Land cover changes and environmental protection:

a study based on transition matrices concerning Sardinia (Italy).

Abstract

Prevention and mitigation of the progressive spread of artificialization are key goals of environmental protection policies leading to the establishment of protected areas. Artificialization processes can be effectively assessed by analyzing land cover and land use changes, which put in evidence different kinds of processes that spur a decrease in natural areas and an increase in artificial ones.

In this article, we first analyze land cover change processes by developing transition matrices using the simplified Land and Ecosystem Account taxonomy, and next we compare and contrast processes that take place in areas characterized by different levels of environmental protection, which we identify as follows: natural protected areas, sites of the European Natura 2000 network, and unprotected areas. We take the Italian island of Sardinia as a case study, since a system of national and regional parks and an extensive Natura 2000 network have been established in this region, and analyze and compare land cover change processes over more than twenty years (i.e. between 1990 and 2012).

Our results highlight significant implications for the definition and implementation of planning policies aiming at preventing or mitigating artificialization processes within the island. However, the methodological approach here proposed can be applied in other European regional contexts so as to tailor planning policies to the local characteristics of ongoing land cover transition processes.

1. Assessing effectiveness of protected areas in preserving natural resources

Environmental protection policies aim at preventing or, at least, at mitigating the progressive spread of artificialization.

In particular, the establishment of protected areas (PAs) represents a cornerstone of international policies related to environmental protection (Sieber et al., 2013). Such policies aim at maintaining (Martinuzzi et al., 2015; Gaston et al., 2006) or restoring (Figueroa and Sanchez-Cordero, 2008) biodiversity and ecological integrity. According to article no. 2 of the Convention on Biological Diversity,[1] PA "means a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives".

The Strategic Plan for Biodiversity 2011-2020,[2] with the Aichi Biodiversity Target no.11, states that at least 17 percent of terrestrial areas and 10 percent of coastal and marine zones should be conserved through a system of PAs and other effective conservation measures by 2020; however, global biodiversity has been reported to be decreasing even within PAs (Coad et al., 2015). Indeed, PAs are directly and indirectly affected by changes in land uses within and outside their boundaries (Martinuzzi et al., 2015) because human activities, which often bring about intensive land uses, are allowed within their boundaries (Sieber et al., 2013). Land-use changes, as one of the main drivers of biodiversity loss, can entail fragmentation and degradation of habitats due to deforestation, agricultural expansion and abandonment, and urbanization (Calvache et al., 2016), which make PAs vulnerable to species decline (Parks and Harcourt, 2002) and introduction of exotic species (Pimentel et al., 2005). Therefore, PAs should be conceived as social-ecological landscape elements (Ament and Cumming, 2016) integrated into a larger ecosystem characterized by ecological and socio-economic interrelationships between PAs and their surroundings (Hansen and DeFries, 2007).

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[1] The Convention on Biological Diversity is an international legally binding treaty entered in force in 1993. It focuses on three objectives: conservation of biological diversity, sustainable use of its components, and fair and balanced sharing of benefits stemming from the use of genetic resources. For more details, the reader can refer to the Convention on Biological Diversity website https://www.cbd.int/ [accessed April 29, 2017].

[2] The Strategic Plan for Biodiversity 2011-2020 was revised in 2010 during the tenth meeting of the Conference of the Parties, held in Japan. The plan provides a flexible framework on biodiversity for all countries and stake-holders that includes a mission, five strategic goals and twenty targets, called Aichi Targets. For more details, the reader can refer to the Convention on Biological Diversity website https://www.cbd.int/sp/default.shtml [accessed April 29, 2017].

From this conceptual perspective, the assessment of PAs' effectiveness in terms of maintaining biodiversity has become a key theme in international debates (Ruiz Benito et al., 2010), not least because measuring ecological effectiveness of PAs is advocated as a means to improve effectiveness and efficiency of conservation measures and to promote and facilitate appropriate management actions (Gaston et al., 2006).

The effectiveness of PAs can be analyzed in both qualitative and quantitative terms (Geldmann et al., 2013).

Qualitative assessments are often grounded on expert-based evaluations, such as judgments expressed by park managers, who are fully conversant with the limitations and advantages of management strategies in the PAs in which they work; such approaches can be affected by the subjectivity embedded in experts' opinions concerning the effectiveness of conservation measures and make it quite difficult to compare assessments across sites (Hockings, 2003). Other types of qualitative analyses are based on the assessment of the representativeness of PAs in terms of species and habitats, with reference to the presence of endemic or threatened species. The main disadvantage of qualitative approaches is to be found in their inability to describe and evaluate changes of PAs over time (Geldmann et al., 2013).

Quantitative analyses are usually based on approaches and techniques for mapping land cover changes. Such studies can be further subdivided into two main groups, of which the first comprises several studies that compare the rate of land cover changes within PAs and in their surroundings (as in Figueroa and Sanchez-Cordero, 2008; Ruiz Benito et al., 2010) according to the overarching idea that these areas are characterized by similar features, such as accessibility and attitude towards conversion (Nagendra, 2008). For instance, Calvache et al. (2016) compare land cover changes in a given time period (1990-2006) inside three PAs located in France, Portugal and Spain, as well as in a 15-km buffer zone around them, while Ament and Cumming (2016) examine land cover changes between 2000 and 2009 within nineteen national parks in South Africa and in their close surroundings. A second group analyzes land cover changes that occur within the PAs boundaries only; in particular, Kamlun et al. (2016) monitor deforestation in two protected areas in Malaysia from 1985 to 2013, while Sieber et al. (2013) assess quantitative changes in forest and agricultural land cover in two Russian protected areas between 1984 and 2010. A subset of studies belonging to this second group compares the rates of land cover changes before and after the establishment of PAs; although such approaches are less common due to the difficulty of acquiring baseline data (Sader et al., 2001), a combination of these methods and the assessment of land cover changes within and outside the PAs boundaries might possibly represent a better choice (Nagendra, 2008; Willcock et al., 2016). Nagendra (2008), for instance, proposes a quantitative assessment of land cover changes in 49 PAs from 22 countries; specifically, the rate of land cover change is evaluated before and after the establishment of 37 PAs and, in 17 cases, within and outside the established PAs.

With reference to the Italian insular region of Sardinia, this essay studies land cover changes which entail artificialization processes so as to assess whether different levels of environmental protection of the areas where artificialization occurs play any role. We take into consideration three levels of environmental protection, as follows.

The first level is represented by natural protected areas established under the provisions of national and regional acts. The set of sites of the Natura 2000 network located in Sardinia is the second level of environmental protection. A third level is identified by areas which are not subject to any environmental protection rules.

Our assessments are based on the CORINE Land Cover[3] taxonomy of the EEA (European Environment Agency) (EEA, 1995) aggregated following the methodology defined in the Land and Ecosystem Accounting (LEAC) project (EEA, 2006). For each level of environmental protection, we define a transition matrix describing the land cover changes that occur in the cartographic units of the LEAC-based taxonomy in the 1990-2012 time period. Hence, this essay describes and analyzes land cover changes related to the LEAC-based taxonomy and compares the characteristics identified as regards the three levels of environmental protection here considered.

Our results put in evidence important issues and consequences for the definition and implementation of planning policies concerning the mitigation of artificialization processes occurring in the insular

[3] CORINE is the acronym of COoRdination de l'INformation sur l'Environnement [Coordination of the information concerning the environment].

region of Sardinia (Italy). Moreover, the approach proposed and applied in this essay can easily and effectively be exported to other European regional contexts in order to define environmental planning policies based on observed consistencies and differences related to comparative assessments based on the same methodological premises.

The essay is organized as follows. In the second section, we analytically present the methodology we use to implement our assessments, as well as the data used for the analyses concerning the definition of land cover changes.

The results are presented in detail in the third section, whereas the fourth section puts forward an analytical discussion of the outcomes. In the conclusion we highlight strengths and limitations of the implemented methodological approach, the issue of its exportability and directions for future research.

2. Data and methods

2.1 Study area

The second largest island in the Mediterranean sea (approximately 24,000 km^2), Sardinia is completely included within the Mediterranean biogeographic region (EEA 2012, p. 31). In this study, three different protection levels are identified within the region: natural protected areas, Natura 2000 sites, and unprotected areas. The first and the second are in this study understood as two different kinds of PAs as presented in the previous section.

Natural protected areas are designated either under national law no. 394 of December 6, 1991 (National Parks and National Reserves) or under regional law no. 31 of June 7, 1989 (Regional Parks, Regional Reserves, Natural Monuments, Areas of Relevant Natural Interest). Moreover, public woods are protected and managed by the Regional Agency for Forests under regional law no. 8 of April 27, 2016; public woods outside national and regional protected areas, despite not being nature conservation areas themselves *strictu sensu*, do enjoy a protected status meaning that the Agency must ensure that the landscape and the environment are preserved (for instance against fires and hydro-geological risks) and that natural resources (comprising not only wood, but also non-wood forest products) are used within the limits of their natural regeneration.

A cornerstone of the European Union (EU) policy on conservation of biodiversity, the Natura 2000 network is an ambitious project aiming at establishing a network of protected areas covering the whole EU. Natura 2000 sites are designated under Directive 92/43/EEC ("Habitats" Directive) and presently take three forms: Special Protection Areas (SPAs), designated in compliance with the "Birds" Directive (Directive 2009/147/EC, codified version of the previous Directive 79/409/EEC), Sites of Community Interest (SCIs) and Special Areas of Conservation (SACs), both designated in compliance with the Habitats Directive. Actually, SCIs are due to become SACs within six years since their being enlisted as SCIs, and this transition is currently ongoing in the Mediterranean biogeographical region. Under the two above mentioned Directives, a total of 93 SCIs and 37 SPAs were identified in Sardinia, while no SACs have been established yet. It is here important to highlight that, because we analyze land cover change processes, the marine share Natura 2000 sites is not considered here. Moreover, and following Martínez-Fernández et al. (2015), when a Natura 2000 site overlaps a natural protected area, the overlapping part is treated here as natural protected area, while the rest of the site is regarded as Natura 2000. The reason is that the protection regime is more conservative in natural protected areas, hence human-induced land cover changes are assumed to be less likely in natural protected areas than in Natura 2000 sites.

Finally, and again after Martínez-Fernández et al. (2015), unprotected areas are here regarded as areas that do not belong to either natural protected areas or Natura 2000 sites, and that moreover are further away than 5 kilometers from National and Regional Parks and from Natura 2000 sites.

A map showing the three protection levels is shown in Figure 1, while some figures on sizes and percentages are provided in Table 1. Map and figures were obtained by processing spatial datasets downloaded from the regional geoportal[4] (natural protected areas, including national and regional protected parks as well as public woods managed by the Regional Agency for Forests) and from the website of the Italian minister for the environment and the protection of land and sea[5] (Natura 2000 sites in Italy).

