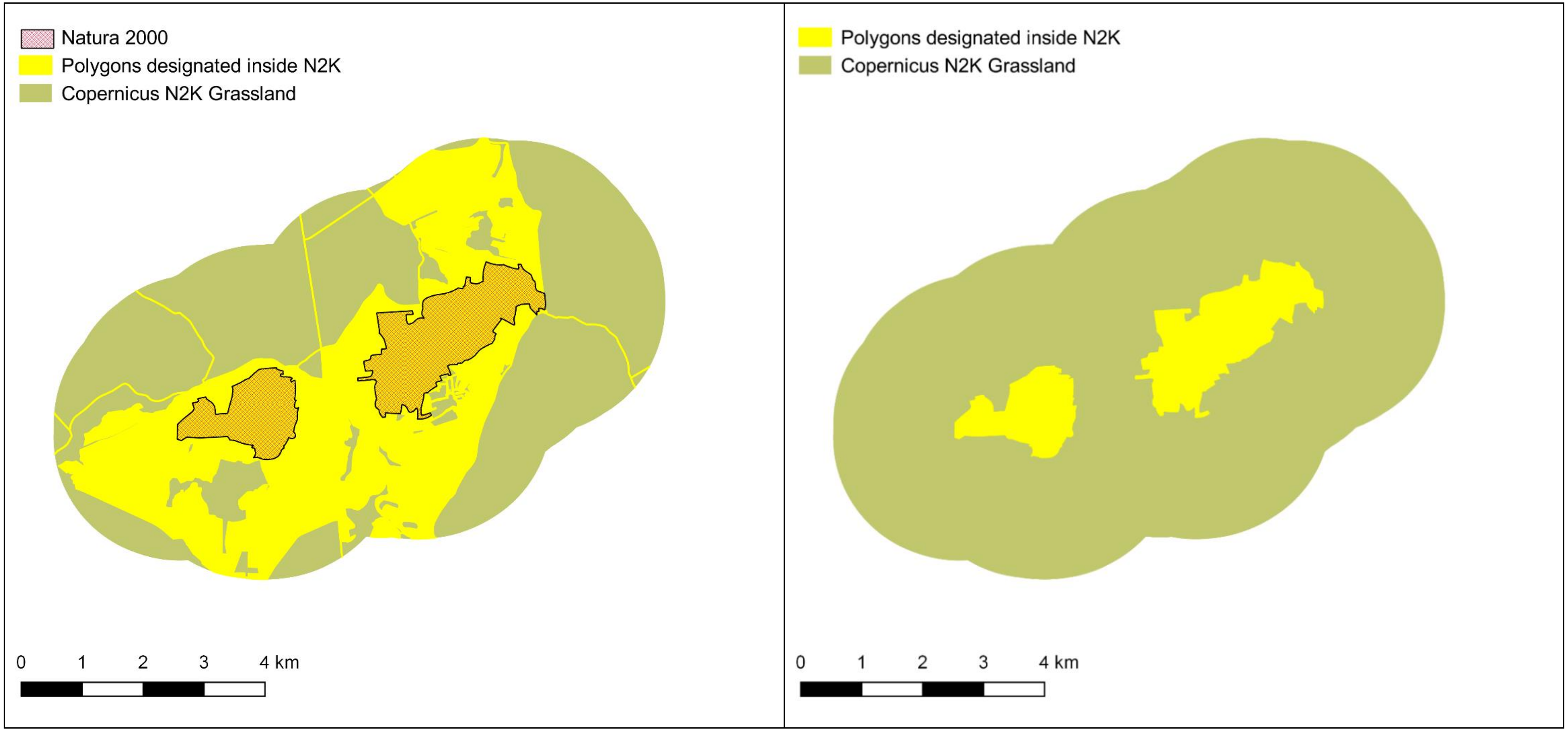

Figure 4.4 Comparison of unmodified Copernicus N2000 grassland layer (left) and processed layer used as basis for present analysis (right). All yellow polygons are affiliated with a Natura 2000 SITECODE. In the N2000-GRA layer this includes all polygons which touch N2000 boundary. A geometric union is needed to separate polygons located within and outside of the site. (Source: ETCBD- Report 175A 2017)

4.2.2 Land cover change and pressure statistics

In total, the current product has identified 885 different changes occurring between the 55 classes at MAES Level 4.

Table 4.2 provides change statistics at the MAES Level 1. The data gathered at this basic level already provides some insights into change dynamics of grassland sites. Urban classes and cultivated land are the only classes to feature larger amounts of surface area outside of the site perimeter. In terms of relative proportions these classes feature more than 6 and 3 times as high proportions outside in comparison to inside sites. There is substantially less agriculturally utilized area inside protected areas. Outside of sites cropland area also increased whereas this was the opposite case inside sites.

Interestingly, grasslands are of similar relative extent within and outside of the buffer zone, amounting to approx. 20%. However, outside of sites these areas are diminishing at rate more than 5 times as quickly compared to inside protected area. Approximately half of the total land surface in protected areas is woodland and forest. This is roughly 10% more than outside. Heathland and shrub appears to be converted to other classes at similar rates independent of location.

Wetlands appeared to be reduced at a higher rate inside in comparison to outside of the protected sites, which is a concerning observation.

Overall, the results are very similar to those calculated for the 2017 exercise. This is interesting given the difference in covered spatial extent and added locations.

Table 4.2 Changes inside and outside of N2000 sites between 2006 and 2012 in ha and percent at MAES 1 level. Changes are calculated relative to 2006