[4] http://www.sardegnageoportale.it/ [accessed April 29, 2017]
[5] ftp://ftp.minambiente.it/Pnm/Natura2000/TrasmissioneCE_2015/ [accessed April 29, 2017]

[FIGURE 1]

[TABLE 1]

2.2 Data

In order to evaluate land cover transition processes, we used two spatial datasets describing land covers in 1990 and in 2012, available from the website of ISPRA, the Italian National Institute for Environmental Protection and Research,[6] where land covers are classed in compliance with the European Corine Land Cover project. The 1990 dataset was implemented by Italian regions under the supervision of a national research and technical centre, hence the dataset has been regarded as homogeneous and consistent across Italy (ISPRA, 2010, p. 13), while the 2012 dataset was produced by ISPRA.[7] For both maps, scale is 1:100.000, minimum mapping unit is 25 hectares, geometric accuracy equals 100 meters, and the same taxonomy (44 classes, Level III of the European Corine Land Cover project) applies.

The two datasets were separately reclassified in this study in GIS environment, so as to cluster land cover classes into eight groups using the aggregation scheme for land cover accounts proposed by the European Environment Agency (EEA, 2006, Appendix B, p. 98). LEAC land cover groups here used are therefore as follows:

i. Artificial surfaces (A);

ii. Arable land and permanent crops (ARA);

iii. Pastures and mosaic farmland (PMF);

iv. Standing forests (FOR);

v. Transitional woodland and shrub (TRW);

vi. Natural grassland, heathland, sclerophylous vegetation (GRSH);

vii. Open space with little or no vegetation (OPEN);

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[6] http://www.sinanet.isprambiente.it/it/sia-ispra/download-mais/corine-land-cover [accessed April 29, 2017]
[7] http://geoportale.isprambiente.it/dettagli/?uuid=ispra_rm%3A20101019%3A120000 [accessed April 29, 2017]

viii. Wetlands and water bodies (WAT).

2.3 Land cover change: processes

Once the two datasets describing LEAC land cover groups were obtained, they were further processed so as to identify land cover change processes in the 1990-2012 timeframe building upon Martínez-Fernández et al. (2015), who propose a simplified version of the detailed classification by Gómez and Páramo (2005).

[FIGURE 2]

The processes are graphically summarized in Figure 2, showing a matrix in which cells in the diagonal denote persistence, while cells off the diagonal correspond to the shift from a land cover group to a different one and are therefore assigned a code corresponding to a given land cover change process. Such processes, together with their codes, are arranged into four groups, thereby differentiating among anthropization processes (first-digit code: 1), processes conducive towards higher naturalization (first-digit code: 2), internal changes in natural areas (first-digit code: 3), and finally processes leading to increase in water surfaces (first-digit code: 4).

Furthermore, for the whole island and for each protection level, we calculate the relative net change (NC); for a given land cover group, NC is the ratio of absolute net change (i.e., the difference between its surface in 2012 and 1990) to its surface in 1990:

$NC_i = [(S_{i,t1}-S_{i,to})]/(S_{i,to})$

where *i* is a land cover LEAC group; NC_i is the relative net change land of land cover group *i*; S_i is the surface of land cover group *i*; t_0 and t_1 are the begin and the end year of the time interval in which land cover change is analyzed (respectively, 1990 and 2012 in this study).

2.4 Land cover change: transitions, gains and losses

Land cover changes from 1990 to 2012 are examined through cross tabulation matrixes or transition matrixes following Pontius et al.'s (2004) methodology. In transition matrixes, which compare maps from 1990 and 2012 as regards the whole region and each protection level, rows and columns show land cover group types in 1990 and 2012, respectively. Values in the cells represent the share of land cover that between 1990 and 2012 changes from category *i* (land cover groups in rows) to category *j* (land cover groups in columns) with respect to their 1990 size. In particular, bold-faced figures in the diagonal denote persistence of the category *i*, while numbers off the diagonal display a transition from category *i* to category *j*. For each protection level, the second-to-last column and row represent the total percentage of category *i* in 1990 and of category *j* in 2012, respectively, whereas the last column and row display, respectively, the gross loss (i.e., the total of the category *i* in 1990 minus the persistence of the same category) of the category *i* and the gross gain (i.e., the total of the category *j* in 2012 minus the persistence of the same category) of the category *j* in the 1990-2012 time period.

2.5 Systematic transitions

In order to identify the most significant transitions, the observed values of land cover changes are compared to the expected values. Expected values are those that would be generated by a random process whereby losses of category *i* and gains of category *j* are distributed across other categories proportionally to their values in 2012 and in 1990 respectively. The expected transition is calculated in terms of gains and losses through the following equations for $i \neq j$:

$$L_{ij} = [(P_{i+}-P_{ii})P_{+j}]/(1-P_{+i})$$

$$G_{ij} = [(P_{+j}-P_{jj})P_{i+}]/(1-P_{j+})$$

where L_{ij} and G_{ij} are the expected transitions from category *i* to *j* due to a random process of loss and gain respectively, $P_{i+}-P_{ii}$ and $P_{+j}-P_{jj}$ are the observed total gross loss of category *i* and gross gain of category *j* in the 1990-2012 period, P_{+j} and P_{+i}, and P_{i+} and P_{j+} are the total observed values of the category *j* and *i* in 2012 and of the category *i* and *j* in 1990, respectively.

As proposed by Pontius et al. (2004) and by Alo and Pontius (2008), observed transitions and random (or expected) transitions are compared through a variable, named by Martínez-Fernández et al. (2015) as R that, for each transition, represents the ratio of the difference between observed and expected values to the expected value. In particular, a transition is defined as *systematic* when its observed and expected values diverge significantly. For example, if the difference between observed gain and expected gain is positive, the category in the row systematically gains by the category in the column, otherwise (i.e., if the difference is negative) the category in the row systematically resists being replaced by the category in the column. The reasoning is analogous in terms of losses. Therefore, a process of transition from category *i* (in the row) to category *j* (in the column) is systematic if category *i* gains systematically by category *j* and, similarly, category *j* loses systematically to category *i*. The variable R, depending on the expected value and on the size of the involved category, measures the strength of the systematic transition.

The next step entails the identification of the most systematic transitions, that is those transitions where observed values exceed expected values for both gains and losses, and, as proposed by Martínez-Fernández et al. (2015), R is higher than the 1.5 threshold value. This value is considerably below the average, which equals 8.7.

3. Results

This paper analyzes comprehensive transitions related to the macrocategories of the LEAC groups we use, that is artificial (A), agricultural (comprising arable land and permanent crops (ARA), and pastures and mosaic farmland (PMF)), as well as natural (comprising standing forests (FOR), transitional woodland and shrubs (TRW), natural grassland, heathland, sclerophylous vegetation (GRSH), open space (OPEN), and wetlands and water bodies (WAT)) in relation to three protection levels of our analysis, that is natural protected areas, Natura 2000 sites and unprotected areas outside a 5-km buffer around natural protected areas and Natura 2000 sites in 1990-2012 time period.

Land cover change processes in Sardinia, mapped in Figure 3, are analyzed at the regional scale and for each protection level. Table 2 provides figures, in terms of percentage, concerning land cover flows that is areas showing change processes within the whole region and within each protection level.

[TABLE 2]

[FIGURE 3]

For the whole region and for each protection level, Table 3 describes the size of each land cover group in 1990 and 2012 by providing the area classed as belonging to a certain group as a percentage of the total area (of the region, of natural protected areas, of Natura 2000 sites, of unprotected areas respectively). Table 3 also highlights the dynamics of the whole island compared to the transition processes that occur in each protection level of our analysis.

[TABLE 3]

Furthermore, a graphical representation of land cover changes within the whole region and within each protection level, quantitatively described in Table 4, is provided in Figure 4.

[TABLE 4]

[FIGURE 4]

In particular, comprehensive transitions related to the macrocategories of the LEAC groups we use in this paper, show that the three protection levels of our analysis are quite steady between 1990 and 2012.

The most outstanding changes are related to Natura 2000 sites and unprotected areas (see Table 3). Natura 2000 sites are characterized by a 20 percent increase in artificial areas and by a 11 percent increase in agricultural areas, mostly due to an increase in pastures and mosaic farmland (28 percent), while natural land cover loses a mere 4 percent. This puts in evidence that there is a moderate anthropization pressure in favor of urbanization and agrarian transformation which generates a slightly negative influence on the comprehensive endowment of natural surfaces within Natura 2000 sites (4 percent).

Unprotected areas show a somewhat important artificialization increase (over 40 percent). However, this transition corresponds to about 6,300 hectares, which still keeps the share of artificialized land around natural protected areas and Natura 2000 sites down.

Dynamics related to the whole region show minimal transitions in case of agricultural and natural types (1 percent and 2 percent change, respectively), while the most important change concerns artificial types, whose share grows by nearly a 30 percent between 1990 and 2012.

With reference to the whole region, the shares of the three macrocategories are similar to those observed in unprotected areas, even though natural types prevail over agricultural areas at the regional level (conversely, agricultural land prevails over natural land in unprotected areas), in so far as artificial area shares show a significant relative increase in both cases.

Natura 2000 sites show a very low share of artificial areas with respect to the whole region and to unprotected areas, and quite close to that of natural protected areas. The trend towards artificialization is more important for Natura 2000 sites than for natural protected areas (+20 percent vs. +3 percent). This can be explained in terms of the protection regime, which is much stricter in natural protected areas than in Natura 2000 sites. The share of agricultural areas is less relevant in natural protected areas than elsewhere (less than 3 percent), while it is much higher and steadier in the whole region and in unprotected areas (around 46 percent and 57 percent, respectively). The share of agricultural areas in Natura 2000 sites is somewhat intermediate between that in natural protected areas and in the whole region, with a positive trend (approximately 30 percent in 2012, +11 percent increase).

Finally, the balance between natural surfaces and agricultural areas varies greatly, since the share of natural surfaces is much more relevant in natural protected areas and Natura 2000 sites (approximately 97 percent and 75 percent respectively in 2012) than in the whole island, where still natural surfaces prevail over agricultural areas, while in unprotected areas the balance is reversed with natural surfaces (around 41 percent) by far less important than agricultural areas.

As we explain in the "Data and methods" section, we distinguish between two types of transitions, i.e. random transitions and systematic transitions. With reference to gains or losses concerning the LEAC-related types of the three protection levels of our analysis, a transition (gain or loss) is random if it is smaller than the expected value, whereas it is systematic if it is greater than the expected value. Table 5 shows the most systematic land cover transitions in terms of gains and losses, while the full transition tables are provided in Appendix 1 and Appendix 2.

[TABLE 5]

In the following three subsections, we highlight the connections between the 1990-2012 changes concerning the three LEAC macrocategories, that is artificial types, agricultural types and natural types (see Table 3), and the systematic transitions related to the LEAC types which are comprised in the macrocategories.