	Inside		Outside	
MAES Level 1	2006 Area (ha)	2012 Area (ha)	2006 Area (ha)	2012 Area (ha)
No Data	1485	0	986	610
Urban	75332	76718	1461475	1495530
Cropland	716987	718047	5793180	5780225
Woodland & forest	4725596	4726462	8177171	8178028
Grassland	1872311	1870802	4154280	4130927
Heathland & scrub	796360	795335	565498	564419
Sparsely vegetated	525935	526370	282680	282668
Inland wetlands	247728	245257	99160	99425
Maritime wetlands	70439	70439	4553	4537
Rivers & lakes	150271	153008	317196	319807
Marine	91637	91642	20351	20353
	2006 Area (%)	2012 Area (%)	2006 Area (%)	2012 Area (%)
No Data	0.02	0	0	0
Urban	0.81	0.83	7	7.16
Cropland	7.73	7.74	27.75	27.69
Woodland & forest	50.95	50.96	39.17	39.17
Grassland	20.19	20.17	19.9	19.79
Heathland & scrub	8.59	8.58	2.71	2.7
Sparsely vegetated	5.67	5.68	1.35	1.35
Inland wetlands	2.67	2.64	0.47	0.48
Maritime wetlands	0.76	0.76	0.02	0.02
Rivers & lakes	1.62	1.65	1.52	1.53
Marine	0.99	0.99	0.1	0.1
	Change (%)		Change(%)	
No Data	-100		-38.135	
Urban	1.84		2.33	
Cropland	0.148		-0.224	
Woodland & forest	0.018		0.01	
Grassland	-0.081		-0.562	
Heathland & scrub	-0.129		-0.191	
Sparsely vegetated	0.083		-0.004	
Inland wetlands	-0.998		0.267	
Maritime wetlands	0		-0.347	
Rivers & lakes	1.821		0.823	
Marine	0.006		0.007	

The following diagram (Figure 4.5) shows the aggregation of changes into the groups as described earlier. Information is aggregated at the level of the biogeographic region in order to highlight the specific pressures which are dominant in the different regions.

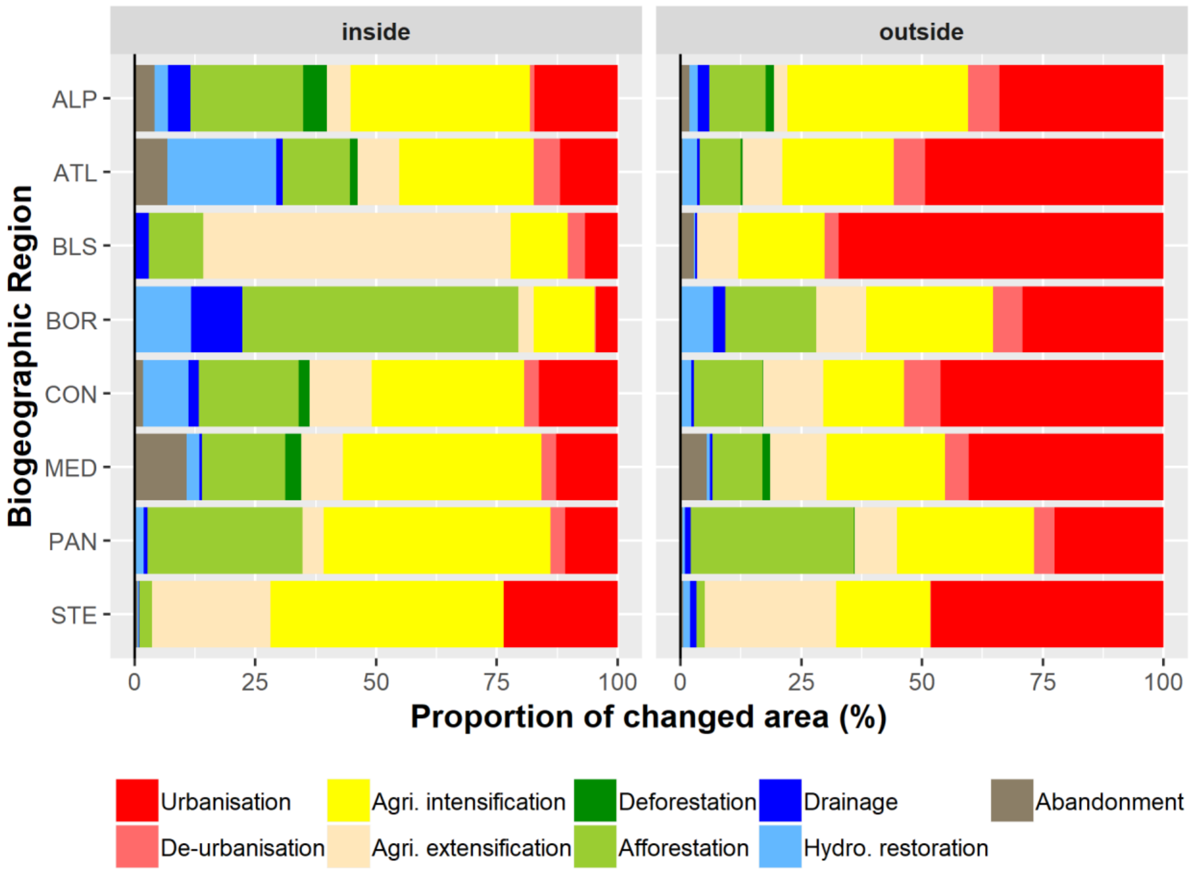

Figure 4.5 Proportion of land cover pressures (pressures and their reverse processes) per biogeographic region and location (inside /outside). Pressure groups are defined on the basis of the pressure matrix for the Grassland mapping developed by the Copernicus service provider

Based on the proportion of changed area it is directly evident that in most regions urbanisation (red) is the key pressure outside of sites, whereas agricultural intensification (yellow) is the main pressure inside most of the biogeographic regions with the exception of the Boreal and Black Sea region.

Land cover change processes which are likely to support conservation goals as they represent a reduction of land use intensity such as afforestation and hydrological restauration generally feature higher or similar rates inside of most sites. Especially in the Atlantic and Boreal region hydrological restoration is of large importance in terms of changed proportions.

Interestingly, the gathered data for agricultural extensification shows that this is taking place at higher rates in Boreal, Mediterranean and Pannonic regions. De-urbanisation, i.e. the conversion of urban landscapes towards more natural environments appears to appear at substantially higher rates outside of sites, however, the outer perimeters also contain larger amounts of urban environments. Deforestation takes place at slightly increased levels higher levels inside protected areas. Here also the overall proportion of woodland and forest areas within site boundaries may cause a larger relative proportion of this negative change. In Mediterranean regions which house large areas of protected semi-natural grassland area the discontinuation of agriculture, i.e. land abandonment appears to be the largest threat.

4.2.3 Conclusive remarks

Due to the fact that a similar analysis will be conducted by the Copernicus service provider, the current change analysis was limited to assessing only broad land cover change groups. It was not attempted to assess changes in grassland types which is also an interesting aspect that could potentially obtain more specific statistics on threatened grassland habitats.