In the discussion we take into consideration the significant systematic transitions (gains and losses), which we define as transitions which: i. are systematic both in terms of gains and losses; and, ii. show at least one out of the two ratios of the difference between the observed and expected value of gain or loss greater than its expected value (at least one out of the two R values greater than 1; the R values are reported in Table 5, where only significant systematic transitions are emphasized). Moreover, we indicate that some transitions are quantitatively irrelevant, even though significant and systematic. It has to be clarified that quantitative irrelevance does not imply that the transitional behavior is not important or should be worth no consideration. As we discuss in the following section, transitional behavior concerning transitions to artificial areas are very important to understand and assess land-taking processes, even when irrelevant in quantitative terms.

3.1 Transition processes in natural protected areas

Transitions amount to a 3 percent increase in artificial surfaces, and to a 7 percent decrease in agricultural areas. The share of natural surfaces remains steady (see Table 3).

The significant systematic transitions in terms of anthropization processes are ARA-A, WAT-A and PMF-ARA, and, to a lesser degree, PMF-A (Table 4 and Table 5). This finding implies that, in a framework characterized by a small increase in artificial land and by a slight decrease in agricultural surfaces, the most relevant transitions in favor of artificialization are generated by pressures on arable and cropped land and, to a lesser degree, on pastures and mosaic farmland (ARA and PMF), and on wetlands and water bodies (WAT). WAT-A transitions are negligible in quantitative terms, since A and WAT account, respectively, to less than 0.5 percent and less than 1 percent of the total surface of natural protected areas both in 1990 and in 2012. Moreover, significant systematic transitions related to agricultural anthropization processes consist of transformation of pastures and mosaic farmland into arable and cropped land (transition PMF-ARA), which is an internal change within agrarian types (see the classification proposed in Figure 2 and Table 2).

The significant systematic transitions in terms of processes to higher naturalization are A-ARA, A-OPEN and ARA-PMF (Table 4 and Table 5). This outcome puts in evidence that, in a context characterized by a small decrease in agricultural surfaces and by an almost stable amount of natural areas, transitions to higher naturalization are systematically generated by processes which involve the transformation of artificial areas into arable and cropped land, and internal changes within agricultural areas from arable and cropped land to pastures and mosaic farmland. A-ARA and ARA-PMF are negligible, since A accounts to less than 0.5 percent and ARA accounts to less than 0.85 percent of the total surface of natural protected areas, both in 1990 and in 2012. For the same reason, the process A-OPEN is negligible as well.

Finally, significant systematic processes concerning internal changes in natural areas consist of transitions from standing forests to transition woodland and shrubs (FOR-TRW) and from the latter to natural grassland, heathland, sclerophylous vegetation (TRW-GRSH). As for processes leading to increase in water surfaces, process ARA-WAT is negligible, since WAT accounts to less than 0.7 percent of the total surface of natural protected areas both in 1990 and in 2012 (see Table 4 and Table 5).

In conclusion, significant systematic processes relevant for natural protected areas in quantitative terms are: ARA-PMF (higher naturalization), and FOR-TRW and TRW-GRSH (internal changes in natural areas).

3.2 Transition processes in Natura 2000 sites

Results reported in Table 3 show that processes of artificialization and agrarian transformation are important within Natura 2000 sites. Transitions amount to a 20 percent increase in artificial surfaces, and to a 11 percent increase in agricultural areas. The share of natural surfaces falls by 4 percent.

The significant systematic transitions in terms of anthropization processes are PMF-A, FOR-A and PMF-ARA (Table 4 and Table 5). This entails that, in a framework characterized by a somewhat relevant increase in artificial and agricultural surfaces, the most important transitions in favor of artificialization are generated by pressures on pastures and mosaic farmland, and on standing forests (PMF and FOR). PMF-A and FOR-A transitions are negligible in quantitative terms, since A accounts to less than 0.7 percent of the total surface of Natura 2000 sites both in 1990 and in 2012. Moreover, significant systematic transitions related to agricultural anthropization processes consist of transformation of pastures and mosaic farmland into arable and cropped land (transition PMF-ARA, see Table 4 and Table 5), which, as we explain above, is just an internal change within agricultural areas (see, once again, the classification proposed in Figure 2 and Table 2).

The only significant systematic transition in terms of processes to higher naturalization is A-TRW, that is a change from artificial areas to transitional woodland and shrubs. This outcome indicates that, in a context characterized by a somewhat relevant increase in agricultural surfaces and a small decrease in natural areas, transitions to higher naturalization systematically take the form of changes from artificial areas to transitional woodland and shrubs, characterized by a small quantitative relevance, since A accounts to less than 0.7 percent of the total surface of Natura 2000 sites both in 1990 and in 2012.

Significant systematic processes concerning internal changes in natural areas consist of (Table 4 and Table 5): i. transitions from standing forests to transitional woodland and shrubs (FOR-TRW); ii. transitions from natural grassland, heathland, sclerophylous vegetation to transitional woodland and shrubs (GRSH-TRW); and, iii. processes from transitional woodland and shrubs to either standing forests (TRW-FOR) or to natural grassland, heathland, sclerophylous vegetation (TRW-GRSH), which are quantitatively irrelevant since the total amount of TRW accounts to less than 0.4 percent of the total surface of Natura 2000 sites in 1990 (see Table 3). This result implies that, in a framework characterized by a small decrease in natural areas, internal changes in natural areas transitions are systematically implemented by mutual changes from transitional woodland and shrubs to standing forests, and from natural grassland, heathland, sclerophylous vegetation to transitional woodland and shrubs. Moreover, as far as processes that lead to increase in water surfaces are concerned, transition processes from artificial areas or from pastures and mosaic farmland to wetlands and water bodies (A-WAT and PMF-WAT), although significant, are irrelevant since the share of water surfaces, which accounts to 5.2 percent of the total surface of Natura 2000 sites, remains almost stable between 1990 and 2012 (see Table 3).

In conclusion, significant systematic processes that are relevant for Natura 2000 sites in quantitative terms are (Table 4 and Table 5): PMF-ARA (anthropization), and FOR-TRW and GRSH-TRW (internal changes in natural areas).

3.3 Transition processes in unprotected areas

Results reported in Table 3 show that processes of artificialization are important for unprotected areas located outside a 5-km buffer around natural protected areas and Natura 2000 sites. Transitions lead to a 41 percent increase in artificial surfaces. The shares of agricultural areas and natural surfaces remain almost steady in the 1990-2012 period (+1 percent and -2 percent respectively).

The only significant systematic transition in terms of anthropization is ARA-A (Table 4 and Table 5). This implies that, in a situation characterized by a relevant increase in artificial surfaces, the most important transitions in favor of artificialization are generated by pressures on arable and cropped land.

Since there is no evidence of significant systematic transitions related to higher naturalization, we can conclude that in unprotected areas there is no significant pressure towards conversion and restoration, heterogeneization or semi-naturalization of agrarian areas and agrarian abandonment (see processes “2” in Table 2).

Significant systematic processes concerning internal changes in natural areas consist of: i. changes from transitional woodland and shrubs to standing forests (TRW-FOR) and vice-versa (FOR-TRW); ii. transitions from transitional woodland and shrubs to natural grassland, heathland, sclerophylous vegetation (TRW-GRSH); iii. transitions from open space with little or no vegetation to transitional woodland and shrubs (OPEN-TRW); and, iv. transitions from open space with little or no vegetation to natural grassland, heathland, sclerophylous vegetation and vice-versa (OPEN- GRSH and GRSH-OPEN) (see Table 4 and Table 5).

Since the unprotected areas shares of TRW and OPEN are lower than 0.8 percent and 0.5 percent respectively both in 1990 and 2012 (Table 3), we conclude that the only quantitatively significant transition in the case of unprotected areas is ARA-A, that is the change from arable and cropped land to artificial areas.

4. Discussion

Transition processes concerning Natura 2000 sites and unprotected areas are quite similar to each other. In both cases, anthropization equals around 6 percent (Table 2), mostly dependent on the creation of heterogeneous and semi-natural agrarian areas (transition "122"). This transition is more significant in Natura 2000 sites (5.25 percent) than in unprotected areas (3.60 percent). On the other hand, anthropization processes are comparatively more influenced by urbanization (transition "11") in unprotected areas than in Natura 2000 sites. This outcome is consistent with the protection regime in force in Natura 2000 sites, where special regulations not applicable in unprotected areas are in force. Pressures in favor of higher anthropization, mostly aimed at increasing profitability derived from land productivity (Radeloff et al., 2012), can be better fulfilled in unprotected land through urbanization, which is severely restricted in Natura 2000 sites and requires a positive Appropriate assessment, which is much less likely to be granted than in the case of transition "122" (Table 2) concerning agrarian transformation projects. This is consistent with Natura 2000 objectives: among anthropization processes, urbanization (comprising housing development, urban growth, urban sprawl) has been found to be the major global threat to natural habitats and biodiversity conservation (Mcdonald et al., 2008; Güneralp and Seto, 2013) that are the main goals of Natura 2000. Conversion of natural areas into agrarian areas has been identified as an important source of biodiversity loss at the global scale, as well (among many, Beaumont and Duursma, 2012); it has to be remarked, however, that in our case "122" is a particular subset of such conversion, entailing creation of non-intensive, semi-natural and heterogeneous farmland that in Sardinia are home to several populations of wild fauna. Hence, in this context it is not surprising that transition "122" is more likely to be allowed through the Appropriate assessment procedure.