The most important finding is that overall area of grassland has declined between the period of 2006 and 2012. This change takes place at substantially higher rates outside of protected areas. In terms of affected area inside sites the **dominant negative pressure is agricultural intensification** which is here defined as the conversion of natural MAES classes (MAES level 1: Classes 3-10) into cropland (MAES level 1: Class 2). The increase of impervious areas is largely reduced within N2000 sites in comparison to their surroundings. These two aspects may indicate how effective the network is in protecting natural environments. However, this may also be simply due to the fact that these areas are generally more remote and less disturbed environments.

Agricultural land abandonment makes up for a large proportion of negative land use changes inside Mediterranean areas and further exemplifies that these areas are specifically threatened by the discontinuation of traditional agricultural practices.

Already with some basic analysis of the N2000 grassland mapping product some interesting findings concerning pressure developments can be deducted. For the ongoing analysis it is recommended to conduct analysis on the level of the biogeographic region in order to provide recommendations which are based on the characteristics of more similar environmental regions.

4.3 Comparing pressure patterns derived from N2000-DB and mapping

This chapter provides a comparison of grassland related pressures recorded within the N2000-DB and mapping. The analysis is based on sites for which a direct link between the mapping and the N2000-DB for 2012 was possible to be established on the basis of a common sitecode[5]. Only those sites containing either managed (MAES level 2 = 41) or semi-natural grassland (maes level 2 = 42) were selected were selected from the mapping. Overall the selection includes 2007 sites.

Approximately 60% (1202) of these sites remained stable in their overall grassland area between the period of 2006 - 2012. A decrease of grassland area could be identified for 27% (539) and a gain for only 13% (266). The net loss of grassland over the entire area of selected sites amounts to 3082 ha. This equates to almost a third of the area of the entire city of Paris.

Whereas gains slightly exceed the loss of semi-natural grassland within N2000 sites, there were very high losses of managed grassland identified (Table 4.3). This indicates a vastly accelerated rate of decrease or turnover of grassland utilized for feed and fodder production as well as pasture.

[5] As the product contains sitecodes from different years and some of which have changed, using the sitecode as common denominator between mapping and N2000-DB results in the loss of sites.

Table 4.3 Statistics for grassland loss and gain inside selected Natura2000 sites

	Gain (ha)	Loss (ha)	Stable (ha)
Managed grassland	832	4031	179834
Semi-natural grassland	4380	4266	550547
Grand Total	**5212**	**8297**	**730381**

Erreur ! Source du renvoi introuvable. shows a matrix of pie charts displaying the composition and ntensity of pressures within the selected sites with regard to changes of grassland area. Changes were categorised into three classes, either showing a gain, loss of grassland. Sites in which grassland did not change are labelled as stable. An analysis of the distribution of grassland changes showed that a differentiation of grassland changes into more levels was not necessary as its distribution is extremely skewed towards high frequency of very small changes.

In total, there were thirteen different pressures recorded within the sites. One pressure – "Unknown" was omitted from further analysis due to a very small amount of records (n=3). Agriculture, human intrusions as well as forestry are the dominant pressures across all selected sites and appear to be consistently high throughout all constellations of grassland development status and pressure intensity.

The least reported pressures are natural catastrophes, mineral extraction, pollution and invasive species which show only very little variation across the entire matrix.

Natural systems modification is dominantly recorded with a high pressure intensity, however, it remains indifferent to changes in grassland development. High forestry pressure is the most frequent in sites that register a loss of grassland and feature high pressure intensity. Despite higher relative importance of agriculture as a pressure within sites that have remained stable over the change period it is the most dominant pressure in sites that record losses. Interestingly, human intrusion is a greater pressure in sites that record a gain of grassland.

Although key pressures in terms of proportions of affected sites can be clearly identified from the N2000-DB a comparison of the recorded pressure intensities and grassland losses reveals only very slight differences in terms of pattern composition of sites that have gained and lost grassland.

In order to obtain more differentiated results it may prove useful to further separate the data by regions. However, this exceeds the allocation of resources for the current task and may be taken up in the upcoming change analysis