Processes to higher naturalization are more important in unprotected areas (around 4 percent) than in Natura 2000 sites (3.25 percent). In both cases, this is mainly due to the abandonment of heterogeneous or semi-natural agricultural areas (transition "232"; 2.78 and 1.89 percent, respectively) and, to a lesser extent, to the process whereby former agrarian land is turned into heterogeneous or semi-natural areas (transition "22"; 0.75 and 0.92 percent, respectively). A more relevant abandonment phenomenon related to unprotected areas than to Natura 2000 sites is consistent with the smaller size of heterogeneous and semi-natural agrarian areas within Natura 2000 sites (less than one fifth of the corresponding areas located in unprotected areas), which implies a comparatively lesser propensity to change. Loss of traditional agricultural practices (which include non-intensive grazing and farming of heterogeneous or semi-natural agricultural areas) with consequent regrowth of bushes, scrubs and forests through successional processes (Lasanta et al., 2015), can be detrimental in Natura 2000 sites because it leads to decrease in habitat diversity and simplification of habitat mosaics (Honrado et al., 2017; Vassilev, 2011) and ultimately to the loss of semi-natural habitats of community interest dependent on light farming activities (Halada et al., 2011). Hence the fact that in our study area abandonment of agricultural activities is less significant in Natura 2000 sites than in unprotected areas can be regarded as positive. The reason could possibly relate to EU agri-environmental support schemes in place in Natura 2000 sites, which subsidize the maintenance of traditional, "low-intensity" (Caraveli, 2000) agricultural activities because they contribute to biodiversity conservation by maintaining habitats and species of community interest that depend on agriculture (Halada et al., 2011; Faria et al., 2012; Queiroz et al., 2014) in a favorable conservation status (Farris et al., 2013), therefore contributing to the general goals of Natura 2000. Internal changes in natural areas in unprotected areas and Natura 2000 sites are lower than in natural protected areas (transition "3"; 2.93 and 5.78 percent vs. 12.04 percent). Transitions related to Natura 2000 sites are almost twice as much as those in unprotected areas. The prevailing processes are successional in both cases (transition "31"), rather than consisting of degradation and simplification, contrary to what happens in natural protected areas (transition "32"). This finding puts in evidence that transitions concerning degradation and simplification do occur in natural protected areas, where improvements in agricultural practices are much more difficult due to the regulations which often prevent the implementation of new agricultural activities. Since agricultural improvement is hindered, land is often abandoned, which leaves room for decay and deterioration. In terms of planning and management of natural protected areas, it is therefore important to identify such areas, which should be prioritized for restoration actions (Öckinger et al., 2006; Campagnaro et al., 2017).

An outstanding general characteristic of the Sardinian transition processes between 1990 and 2012 is that a large share of the regional land does not show any sign of transition processes (see Table 2 and Figure 3). However, transitions in Natura 2000 sites are more relevant than elsewhere, since more than

15.5 percent if its surface is affected by transition processes, while in the other two cases transitions are at most 13.5 percent (see Table 2).

This is due to the land-use structure, described by the LEAC group types, of the Sardinian land within each protection level upon which our analysis is based. Table 3 shows that the LEAC type that is comparatively more exposed to transition pressures is GRSH, whose surface in Natura 2000 sites is comparatively larger than in the other two cases, as its 1990 share was about 46 percent in Natura 2000 sites, 38 percent in natural protected areas and 29 percent in unprotected areas. The decrease of the share of GRSH concerning Natura 2000 sites is much larger (4.4 percent) than in the other two cases, which is consistent with a higher marginal propensity to decrease due to a greater endowment of the LEAC type (GRSH) exposed to transition pressure. The significant systematic transition concerning the change processes from GRSH to TRW (see Table 4 and Table 5) indicates that there are important systematic processes related to internal changes in natural areas which involve flows from natural grassland, heathland etc. to transitional woodland and shrub (transition "31" in Table 2).

Moreover, the PMF agricultural type (which shows a growing tendency in the Sardinian region as a whole, as well as in Natura 2000 sites and in unprotected areas, contrary to what happens in natural protected areas) is comparatively underendowed in Natura 2000 sites with respect to unprotected areas (around 12 percent vs. 26 percent in 1990 respectively), whereas this land use is almost totally forbidden by the strict rules in force in natural protected areas, where it remains low and almost stable during the 1990-2012 period. The increase in the share of PMF concerning Natura 2000 sites is much larger (3.5 percent) than in the other two cases, which is consistent with a higher marginal propensity to increase due to an initial underendowment of the LEAC type (PMF) which shows a growing tendency.

The reasons why PMF is comparatively low in 1990 are the following. Natura 2000 sites were established under the provisions of the already mentioned Habitats and Birds Directives. When the candidate sites for the Sardinian Natura 2000 network were first identified and proposed, during the second half of the 1990's, SCIs and SPAs were identified primarily in areas characterized by a high degree of naturalization, in order to protect habitats of community importance, as well as animal species and their habitats, with comparatively low shares of pastures, mosaic farmland, arable and cropped land. Moreover, since the Habitats Directive states that a mandatory preliminary assessment of the likely significant implications of any plan or project on Natura 2000 sites must be carried out,[8] transitions concerning LEAC types that imply anthropization can be allowed only if an Appropriate assessment is implemented. In general, it is fairly easier that a positive Appropriate assessment is released if transitions which imply an increase in arable and cropped land are very limited or absent. That is most likely the reason why transitions to productive (agrarian) uses have focused on pastures and mosaic farmland, which show a growing tendency in Natura 2000 sites towards the average regional level of this LEAC type. Another possible explanation for this growing tendency of low-intensity agricultural activities, such as grazing and mosaic farmland, in Natura 2000 sites could possibly be found in EU agri-environmental support schemes, as discussed previously with reference to the lower loss of traditional agricultural practices in Natura 2000 sites than in unprotected areas.

Processes that occur in natural protected areas consist almost exclusively of internal changes in natural areas (transition "3"; 12.04 percent out of 13.47 percent), where degradation and simplification processes (transition "32"; 7.17 percent) prevail over successional ones (transition "31"; 4.87 percent).

This outcome is consistent with the composition of natural protected areas in terms of LEAC types, since more than 87 percent of land therein is identified either as FOR (52 percent in 1990 and 50 percent in 2012) or as GRSH (38 percent-37 percent), both in 1990 and in 2012. These figures are much higher than those in unprotected areas or in Natura 2000 sites, since in natural protected areas conservation goals much stricter than elsewhere are set for natural resources such as standing forests and natural grassland, heathland and sclerophylous vegetation. This is not surprising and supports previous studies showing that preservation of forests has been effectively pursued in natural protected areas (among many: Bruner et al., 2001; Ament and Cumming, 2016; Blankespoor et al., 2017) through management measures in their capacity, including both enforcement and boundary delimitation.

[8] In the words of the Directive, "Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives […] [T]he competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public." (Habitats Directive, art. 6, paragraph 3)

The “32” transition process, involving degradation and simplification, can be straightforwardly explained through significant systematic transitions concerning natural protected areas, which, as we put in evidence in the first subsection of the previous section, are very important in terms of transitions from standing forests to transitional woodland and shrubs (the FOR-TRW transition, see Table 5). This transition, which implies degradation and simplification, is quantitatively more important than the other significant systematic transition, from TRW to GRSH (see Table 5) that entails degradation as well. This finding indicates that public management of natural protected areas is, to some extent, ineffective, and needs particular care. Proactive protection policies should be defined and implemented in order to involve local communities in the effective and durable management of natural protected areas (Bruner et al., 2001; Pollnac et al., 2001; Gaymer et al., 2014; Strickland-Munro and Moore, 2013). Without public managers and community partnership, it is easy to forecast that degradation processes will continue and will become increasingly dangerous.

The other significant systematic transition that characterizes natural protected areas is the “22” process ARA-PMF (see Table 5), which signals a transition from arable and cropped land to pastures and mosaic farmland, that is an agrarian abandonment process. This process puts in evidence an increasing degradation (as with the above mentioned FOR-TRW), since structured agricultural activities give way to the implementation of loosely controlled agrarian uses, which are a consequence of loss of profitability, probably due to the strict regulatory regime concerning agricultural land uses in natural protected areas. How to interpret this transition in terms of effectiveness of the protection regime in force in natural protected areas is debatable, as abandonment of agricultural activities, or conversion from more structured to less structured agriculture, is seen either as an opportunity for ecosystem restoration (Beilin et al., 2014) and therefore for providing habitats for native species of fauna (Hamilton et al., 2013) or as an environmentally negative process leading to desertification, soil erosion, increase in both fire risk and flood risk (Caraveli, 2000).

As we highlight above, the only significant systematic transition concerning unprotected areas is ARA-A, which highlights and quantitatively characterizes the most important anthropization processes related to unprotected areas, that is, land uptaken from agricultural productive uses and converted into newly urbanized areas, with a comprehensive impoverishment of agricultural production and a dangerous increase of soil sealing.

Moreover, it must be noticed that, under this perspective, the most significant systematic transition that occurs in Natura 2000 sites is PMF-ARA, which is highly likely connected to pressures in favor of increasing agricultural productivity of agrarian land: to put it with Radeloff et al. (2012), "any pasture that has the opportunity to transition to another more profitable land use will probably transition". In the Natura 2000 context, this implies that pastures and mosaic farmland are converted into arable and cropped land whenever agricultural transformation projects are allowed through Appropriate assessments (transition "13", see Figure 2 and Table 2). The other significant systematic transitions that characterize Natura 2000 sites, represented by processes FOR-TRW and GRSH-TRW, signal the presence of ongoing processes of degradation and simplification, as we clarify above in the case of the "32" transitions in natural protected areas. A comprehensive and thorough public management framework of natural areas, which may possibly include incentives for virtuous and proactive behavior, should be defined and implemented in order to involve landowners and local communities in the implementation of policies aimed at protecting forests and at fostering the recovery and restoration of land cover from simplified or degraded land types towards more evolved and mature ones, e.g. GRSH-TRW-FOR processes.

5. Conclusion

In the discussion proposed in this essay, assessments of the effectiveness of PAs (here including both natural protected areas and Natura 2000 sites) are based on the assumption that effective protection is implemented through the provisions of PAs regulation regimes (Geldmann et al., 2013). Indeed, the success of PAs in terms of conservation measures is closely related to the effectiveness of their management framework (Hockings et al., 2006). Our results emphasize how Natura 2000 sites and natural protected areas are both characterized by processes of degradation and simplification. The findings of our assessment highlight the need to pay more attention to strategies concerning the management of PAs. Moreover, public management of PAs should balance appropriate conservation measures aimed at protecting biodiversity with economic, social and cultural requirements that underpin pressures and land uses.

Our results show that artificialization processes, i.e. transitions from any land cover group to artificial surfaces (A), are quantitatively irrelevant; however, they act as significant qualitative signals of human-induced pressures. For instance, in natural protected areas and Natura 2000 sites, urbanization processes are mainly connected with artificialization from natural areas converted into urban settlements, while the opposite happens in unprotected areas, where artificialization processes mostly affect crops, pastures and semi-natural areas. The smaller significance of urbanization processes in natural protected areas and Natura 2000 sites is ascribable to restrictions related to conservation measures that generally do not allow reductions in the size of non-artificial (natural) areas. Although the choice of the threshold value of R, proposed by Martínez-Fernández et al. (2015), could appear discretionary, in our case study using a higher value, such as the average value, would exclude around 28 percent of the potentially most systematic transitions. Therefore, the use of this precautionary value of R allows to analyze approximately 80 percent of the potentially most systematic transitions, providing useful qualitative information in relation to anthropic pressures.

The outcomes of our study imply a careful consideration on important issues concerning the role of the public sector, at the regional, national and EU levels, in implementing policies to ensure a better protection of natural sites, and the qualitative assessment of the human-induced pressures on natural protected areas and Natura 2000 sites.

A first question concerns the definition of measures to reduce the size of the land-take phenomenon, (transition "11"). Our findings show that a substantial reduction in land-taking processes should imply the establishment of new natural protected areas and Natura 2000 sites, or the increase of the size of the existing protected areas or Natura 2000 sites (see Table 3, first row). In the case of the natural protected areas, the increase in the size of the existing ones or the establishment of new protected areas imply close cooperation between local and regional bodies, since the Italian planning and establishment procedures are very demanding in terms of time and involvement of civil servants and scientific and administrative experts: a positive outcome of the process implies a strong and long-lasting political commitment on behalf of the local, regional and national governments, which entails a proactive participation of their scientific, technical and administrative staff (European Commission, 2012; 2013). An important step towards the implementation of such virtuous processes needs an internally-consistent ruling framework which coordinates the national, regional and local levels. This implies the implementation of a new comprehensive organization of planning rules as regards the normative frame of the Italian country (Zoppi and Lai, 2010).

The case of the establishment of new Natura 2000 sites or the enlargement of existing ones would entail more flexible rules in terms of land uses than in the case of natural protected areas, even though land take is usually prevented in Natura 2000 sites. As a consequence, public policies aimed at increasing the availability of protected areas under the ruling regime of the Habitats and Birds Directives are somewhat less problematic in terms of public consensus on behalf of the local societies, since the protection rules of Natura 2000 sites are less binding than those in force in natural protected areas. The enlargement of existing Natura 2000 sites or newly established Natura 2000 sites need comprehensive coordination and deliberative commitment not only by the national and local authorities, but also by the EU Directorate-General for Environment, since the complex and long-lasting processes which lead from the proposed SCIs to the establishment of the SACs is basically driven and directed by the EU, through the cooperation of the national and regional administrations. In other words, the national and regional public bodies can play a proactive role, but the process has to be finalized and accomplished through the technical and political authority of the EU. Indeed, an SCI becomes a SAC when appropriate conservation measures are stated, which may be part of an SCI management plan. Conservation measures in Sardinia are proposed by the local authorities, approved by the regional authorities, and agreed upon by the Italian Ministry of the environment and of the protection of the territory and of the sea, before an SCI is established as a SAC (European Commission, 2012; 2013). The cooperative and inclusive planning approach implied by the establishment of SACs, which involves the EU, and the Italian national, regional and local public bodies, would entail an important quality improvement of the regional planning processes of the Sardinian administration, which has shown a very poor coordination in the recent decades.

A second point implied by the outcomes of our study is that municipal, province and regional planning offices need the expertise of nature and environment protection scientists and practitioners, which should cooperate with spatial planners and developers to define and approve plans and planning measures concerning natural protected areas and Natura 2000 sites. This skillfulness is almost totally absent in the Sardinian planning offices, especially at the municipal level (Leone and Zoppi, 2016).

Moreover, the Strategic environmental assessment (SEA) procedures related to the local plans, which are mandatory under the provisions of the Italian legislation on SEA (National Law enacted by decree n. 2006/152, second part, first and second title), imply the integration of sustainability-related and natural resource protection-related objectives into the planning frameworks. The implementation of SEA procedures may possibly entail proposals for the enlargement of existing natural protected areas and Natura 2000 sites or the establishment of new ones, even though such proposals were missing in the original drafts of the plans (Zoppi and Lai 2014).

Fourthly, measures aimed at protecting habitats and species, which are very effective in mitigating land-taking processes as our findings show, can be extended outside Natura 2000 sites, in order to spread their beneficial impacts on nature protection. This outcome implies the availability of detailed spatial knowledge concerning the habitats and species locations and a strong commitment by the national, regional and local political bodies.

Furthermore, a fundamental consequence of our study concerning the functioning of the public planning framework is that coordination matters. Several public bodies are involved in the definition and implementation of plans of natural protected areas and in the establishment of conservation measures and management plans of Natura 2000 sites. A comprehensive organization of EU, national, regional and local public bodies is necessary, in order to promote internally-consistent and efficient public policies. A coordinated effort by the European, national and regional legislators would help establishing a coherent and effective ruling framework related to environmental and spatial planning which at present is missing.[9]

A final point to be carefully taken into consideration is the potential conflict that may arise as a consequence of the impact of conservation measures on traditional land uses, such as pastures, agriculture and rural settlements, which may be partially or totally forbidden in order to maintain and possibly enhance

[9] The role of the Sardinian regional government in the decision-making processes related to municipal plans is stated in Art. 9 of Sardinian Regional Law no. 28/98.

biodiversity and protection of endangered species and habitats (Kovács et al., 2015; Leone and Zoppi, 2016). The question of the willingness-to-accept natural protection policies by the local communities should not be neglected, and their proactive participation to decision-making processes is a necessary condition for the effectiveness of spatial policies related to natural protected areas and Natura 2000 sites. PAs represent a cornerstone for the maintenance and enhancement of biodiversity, species and habitats; however, relationships and interactions between PAs and the surrounding areas, in terms of spatial planning, are controversial and not characterized by stylized behavioral patterns. This issue is quite problematic and represents a promising research field. The management of PAs needs to deal with physical and social characteristics of neighboring zones, such as landscape dynamics and local communities' attitudes, preferences and expectations. In addition, although we do not propose analytical causality relations, our study entails the definition of spatial planning policies either to drive favorable land cover transition processes or to prevent those that are significant, systematic, and unwanted.

More detailed analysis, e.g. based on the use of the taxonomy of the CORINE Land Cover Project, which identifies 44 land cover classes in its third level, rather than the simplified eight LEAC land cover groups we used here, could be an adequate reference point to develop an analytical study concerning the characterization of land-taking processes. However, despite the potential for future research, it has to be stressed that more detailed taxonomies inevitably result in more complicated implementation and assessment of land cover change transitions, since a too large number of land types could make the identification of clear patterns quite hard.

Moreover, a future follow-up research could implement the methodology, used in this paper, in other European and national case studies. For example, analyzing the whole national territory, as in Martínez-Fernández et al. (2015), could represent a significant opportunity to test this methodology in a broader context characterized, on the one hand, by different biomes, and on the other hand, by the same regulatory framework with the exception of regional rules and directions. In this way, starting from the same national regulatory framework, we could understand in what way regional rules and management issues may influence transitions within and in the surrounding of PAs. In addition, comparing different European case studies, as in Calvache et al. (2016), could provide significant information in relation to the management of Natura 2000 sites, and more in general, of PAs.

Therefore, a significant strong point of this research is its potential generalization to other contexts, since the implementation of transition matrices based on LEAC-related types into interpretive research on land cover change processes can be easily exported to other regions of the European Union and of the Pan-European Ecological Network, whose nodes and branches, that is, natural protected areas and ecological corridors, parallel the Natura 2000 network located in the European countries outside the European Union.

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FIGURES

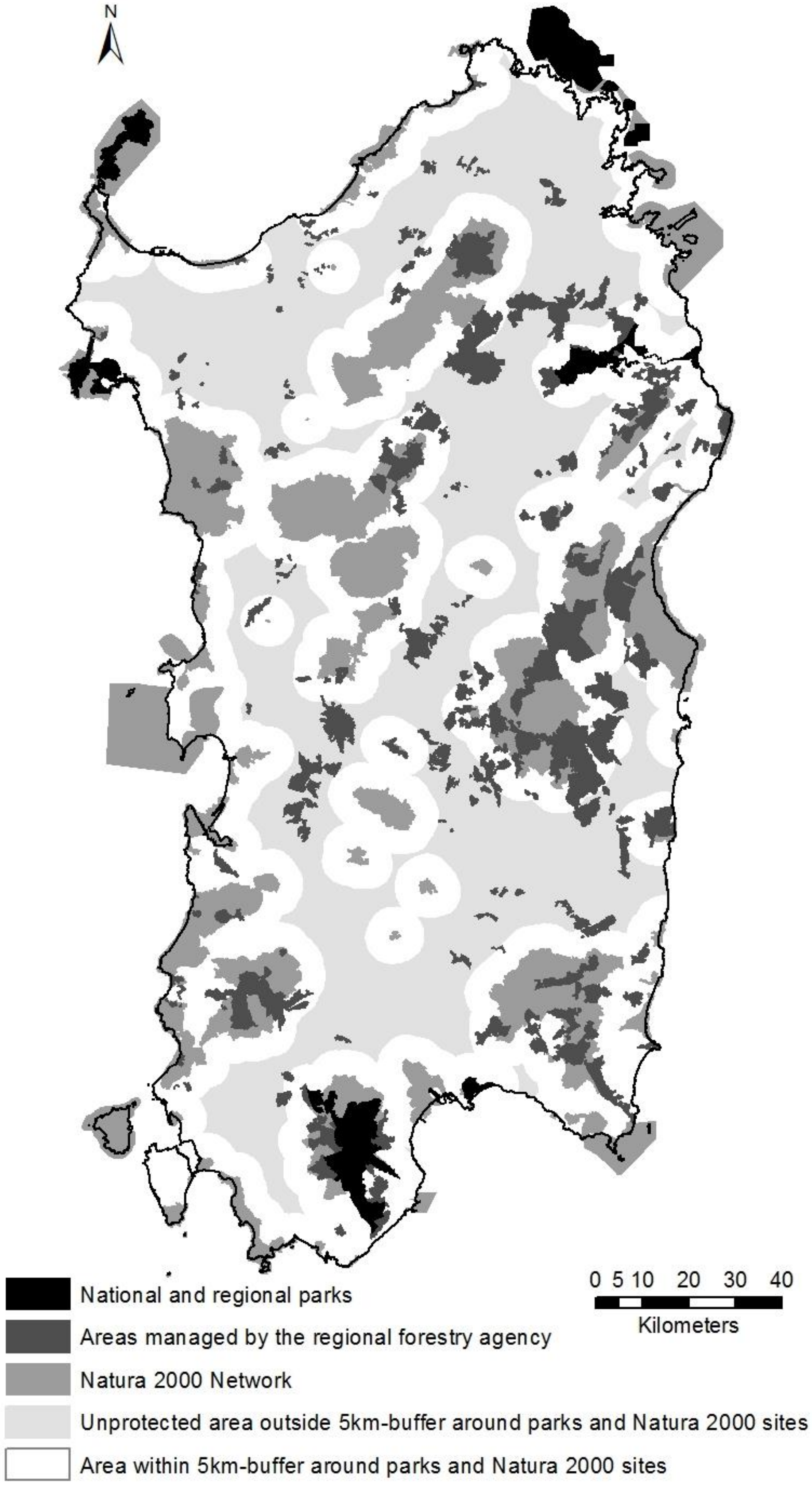

Figure 1. Map of the Sardinian protection levels considered.