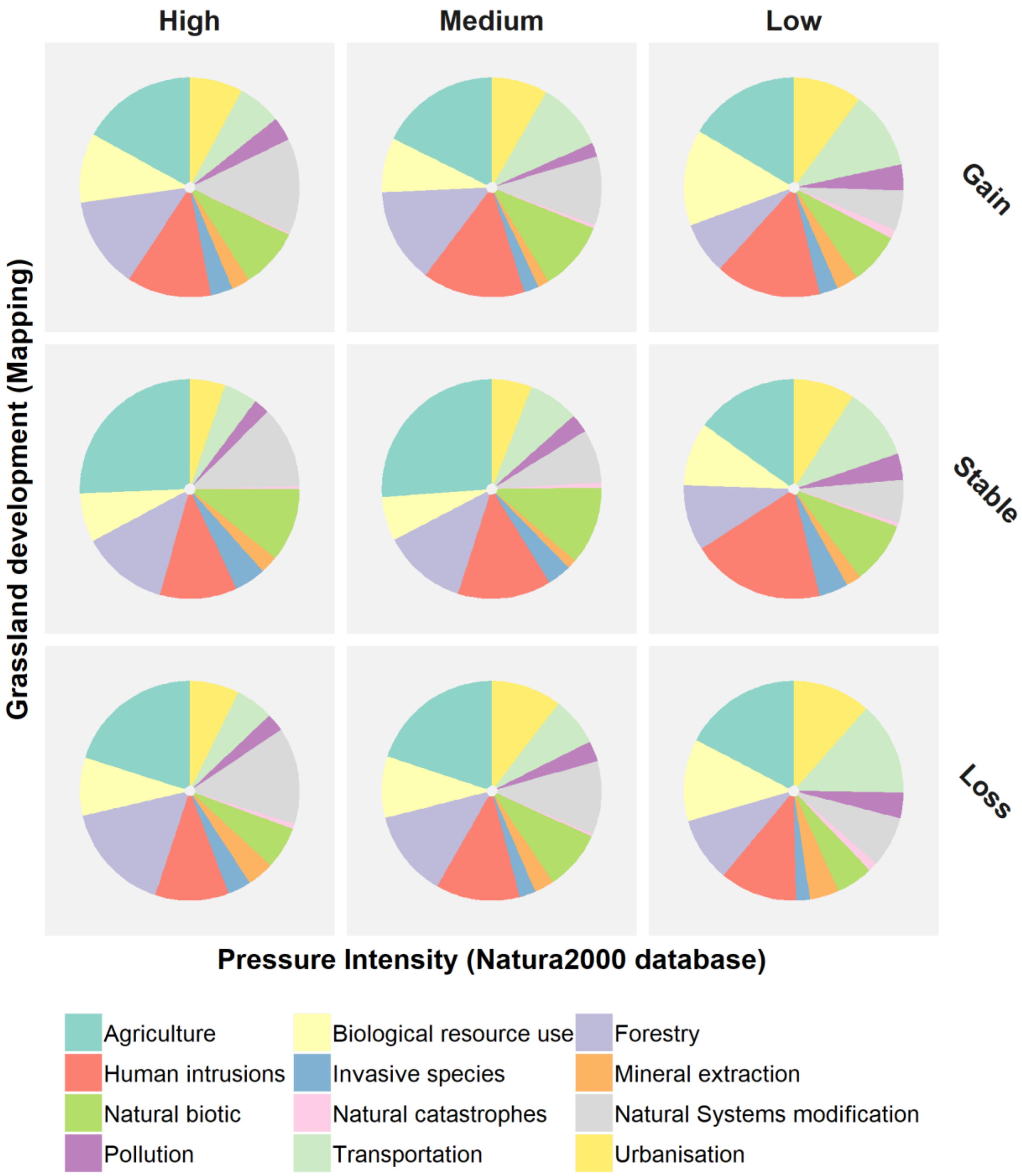

Figure 4.6 Pie chart matrix showing proportions of recorded pressures for N2000 sites by pressure intensity ("High", "Medium", "Low") as well character of grassland change ("Gain", "Stable", "Loss"). The latter is determined on the basis of the mapping

Pressures derived from the mapping in relation to overall in-site development of grasslands are displayed in Figure 4.7. In contrast to the pressure composition observed within the database the calculated changes appear to vary more strongly with grassland development.

It can be observed that within all grassland development stages pressure intensification processes (Urbanisation, Agri. Intensification, Deforestation, Drainage, and Abandonment) exceed extensification processes.

Sites which have gained in grassland report the highest pressure from agricultural intensification. The relative importance of agricultural intensification within these sites is almost tripled in comparison to sites that have lost grassland. However, this may also be exaggerated by the circumstance that grassland gain itself is designated as agricultural intensification within the utilized change categorisation stemming from the Copernicus service provider.

Following agricultural intensification the second most dominant landscape change within areas that have lost grassland is afforestation, although this denotes the gain of forest environments, it may also point towards more intensive forest management. This corresponds well with the observed pressures from the database. Changes related to urbanisation amount to almost 17% of changes within areas where grassland decreased. In addition to urbanisation itself the N2000 pressure database contains also a differentiation between transportation and mineral extraction which are part of urbanisation within the Copernicus service provider change matrix.

Abandonment almost exclusively occurs in sites which have lost grassland and accounts for approx. 7% of all changes. This indicates its importance as a threat to grassland habitats.

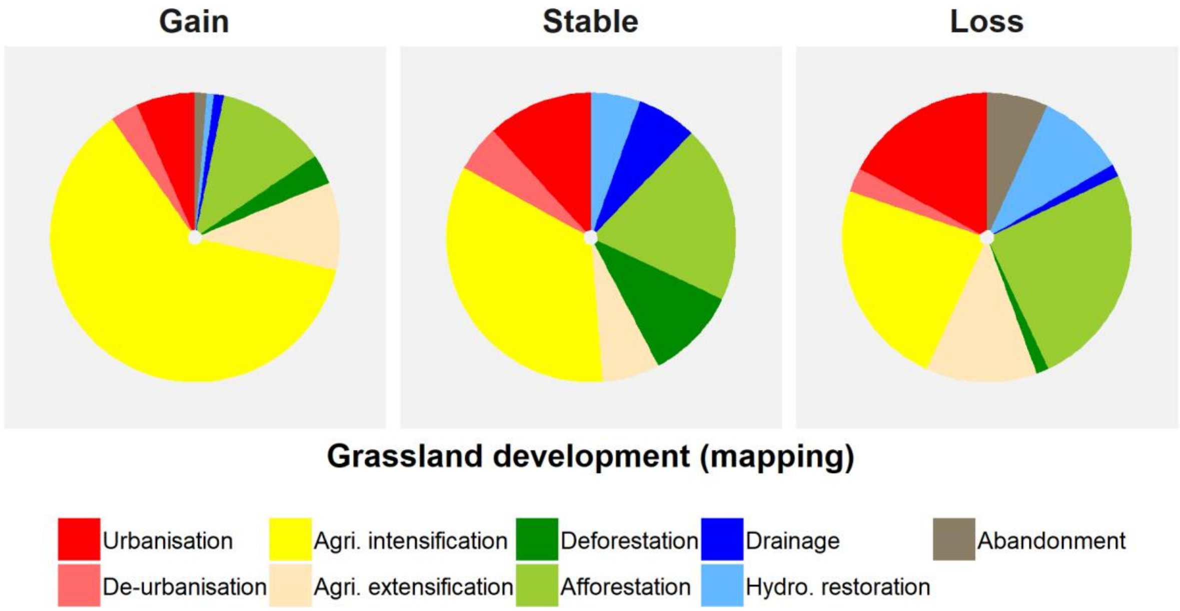

Figure 4.7 Proportion of pressures and counter development for selected grassland sites. Pressures follow definition established by Copernicus service provider change matrix. Data is separated by change of grassland development within sites (gain, stable, loss)

4.4 Summary

The observed land cover change processes of agricultural intensification, urbanisation and afforestation are the key landscape change processes within the selected grassland sites.

The associated drivers of these developments - agriculture, forestry and urban expansion – are also the dominant pressures designated within the N2000-DB. This clear commonality between the mapping and database suggests that the mapping and pressure database convey a coherent message concerning threats to grassland habitats.

However, the composition of pressures from the DB was largely independent of grassland development, whereas the pressures defined on the basis of land cover changes within the mapping, varied strongly. This might be due to the fact that the categorisation of grassland development was conducted on the basis of the mapping and the change groups also contain grassland changes.

With the exception of "human intrusions", pressures from the N2000-DB which not manifest in changes of land cover such as invasive species or pollution showed mainly small proportions of recorded pressures. This provides support for land-cover change based assessments on grassland pressures.