1990 \ 2012	Artificial surfaces (A)	Arable land and permanent crop (ARA)	Pastures and mosaic farmland (PMF)	Standing forest (FOR)	Transition woodland and shrubs (TRW)	Natural grassland, heathland, sclerophylous (GRSH)	Open space with little or no vegetation (OPEN)	Wetlands and water bodies (WAT)
Artificial surfaces (A)		211	212	213	213	213	213	4
Arable land and permanent crop (ARA)	111		22	231	231	231	231	4
Pastures and mosaic farmland (PMF)	111	13		232	232	232	232	4
Standing forest (FOR)	112	121	122		32	32	32	4
Transition woodland and shrubs (TRW)	112	121	122	31		32	32	4
Natural grassland, heathland, sclerophylous (GRSH)	112	121	122	31	31		32	4
Open space with little or no vegetation (OPEN)	112	121	122	31	31	31		4
Wetlands and water bodies (WAT)	112	121	122	31	31	31	31	

Persistence (without changes)

Anthtopization processes

Processes to higher naturalization

Internal changes in natural areas

Processes that lead to increase in water surface

Figure 2. Land cover flows. Land covers are here grouped following EEA 2006 (Appendix 1 - "LEAC groups") by aggregating the standard Corine Land Cover types. Change processes are identified building upon Martínez-Fernández et al., 2015, as a simplified version of the detailed classification proposed by Gómez and Páramo, 2005.

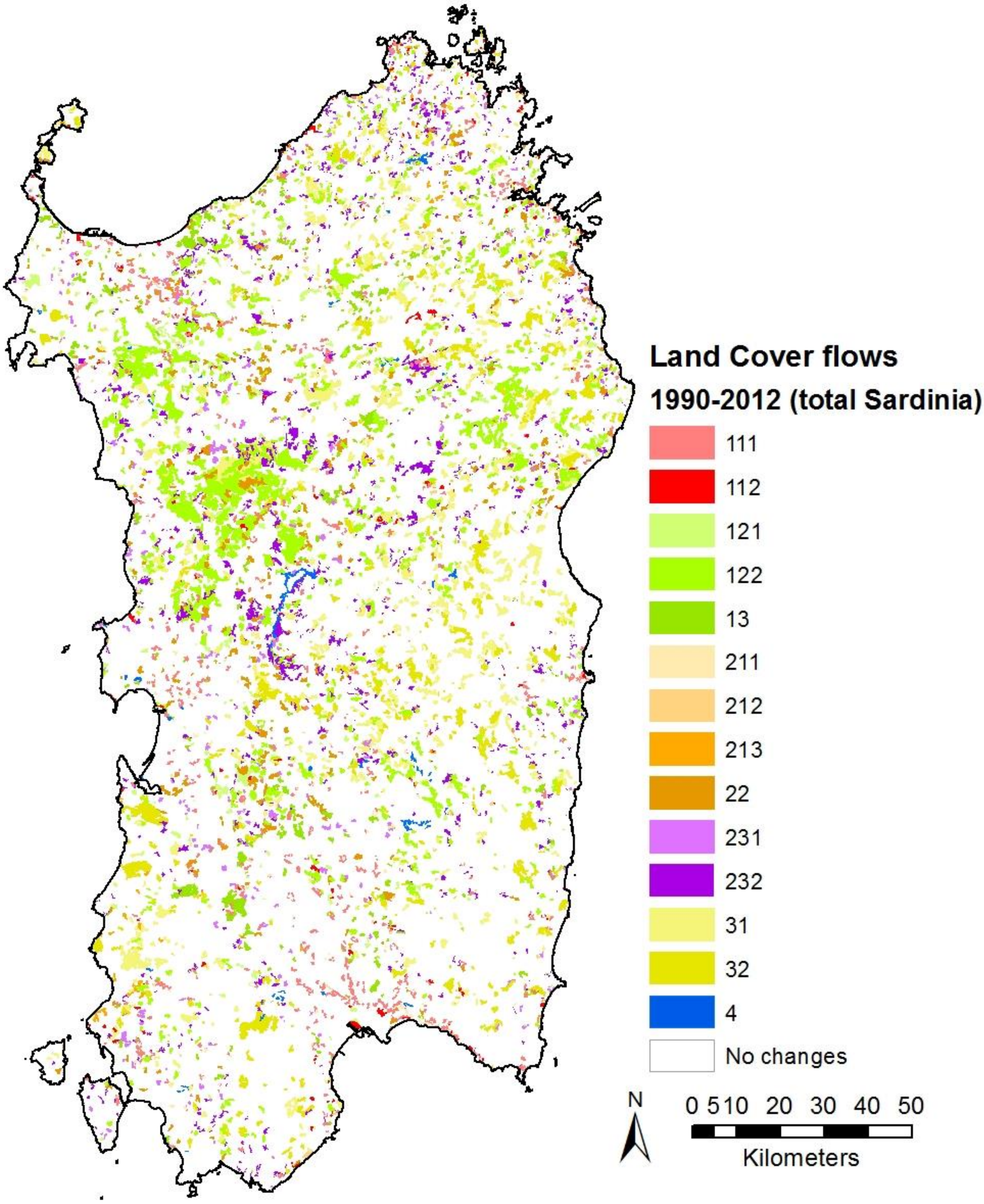

Figure 3. A spatial representation of land cover flows: transition processes.

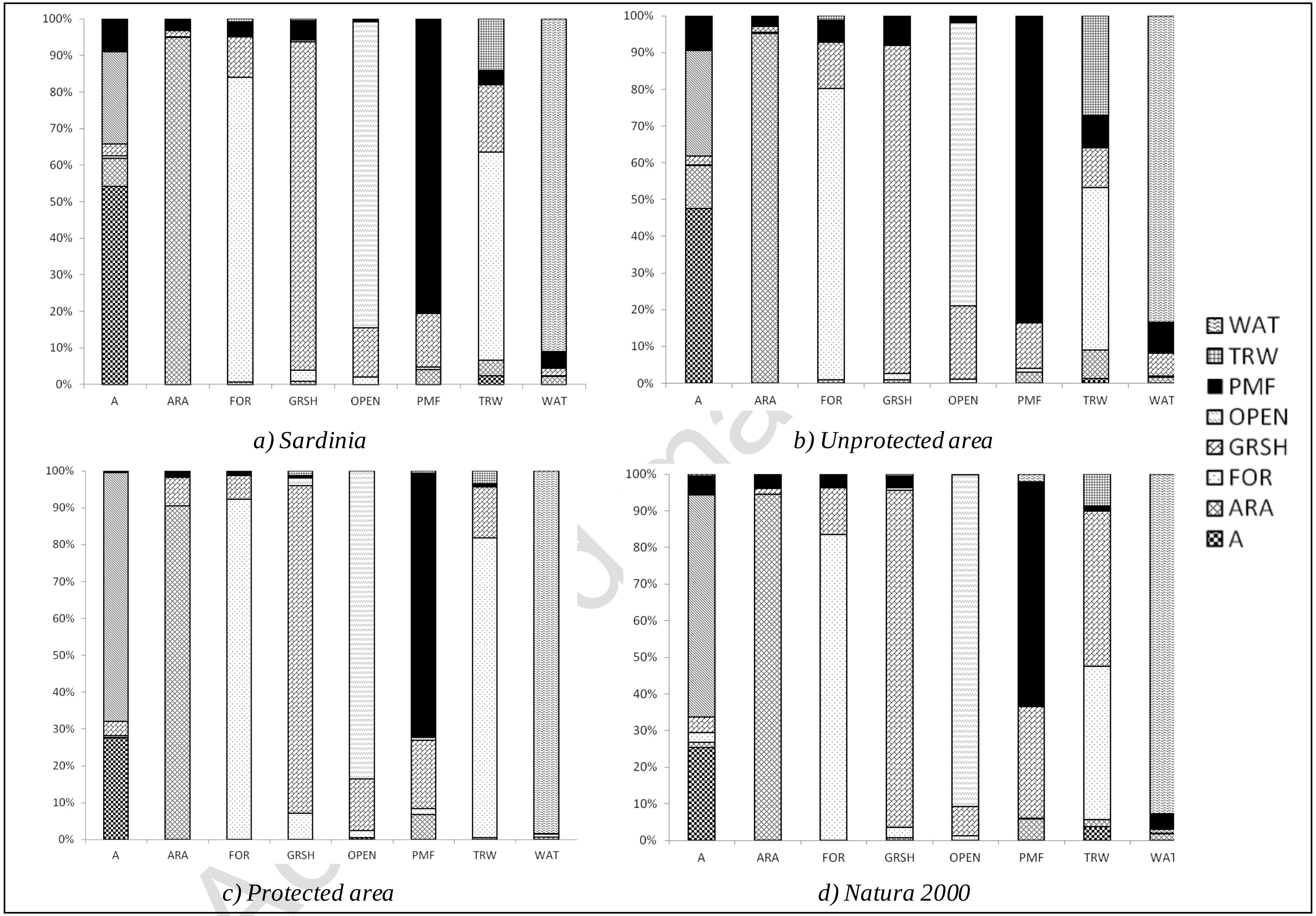

Figure 4. Land cover change processes within the whole region (a) and within each protection level (b, c, d).
For each LEAC group, percentages are calculated with reference to the group's surfaces in 1990 in the region (a) or in the given protection level (b, c, d).

TABLES

Sardinia: total area	**Natural protected area**		**Natura 2000 network**		**Unprotected area**			
					within 5-km buffer around natural protected areas and Natura 2000 sites		***outside 5-km buffer around natural protected areas and Natura 2000 sites***	
[km^2]	[km^2]	[%]	[km^2]	[%]	[km^2]	[%]	[km^2]	[%]
24,088	2,364	9.81	3,502	14.54	9,599	39.85	8,622	35.79

Table 1. Area and percentage of each protection level in Sardinia.