Evidently, the environmental pressures within mapping and database are derived from fundamentally different approaches (in-situ expert judgement vs. mapped land cover change) and therefore establishing closer links between both datasets is of crucial importance to support the allocation of affected area towards individual land-cover change based pressures within the database.

This requirement for more direct links is addressed in the subsequent chapter.

5 Creating a N2000 pressure / mapping linkages database

The comparison of pressures from mapping and N2000-DB underlined that there is a the need to determine more direct links between the two datasets in order to facilitate more targeted comparisons and support the pressures determined within the DB with a quantitative component. For this purpose a database was created to assign changes identified in land cover with changes that have been recorded in the database.

5.1 Creating a linkages database to combine mapping and native N2000 pressure records

Information on state and trends of pressures within N2000 is best supported by spatial information. The present database aims at linking spatial information from the mapping to the native N2000 pressures.

From the 414 pressures and threats listed within the N2000-DB in total 70 pressures were selected which have the potential to be associated to changes and land cover classes within the MAES Level 3 nomenclature. These cross-links were recorded within an excel sheet which is delivered along with the report: ETCBD175A_N2000_IMPACT_MAES_LVL3_LINKAGES.xlsx

In total 3687 unique combinations of MAES Level 3 change code pairs and pressures could be identified. These combinations include duplicate recordings for change code pairs. The created change code-pressure database contains 1195 unique MAES Level 3 change code pairs.

MAES Level 3 instead of the available MAES Level 4 was selected for simplified change matching.

Pressure groups which can be linked to the mapping are inherently restricted to changes or objects which are evident in land cover. For example, recreational activities such as hiking or invasive species cannot be detected within the resolution of the sensors applied to produce the mapping and therefore have to be excluded. Table 5.1 provides an overview on the identified categories and the proportion of pressures within those categories for which a change within the mapping could be assigned. As the aim was to create a database for all pressures there was no specific focus on pressures relevant for grasslands exclusively. Yet, these can be easily extracted from the cross-link database.

Table 5.1 Number of selected pressure groups from the available reference list for threats, pressures and activities

Pressure group	No. of pressures which can be identified in mapping	Total no. of pressures	Proportion
A Agriculture	18	43	42%
B Sylviculture, forestry	2	17	12%
C Mining, extraction of materials and energy production	11	27	41%
D Transportation and service corridors	9	30	30%
E Urbanisation, residential and commercial development	14	22	64%
G Human intrusions and disturbances	9	43	21%
J Natural System modifications	4	70	6%
L Geological events, natural catastrophes	3	10	30%

Some pressures from the N2000-DB can be linked directly with MAES land cover classes or specific changes identified by the N2000 grassland mapping. The defined pressure grassland removal for arable land (A03.01), directly relates to the changes of the classes 41X – 211 within the MAES Level 3 nomenclature of the Copernicus grassland layer. Likewise, airports (D04.01) are distinctive land cover elements mapped as MAES code 124.

Others pressures may feature more complex one-to-many relationships meaning that one N2000 pressure can be linked to multiple MAES codes/ changes and one MAES code towards many different N2000 classes. For example, in the case of a change of arable land (MAES: 211) to mining, construction and dump sites (MAES: 131), the change could relate to a range of different, urbanisation (E) and mining (C) pressures due to the fact that the class may include both, mining and construction activities.

However, if the N2000-DB records that either urbanisation (E) or mining (C) is recorded as pressure for the site, the MAES change can be assigned towards the correct pressure. Thereby, the assessment of the intensity of the pressure within the N2000-DB can be linked to the amount of area of the land cover / land cover change within the site. In cases where a detected change could be linked to more than one pressure on the reference list (RL) and more than one corresponding pressure has been recorded for the site it is not possible to link up MAES codes with N2000-DB pressures.

The workflow to link mapping and pressures are suggested further below. Due to the complexity and uncertainty associated with using the linkages DB, it is recommended to proceed applying it with care and tailor it´s use specific fields of research concerning land cover development within N2000.

The linkages database may be used for the following applications:

- Accounting of affected area by a certain pressure (N2000-DB) on the basis of the mapping (i.e. land cover change code)
    - Location and proportion of affected area might be relevant for conservation goals of specific sites or to study the spatial pattern of pressures across Europe.
- Geospatial analysis of recorded pressure intensity within the N2000-DB.
- Verification of observed (mapping) and recorded (N2000-DB) pressures:
    - The provided ordinal scaled pressure intensity (“low”, “medium”, “high”) within the N2000-DB now is backed by a quantitative figure which can be used for improved hot spot identification as well as measuring the condition and performance of affected sites within the grassland assessment report.

5.2 Generic processing workflow to assign unambiguous links between mapping and pressures

As stated above, the main problem in linking N2000-DB pressures and mapping is that mapped land cover changes relate to a number of different pressures and vice versa. The following workflow shows how this ambiguity can be reduced by applying a cascade of “joins” within the data.

Thereby it is based on the datasets specified in chapter 2. It was implemented in open-source GIS and PostgreSQL. Currently, (status 06.12.2018) the workflow is still in an experimental stage it was only tested on a subset of sites.