Code			Process definition	Sardinia [%]	Protection level: Natural protected area [%]	Protection level: Natura 2000 [%]	Protection level: Unprotected area [%]
1			*Anthropization processes*	*5.49*	*0.56*	*6.25*	*5.90*
	11		Urbanization	0.82	0.07	0.23	0.83
		111	Urbanization and artificialization from crops, pastures and semi-natural areas	0.64	0.01	0.10	0.73
		112	Urbanization and artificialization from natural areas	0.17	0.07	0.13	0.09
	12		Agrarian creation from natural areas	3.88	0.48	5.50	4.18
		121	Creation of new predominantly homogeneous agrarian areas	0.46	0.06	0.25	0.58
		122	Creation of new heterogeneous or semi-natural agrarian areas	3.41	0.42	5.25	3.60
	13		Homogenization or simplification of agrarian areas	0.80	0.01	0.52	0.89
2			*Processes to higher naturalization*	*3.61*	*0.86*	*3.25*	*4.02*
	21		Conversion and restoration from artificial area	0.14	0.06	0.11	0.11
		211	Conversion from artificial to agrarian areas predominantly homogeneous	0.03	0.00	0.02	0.03
		212	Conversion from artificial to heterogeneous or semi-natural agrarian areas	0.03	0.00	0.00	0.03
		213	Restoration from artificial to natural areas	0.07	0.06	0.10	0.05
	22		Heterogeneization or semi-naturalization of agrarian areas	0.82	0.13	0.92	0.75
	23		Agrarian abandonment	2.65	0.67	2.22	3.16
		231	Abandonment of “homogenous” agrarian areas	0.36	0.05	0.33	0.38
		232	Abandonment of “heterogeneous or semi-natural” agrarian areas	2.29	0.62	1.89	2.78
3			*Internal changes in natural areas*	*4.40*	*12.04*	*5.78*	*2.93*
		31	Successional processes (e.g. recovery, densification, shrub encroachment)	2.45	4.87	3.48	1.93
		32	Processes derived from disturbances, conducive towards higher simplification or degradation or less dominance and density	1.95	7.17	2.30	1.00
4			*Processes that lead to increase in water surfaces*	*0.10*	*0.01*	*0.38*	*0.08*
			Total area with change	**13.60**	**13.47**	**15.66**	**12.93**
			Total area without changes (persistence)	**86.40**	**86.53**	**84.34**	**87.07**

Table 2. Land cover flows: areas showing change processes. Change processes are coded following Martínez-Fernández et al., 2015, and result from aggregating the transition types shown in

1990 \ 2012	Artificial surfaces (A)	Arable land and permanent crop (ARA)	Pastures and mosaic farmland (PMF)	Standing forest (FOR)	Transition woodland and shrubs (TRW)	Natural grassland, heathland, sclerophylous (GRSH)	Open space with little or no vegetation (OPEN)	Wetlands and water bodies (WAT)
Artificial surfaces (A)		211	212	213	213	213	213	4
Arable land and permanent crop (ARA)	111		22	231	231	231	231	4
Pastures and mosaic farmland (PMF)	111	13		232	232	232	232	4
Standing forest (FOR)	112	121	122		32	32	32	4
Transition woodland and shrubs (TRW)	112	121	122	31		32	32	4
Natural grassland, heathland, sclerophylous (GRSH)	112	121	122	31	31		32	4
Open space with little or no vegetation (OPEN)	112	121	122	31	31	31		4
Wetlands and water bodies (WAT)	112	121	122	31	31	31	31	

- Persistence (without changes)
- Anthtopization processes
- Processes to higher naturalization
- Internal changes in natural areas
- Processes that lead to increase in water surface

Figure 2, where cell values coincide with the codes listed in this table.

		Sardinia			Natural protected area			Natura 2000			Unprotected area		
		1990 [%]	**2012 [%]**	**NC [%]**	**1990 [%]**	**2012 [%]**	**NC [%]**	**1990 [%]**	**2012 [%]**	**NC [%]**	**1990 [%]**	**2012 [%]**	**NC [%]**
(Artificial types)	**A**	2.28	2.96	0.29	0.47	0.48	0.03	0.54	0.65	0.20	1.76	2.49	0.41
(Agricultural types)	**ARA**	25.00	24.79	-0.01	0.85	0.73	-0.13	14.46	13.90	-0.04	31.19	31.16	0.00
	PMF	20.60	21.38	0.04	2.05	1.96	-0.04	12.49	15.95	0.28	25.68	26.01	0.01
(Natural types)	**FOR**	16.00	17.03	0.06	52.39	50.20	-0.04	17.69	19.00	0.07	11.31	12.82	0.13
	GRSH	32.99	30.03	-0.09	38.07	37.32	-0.02	45.59	40.18	-0.12	28.66	25.80	-0.10
	OPEN	1.44	1.48	0.03	4.69	4.51	-0.04	3.60	3.59	0.00	0.43	0.47	0.08
	TRW	0.57	1.19	1.10	0.82	4.13	4.05	0.40	1.50	2.79	0.56	0.77	0.39
	WAT	1.12	1.14	0.03	0.66	0.67	0.01	5.23	5.22	0.00	0.41	0.48	0.17
Total artificial surfaces		2.28	2.96	0.29	0.47	0.48	0.03	0.54	0.65	0.20	1.76	2.49	0.41
Total agricultural surfaces		45.60	46.17	0.01	2.89	2.70	-0.07	26.95	29.85	0.11	56.87	57.17	0.01
Total natural surfaces		52.12	50.87	-0.02	96.64	96.82	0.00	72.52	69.49	-0.04	41.37	40.34	-0.02

Table 3. Surface of land cover types (classed according to LEAC groups as in EEA, 2006) in 1990 and 2012 and relative net change (NC) for the whole region and for each protection level. Relative net change is the ratio of absolute net change (i.e. difference between land cover surfaces in 2012 and 1990) to land cover surfaces in 1990.

		A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT		
		Sardinia (2012) [%]								**tot. 1990**	**Loss**
Sardinia (1990) [%]	**A**	**2.14**	0.03	0.01	0.04	0.00	0.03	0.03	0.00	*2.28*	*0.14*
	ARA	0.31	**23.50**	0.09	0.22	0.00	0.82	0.05	0.02	*25.00*	*1.50*
	FOR	0.03	0.03	**14.21**	0.88	0.02	0.15	0.68	0.00	*16.00*	*1.79*
	GRSH	0.13	0.42	1.87	**26.98**	0.20	3.15	0.22	0.02	*32.99*	*6.01*
	OPEN	0.00	0.00	0.02	0.18	**1.24**	0.00	0.00	0.00	*1.44*	*0.20*
	PMF	0.34	0.80	0.68	1.56	0.01	**17.12**	0.04	0.05	*20.60*	*3.48*
	TRW	0.00	0.01	0.16	0.17	0.00	0.06	**0.17**	0.00	*0.57*	*0.40*
	WAT	0.01	0.00	0.00	0.00	0.00	0.05	0.00	**1.04**	*1.12*	*0.07*
	Total 2012	*2.96*	*24.79*	*17.03*	*30.03*	*1.48*	*21.38*	*1.19*	*1.14*		
	Gain	*0.82*	*1.29*	*2.82*	*3.05*	*0.24*	*4.26*	*1.02*	*0.10*		
		Protected area (2012) [%]								**tot. 1990**	**Loss**
Natural protected	**A**	**0.41**	0.00	0.01	0.02	0.02	0.00	0.01	0.00	*0.47*	*0.06*
	ARA	0.00	**0.66**	0.00	0.03	0.00	0.13	0.02	0.00	*0.85*	*0.19*
	FOR	0.01	0.00	**46.32**	2.59	0.09	0.03	3.35	0.01	*52.39*	*6.07*
	GRSH	0.06	0.06	3.23	**33.16**	0.63	0.36	0.57	0.00	*38.07*	*4.91*
	OPEN	0.00	0.00	0.12	0.78	**3.76**	0.01	0.01	0.00	*4.69*	*0.93*
	PMF	0.00	0.01	0.36	0.24	0.00	**1.41**	0.02	0.00	*2.05*	*0.64*
	TRW	0.00	0.00	0.15	0.51	0.00	0.01	**0.15**	0.00	*0.82*	*0.67*
	WAT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.66**	*0.66*	*0.00*
	Total 2012	*0.48*	*0.73*	*50.20*	*37.32*	*4.51*	*1.96*	*4.13*	*0.67*		
	Gain	*0.07*	*0.07*	*3.88*	*4.16*	*0.74*	*0.56*	*3.98*	*0.01*		
		Natura 2000 (2012) [%]								**tot. 1990**	**Loss**
Natura 2000 (1990) [%]	**A**	**0.42**	0.02	0.01	0.04	0.00	0.00	0.05	0.01	*0.54*	*0.12*
	ARA	0.02	**13.11**	0.06	0.24	0.00	0.92	0.03	0.08	*14.46*	*1.35*
	FOR	0.05	0.00	**15.79**	1.13	0.05	0.04	0.63	0.01	*17.69*	*1.90*
	GRSH	0.07	0.24	2.43	**37.00**	0.29	4.86	0.64	0.06	*45.59*	*8.59*
	OPEN	0.00	0.00	0.03	0.30	**3.26**	0.01	0.00	0.00	*3.60*	*0.35*
	PMF	0.08	0.52	0.62	1.24	0.01	**9.79**	0.02	0.22	*12.49*	*2.71*
	TRW	0.00	0.00	0.06	0.21	0.00	0.00	**0.13**	0.00	*0.40*	*0.26*
	WAT	0.01	0.01	0.00	0.02	0.00	0.34	0.00	**4.85**	*5.23*	*0.38*
	Total 2012	*0.65*	*13.90*	*19.00*	*40.18*	*3.59*	*15.96*	*1.50*	*5.22*		
	Gain	*0.23*	*0.79*	*3.21*	*3.18*	*0.34*	*6.17*	*1.37*	*0.38*		
		Unprotected area (2012) [%]								**Tot. 1990**	**Loss**
Unprotected area (1990) [%]	**A**	**1.66**	0.03	0.01	0.03	0.00	0.03	0.01	0.00	*1.76*	*0.11*
	ARA	0.41	**29.65**	0.12	0.20	0.00	0.75	0.06	0.01	*31.19*	*1.54*
	FOR	0.00	0.07	**10.15**	0.47	0.01	0.26	0.34	0.00	*11.31*	*1.15*
	GRSH	0.09	0.50	1.62	**23.00**	0.09	3.25	0.08	0.03	*28.66*	*5.66*
	OPEN	0.00	0.00	0.00	0.07	**0.36**	0.00	0.00	0.00	*0.43*	*0.07*
	PMF	0.33	0.89	0.77	1.94	0.01	**21.64**	0.06	0.04	*25.68*	*4.04*
	TRW	0.00	0.01	0.15	0.09	0.00	0.09	**0.21**	0.00	*0.56*	*0.35*
	WAT	0.00	0.01	0.00	0.00	0.00	0.00	0.00	**0.40**	*0.41*	*0.01*
	Total 2012	*2.49*	*31.16*	*12.82*	*25.80*	*0.47*	*26.01*	*0.77*	*0.48*		
	Gain	*0.83*	*1.51*	*2.67*	*2.80*	*0.11*	*4.38*	*0.56*	*0.08*		

Table 4. Cross tabulation matrixes comparing 1990 and 2012 land cover maps for the whole region and for each protection level. Gains and losses are calculated using Pontius et al.'s (2004) methodology. Bold faced numbers denote persistence.