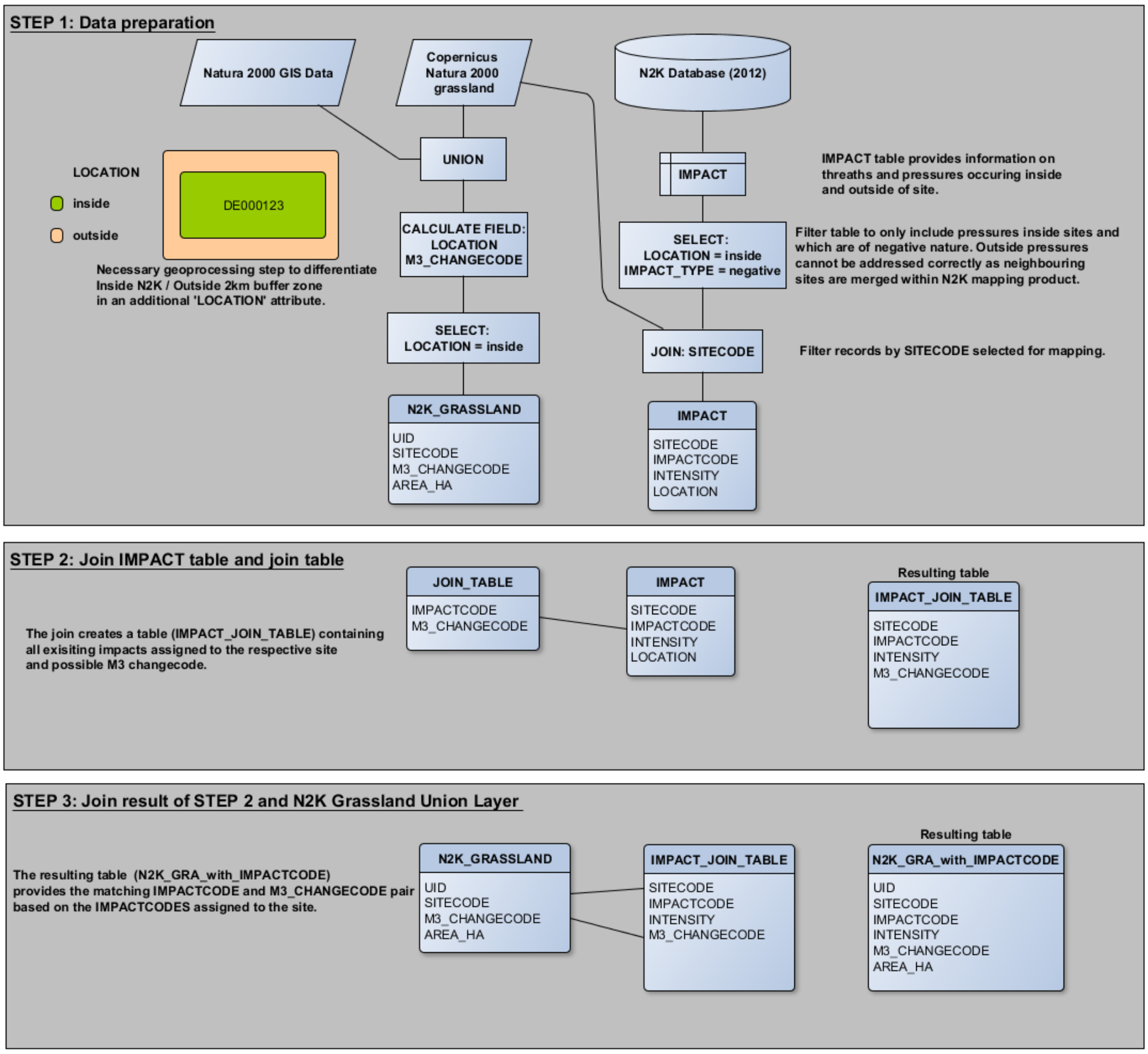

Figure 5.1 **Processing workflow using the established pressure-MAES level 3 change code database. The approach involves a cascade of geoprocessing, query and join operations. The end product is a table in which a N2000-grassland polygon is assigned with a pressure code and intensity provided from N2000-DB**

5.3 Example application of linkages database

Rather than applying the linkages DB to study aggregated change groups it is best used to target specific pressures because this minimizes the amount of potentially overlapping changecode pairs in the mapping that are associated with to a certain pressures.

The following example is a change statistics which can be calculated using the N2000-DB / N2000-mapping linkage database. As an example the pressure A04 – denoting pressure from grazing activity was selected to illustrate the potential of linking the mapping with the N2000-DB. As many of the secondary and tertiary level (e.g. A04.XX / A04.01.XX, excluding A04.03) grazing pressures listed within the N2000-DB cannot be distinguished within the MAES nomenclature the pressures are aggregated to the level of A04. Only those sites were selected which have a listing for the pressure within the N2000-DB and for which a corresponding change to the pressure could be identified within the mapping.

The selection contains 87 individual sites, all of which feature a conversion of a range of land-cover classes to managed grassland (410).

Figure 5.2 shows a boxplot with the proportion of converted grassland in relation to all 2012 grassland area within the site to be able to relate the intensity of change to the actually changed site proportion. Due to extremely large differences within the calculated proportions, affected site area has been normalized for better visibility.

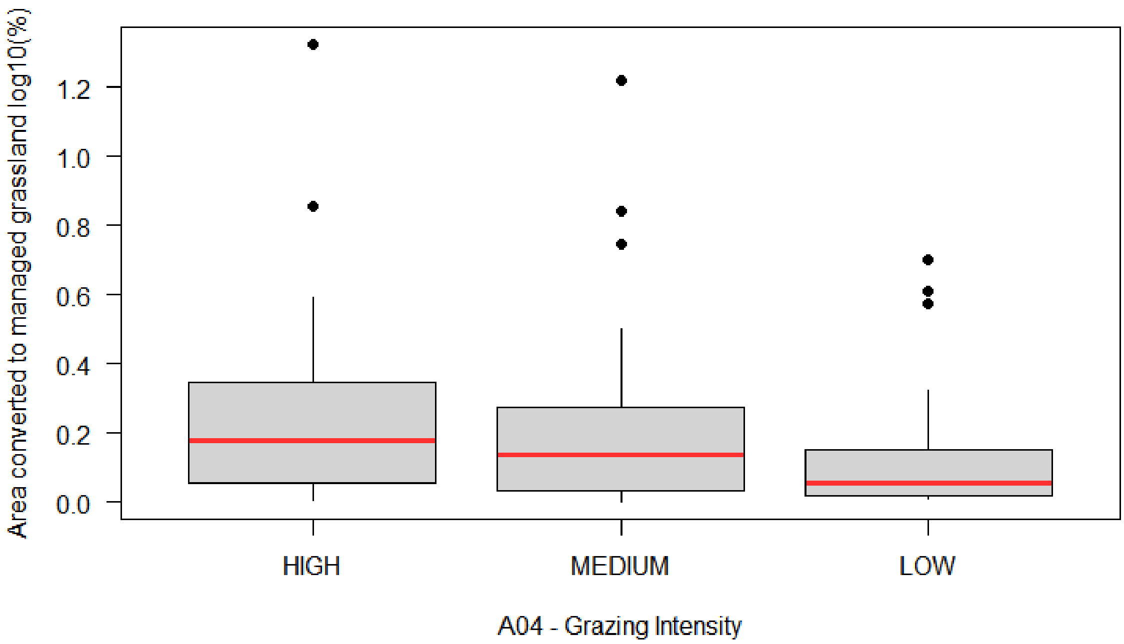

Figure 5.2 Boxplot of area converted to managed grassland (410) and recorded grazing intensity inside selected N2000 sites. Due to large differences in affected site proportions the values were log-transformed and multiplied by a constant (1)

The calculated results validated the assumption that high grazing pressure defined in the N2000-DB is also associated with a greater tendency of conversion of different land-classes towards managed grassland. This also applies to low pressures which also features a lower degree of conversion. Despite this, many sites still feature a net loss of grassland within the site.

Almost 77% of sites within the current N2000 grassland mapping feature a decline of both managed (410) and semi-natural (42X) grassland classes. The conversion of semi-natural grassland and other land-cover classes into managed grassland could thus point towards a development of intensification of grassland use within sites that are prone to grazing activity.

Despite the circumstantially inconspicuous nature of the provided example, it demonstrates that the N2000-DB pressures and mapping can indeed be meaningfully linked.

5.4 Linking the N2000-DB pressure information with the N2000 grassland mapping: Lessons learnt

There are a range of different characteristics relating to both the N2000-DB data and N2000 grassland layer which render the attempt of linking the two via a simple crosswalk an intricate task. These challenges have been compiled below:

- The key challenge that remains are many-to-many relationships between changecode pairs and N2000-designated pressures. Due to the complexity of linking changes in land-cover to specific pressures the linkages DB could profit from its use in analysis tailored to specific pressures only. Further testing is needed to reflect on the manifold possibilities in linking the mapping and the database.
- The version of Natura 2000 polygons which was used for production is not recorded within the N2000-DB. Whereas this is not of great importance to most users, the SITECODE is of crucial importance to link the DB to the mapping. As sitecodes can change over years links to the end2012 N2000 database and may be omitted.
- The analysis of pressures is limited to the analysis of pressures inside N2000 sites only. The N2000-DB contains location information (i.e. description on whether pressure is in-/ or outside of site) even after further processing steps to establish a "hard" N2000 boundary within the mapping, only those pressures from the N2000-DB assigned to occur inside of sites are possible to be linked directly to the mapping. This is due to the fact that in areas where the buffer around two different N2000 sites located less than 2km apart from each other is merged together, making it impossible to assign a polygon located in the outer perimeter of merged sites towards a specific site regardless of the availability of this information within the N2000-DB.
- The N2000-DB IMPACT table contains duplicate entries for unique row combinations. Without prior "cleaning" of the dataset pressures for individual sites may be exaggerated when the current workflow is applied.
- There are extreme differences in pressure designation within the N2000-DB between 2012 / 2017 versions which question the completeness of the of pressure assessments. For example, the pressure database filtered for the mapped SITECODES and negative IMPACT_TYPE´s contains approx. 12,000- whereas this is increased to 19,000 records in 2017 (>60% increase). This does not correspond to the increase in N2000 area. Some very relevant pressures for grassland based assessments such as A02.03 (grassland removal for arable land) were not recorded for any of the mapped sites in 2012. However, a comparison with N2000-DB data from end 2017 showed that this had changed for some sites.
- An ideal comparison of the database and mapping would ideally include a comparison of pressure development on the basis of the N2000-DB between the years 2006 and 2012, however this is not possible as Natura2000 data within the required format are only accessible until 2008.

5.5 Summary

The aim of the present task was to establish a link between N2000 pressure DB and the spatial information contained in the Copernicus N2000 grassland mapping.

The created cross-link database which contains over 3000 links between recorded pressures and mapped changes between land cover classes can be seen as an initial step towards improving the monitoring and assessment capabilities for threatened N2000 sites by further integration of Copernicus products.

Although there are several limitations to keep in mind while using the DB, the example calculation for a relevant grassland pressure showed that the intensity of pressures provided in the database is reflected in the amount of affected site area.

The added-value of the present analysis is the conceptual basis to establish this link to ultimately achieve supporting N2000 pressure designation with a quantitative and spatial component. The linkages could be used to identify in which regions the most losses occur and which pressures are of priority in terms of affected area.

Due to the many conceptual and methodological challenges which have been identified, the linkages database could profit from a validation and exchange with multiple experts from different regions in order to improve the association of pressures with specific changecodes and thereby ultimately improve the accounting of pressures within N2000 sites.

6 Conclusions & Suggestions for Planned Change Analysis

Conclusions from current activity

The comparison of the composition of pressures defined from changes within the period of the mapping and database suggest that the key pressures encountered within N2000 sites stem from agriculture, forestry, urbanisation and human intrusion. Pressures which are not exhibited in changes of land cover, were mostly reported to be of lesser importance with regard to the frequency of their reporting. This circumstance generally supports the approach of using land-cover based change assessments as proxy for environmental pressure within the N2000 network.

The current exercise created a link between land cover changes within the mapping and pressures from human activities which are recorded in the native N2000-DB with the goal to verify and improve pressure accounting for N2000-sites. The database and methodology to assign specific land cover changes towards designated pressures is one of the key outcomes of the present report and may provide a base for further, more targeted analysis focusing on individual pressures rather than analysing groups of changes. Indeed the approach is hampered by a range of limitations which have been outlined in the relevant chapter. With careful regard to its limitations the linkages database may provide a conceptual basis to feed the N2000 pressure dataset with land cover information. This will require further explorative analysis and more targeted applications regarding the selection of pressures.

Suggestions for change analysis

Although the previously conducted change analysis was extensive and thematically comprehensive on the subject of grassland threats, the subsequent suggestions should be considered for the upcoming analysis.

A key component of the change analysis is the change matrix - This could be slightly modified to differentiate more between the character of specific land cover changes. For example, as to the moment there is no differentiation within the changecode matrix which makes use of the differentiation between artificial and non-artificial forest and woodland within the applied MAES nomenclature. This environmentally sensitive information is lost when it is aggregated into the change group of “afforestation”. Furthermore, there should ideally also be a differentiation between areas lost by flooding (e.g. through damming and channelization) and hydrological restoration which is of a more environmentally beneficial nature like the restoration of drained grassland to wetland environments. These suggestions entail an update of the naming nomenclature of pressures and their counter developments which omits the term of “relaxations”. Instead the following terminology is proposed.

Table 6.1 Suggested terminology for change groups

Target area	Negative	Positive
Artificial surfaces	**Urbanisation**	**De-urbanisation**
Agricultural areas	**Agricultural intensification**	**Agricultural extensification**
		Agricultural Land abandonment
Forest & semi-natural areas	**Deforestation**	**Afforestation – Natural succession**
		Afforestation – Plantation
Wetlands & Water Bodies	**Drainage**	**Hydrological Restoration**
	Hydrological Restructering	

Another aspect which might be addressed is the representation of grassland specific changes. This might be improved by the use of sankey diagrams. These are flow diagrams in which the width of a flow (from one class to another) is proportionate to its area. These diagrams are ideally suited to visualize the development of grassland between two periods and can be implemented using open source software (e.g. R). They are superior to using a tables to illustrate changes as they can be directly understood without having to compare individual figures.

7 Annex

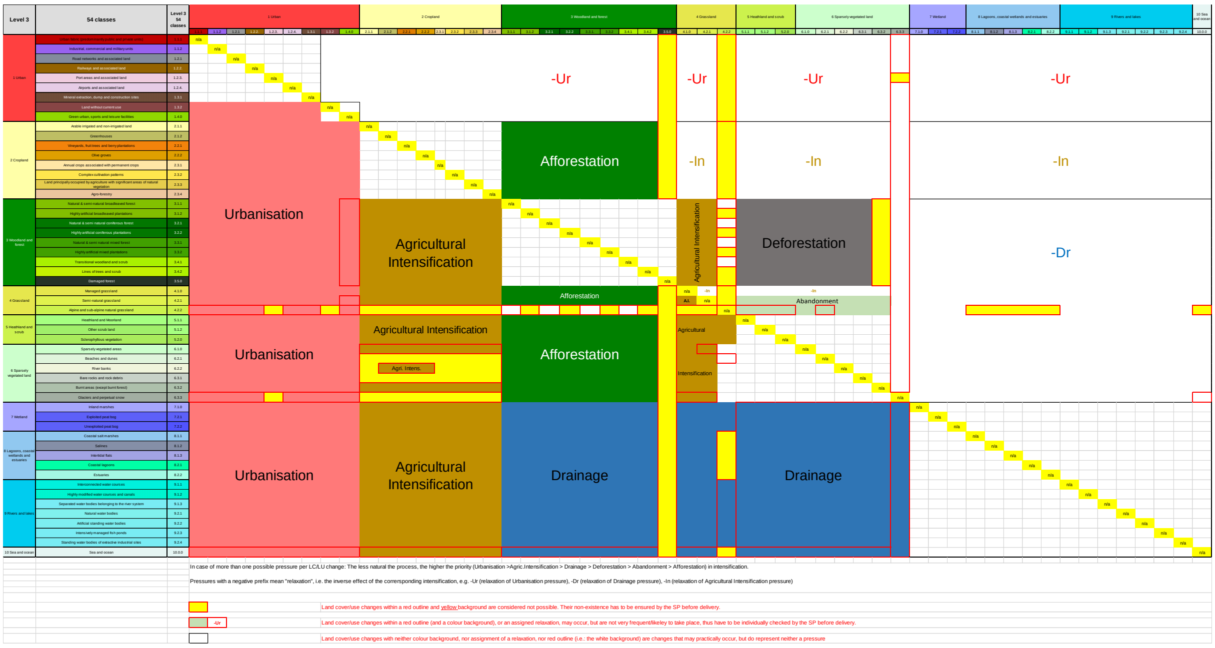

Figure 7.1 Pressure matrix based on MAES level 3 developed by the Copernicus service provider. Within the matrix each possible change is aggregated towards a specific land cover change group indicating either a pressure (negative) or positive development in terms of land cover change

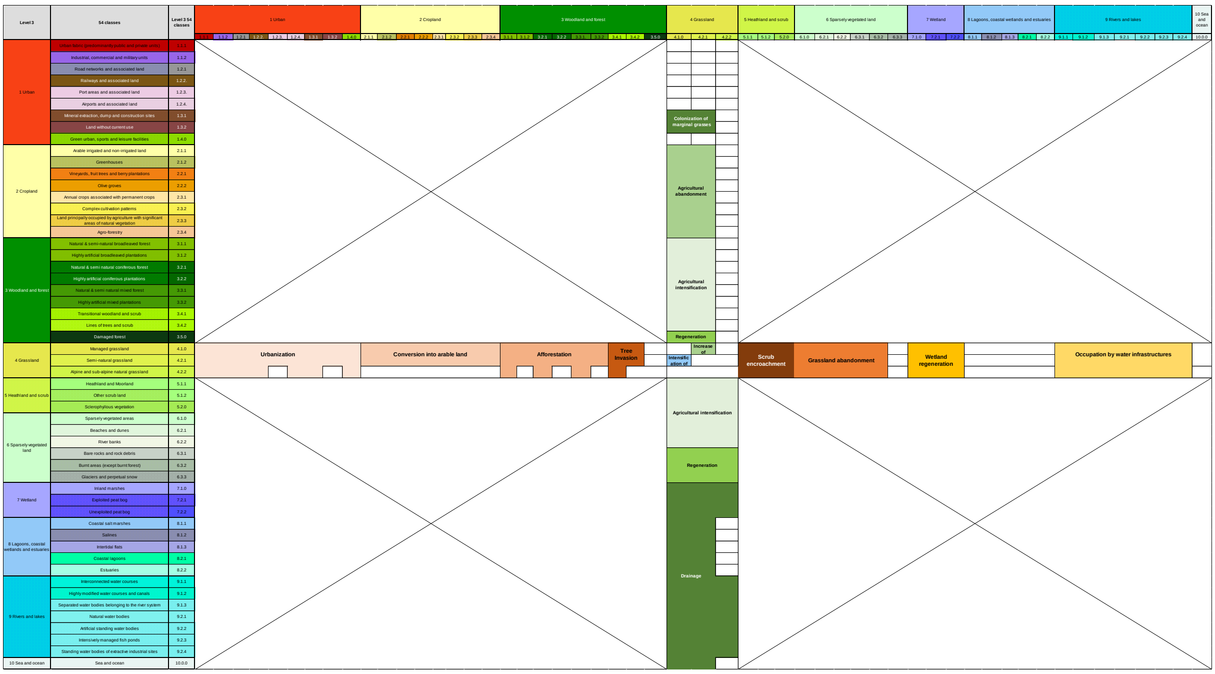

Figure 7.2 Grassland specific pressure matrix based on MAES level 3 developed by Copernicus service provider