		Natural protected areas		Natura 2000 sites		Unprotected areas	
		gain	**loss**	**gain**	**loss**	**gain**	**loss**
111	ARA-A	**3.56**	**2,16**	-0.35	1,13	0.54	**6,30**
	PMF-A	**1.82**	0,35	**1.76**	**2,81**	0.51	1,42
112	FOR-A	-0.85	-0,90	0.11	**1,98**	-0.95	-0,85
	WAT-A	**4.62**	**205,08**	-0.21	2,65	-1.00	-1,00
13	PMF-ARA	**8.03**	**1,82**	**3.51**	0,16	0.59	-0,48
211	A-ARA	**7.36**	**5,35**	2.01	-0,12	-0.27	-0,17
213	A-TRW	-0.62	1,86	**6.36**	**28,53**	-0.05	10,23
	A-OPEN	**5.55**	**7,66**	-0.90	-0,96	-1.00	-1,00
22	ARA-PMF	**26.79**	**35,39**	-0.10	2,67	-0.59	0,29
31	TRW-FOR	1.29	-0,57	**2.79**	0,14	**8.19**	**2,44**
	GRSH-TRW	-0.63	0,77	0.01	**1,95**	-0.48	0,42
	OPEN-TRW	-0.96	-0,80	-1.00	-1,00	0.17	**4,06**
	OPEN-GRSH	1.48	1,16	0.43	1,09	**3.08**	**2,67**
32	FOR-TRW	0.60	**5,67**	**1.59**	**16,91**	**4.36**	**32,43**
	TRW-GRSH	**8.24**	0,94	**7.93**	0,91	**3.13**	0,01
	GRSH-OPEN	1.12	0,79	0.79	-0,44	**2.02**	**1,61**
4	A-WAT	-1.00	-1,00	**2.92**	0,31	-1.00	-1,00
	ARA-WAT	**43.76**	**2,48**	0.39	-0,02	-0.70	-0,30
	PMF-WAT	-1.00	-1,00	**3.38**	0,30	0.99	0,56

Table 5. Most systematic land cover transitions in terms of gains and losses analyzed using the "R" value (R: ratio difference observed value minus expected value to expected value) for each protection level. In evidence values over 1.50 (bold) and over 4.00 (bold and grey background).

APPENDIX 1

	2012 A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT	Total 1990	Loss
1990										
A	**2.14**	**0.03**	**0.01**	**0.04**	**0.00**	**0.03**	**0.03**	**0.00**	**2.28**	**0.14**
	2.14	*0.04*	*0.08*	*0.10*	*0.01*	*0.12*	*0.02*	*0.00*	*2.51*	*0.37*
	(0.00)	(-0.01)	(-0.07)	(-0.07)	(0.00)	(-0.09)	(0.00)	(0.00)	(-0.23)	(-0.23)
	[0.00]	[-0.14]	[-0.93]	[-0.64]	[-0.54]	[-0.73]	[0.19]	[-0.01]	[-0.09]	[-0.62]
ARA	**0.31**	**23.50**	**0.09**	**0.22**	**0.00**	**0.82**	**0.05**	**0.02**	**25.00**	**1.51**
	0.21	*23.50*	*0.84*	*1.14*	*0.06*	*1.34*	*0.26*	*0.03*	*27.37*	*3.87*
	(0.10)	(0.00)	(-0.75)	(-0.92)	(-0.06)	(-0.53)	(-0.21)	(0.00)	(-2.36)	(-2.36)
	[0.47]	[0.00]	[-0.89]	[-0.81]	[-0.96]	[-0.39]	[-0.81]	[-0.16]	[-0.09]	[-0.61]
FOR	**0.03**	**0.03**	**14.21**	**0.88**	**0.02**	**0.15**	**0.68**	**0.00**	**16.00**	**1.79**
	0.13	*0.28*	*14.21*	*0.73*	*0.04*	*0.86*	*0.16*	*0.02*	*16.43*	*2.22*
	(-0.11)	(-0.24)	(0.00)	(0.15)	(-0.01)	(-0.71)	(0.51)	(-0.01)	(-0.43)	(-0.43)
	[-0.79]	[-0.89]	[0.00]	[0.21]	[-0.37]	[-0.83]	[3.13]	[-0.85]	[-0.03]	[-0.19]
GRSH	**0.13**	**0.42**	**1.87**	**26.98**	**0.20**	**3.15**	**0.22**	**0.02**	**32.99**	**6.01**
	0.28	*0.57*	*1.11*	*26.98*	*0.08*	*1.77*	*0.34*	*0.03*	*31.16*	*4.18*
	(-0.15)	(-0.15)	(0.76)	(0.00)	(0.12)	(1.38)	(-0.12)	(-0.01)	(1.84)	(1.84)
	[-0.54]	[-0.26]	[0.69]	[0.00]	[1.48]	[0.78]	[-0.35]	[-0.32]	[0.06]	[0.44]
OPEN	**0.00**	**0.00**	**0.02**	**0.18**	**1.24**	**0.00**	**0.00**	**0.00**	**1.44**	**0.20**
	0.01	*0.02*	*0.05*	*0.07*	*1.24*	*0.08*	*0.01*	*0.00*	*1.48*	*0.24*
	(-0.01)	(-0.02)	(-0.03)	(0.11)	(0.00)	(-0.07)	(-0.01)	(0.00)	(-0.04)	(-0.04)
	[-0.65]	[-0.96]	[-0.66]	[1.70]	[0.00]	[-0.96]	[-0.88]	[-0.86]	[-0.03]	[-0.16]
PMF	**0.34**	**0.80**	**0.68**	**1.56**	**0.01**	**17.12**	**0.04**	**0.05**	**20.60**	**3.48**
	0.17	*0.35*	*0.69*	*0.94*	*0.05*	*17.12*	*0.21*	*0.02*	*19.56*	*2.44*
	(0.17)	(0.44)	(-0.02)	(0.62)	(-0.04)	(0.00)	(-0.17)	(0.03)	(1.04)	(1.04)
	[0.97]	[1.24]	[-0.02]	[0.66]	[-0.79]	[0.00]	[-0.79]	[1.46]	[0.05]	[0.43]
TRW	**0.00**	**0.01**	**0.16**	**0.17**	**0.00**	**0.06**	**0.17**	**0.00**	**0.57**	**0.40**
	0.00	*0.01*	*0.02*	*0.03*	*0.00*	*0.03*	*0.17*	*0.00*	*0.26*	*0.09*
	(0.00)	(0.00)	(0.14)	(0.15)	(0.00)	(0.03)	(0.00)	(0.00)	(0.31)	(0.31)
	[-0.20]	[-0.22]	[7.21]	[5.64]	[-0.21]	[0.86]	[0.00]	[-1.00]	[1.18]	[3.32]
WAT	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**1.04**	**1.11**	**0.07**
	0.01	*0.02*	*0.04*	*0.05*	*0.00*	*0.06*	*0.01*	*1.04*	*1.23*	*0.19*
	(0.00)	(-0.01)	(-0.04)	(-0.05)	(0.00)	(-0.01)	(-0.01)	(0.00)	(-0.12)	(-0.12)
	[-0.06]	[-0.77]	[-0.98]	[-0.91]	[-1.00]	[-0.10]	[-1.00]	[0.00]	[-0.10]	[-0.62]
Total 2012	**2.96**	**24.79**	**17.03**	**30.03**	**1.48**	**21.38**	**1.19**	**1.15**	**100.00**	**13.60**
	2.96	*24.79*	*17.03*	*30.03*	*1.48*	*21.38*	*1.19*	*1.15*	*100.00*	*13.60*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Gain	**0.82**	**1.29**	**2.82**	**3.05**	**0.24**	**4.26**	**1.02**	**0.10**	**13.60**	
	0.82	*1.29*	*2.82*	*3.05*	*0.24*	*4.26*	*1.02*	*0.10*	*13.60*	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	

Table 6. Systematic land cover change transition matrix for the whole region in terms of gains. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012 A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT	Total 1990	Loss
1990										
A	**2.14**	**0.03**	**0.01**	**0.04**	**0.00**	**0.03**	**0.03**	**0.00**	**2.28**	**0.14**
	2.14	*0.04*	*0.02*	*0.04*	*0.00*	*0.03*	*0.00*	*0.00*	*2.28*	*0.14*
	(0.00)	(0.00)	(-0.02)	(-0.01)	(0.00)	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)
	[0.00]	[-0.05]	[-0.78]	[-0.13]	[0.21]	[0.10]	[15.35]	[0.44]	[0.00]	[0.03]
ARA	**0.31**	**23.50**	**0.09**	**0.22**	**0.00**	**0.82**	**0.05**	**0.02**	**25.00**	**1.51**
	0.06	*23.50*	*0.34*	*0.60*	*0.03*	*0.43*	*0.02*	*0.02*	*25.00*	*1.50*
	(0.25)	(0.00)	(-0.25)	(-0.38)	(-0.03)	(0.39)	(0.03)	(0.00)	(0.00)	(0.00)
	[4.18]	[0.00]	[-0.73]	[-0.64]	[-0.93]	[0.91]	[1.08]	[-0.04]	[0.00]	[0.00]
FOR	**0.03**	**0.03**	**14.21**	**0.88**	**0.02**	**0.15**	**0.68**	**0.00**	**16.00**	**1.79**
	0.06	*0.53*	*14.21*	*0.65*	*0.03*	*0.46*	*0.03*	*0.02*	*16.00*	*1.79*
	(-0.04)	(-0.50)	(0.00)	(0.23)	(-0.01)	(-0.32)	(0.65)	(-0.02)	(0.00)	(0.00)
	[-0.56]	[-0.94]	[0.00]	[0.36]	[-0.22]	[-0.69]	[25.46]	[-0.90]	[0.00]	[0.00]
GRSH	**0.13**	**0.42**	**1.87**	**26.98**	**0.20**	**3.15**	**0.22**	**0.02**	**32.99**	**6.01**
	0.25	*2.13*	*1.46*	*26.98*	*0.13*	*1.84*	*0.10*	*0.10*	*32.99*	*6.01*
	(-0.13)	(-1.71)	(0.41)	(0.00)	(0.07)	(1.32)	(0.12)	(-0.08)	(0.00)	(0.00)
	[-0.50]	[-0.80]	[0.28]	[0.00]	[0.57]	[0.72]	[1.15]	[-0.76]	[0.00]	[0.00]
OPEN	**0.00**	**0.00**	**0.02**	**0.18**	**1.24**	**0.00**	**0.00**	**0.00**	**1.44**	**0.20**
	0.01	*0.05*	*0.04*	*0.06*	*1.24*	*0.04*	*0.00*	*0.00*	*1.44*	*0.20*
	(0.00)	(-0.05)	(-0.02)	(0.12)	(0.00)	(-0.04)	(0.00)	(0.00)	(0.00)	(0.00)
	[-0.32]	[-0.98]	[-0.53]	[1.86]	[0.00]	[-0.92]	[-0.25]	[-0.91]	[0.00]	[0.00]
PMF	**0.34**	**0.80**	**0.68**	**1.56**	**0.01**	**17.12**	**0.04**	**0.05**	**20.60**	**3.48**
	0.13	*1.10*	*0.75*	*1.33*	*0.07*	*17.12*	*0.05*	*0.05*	*20.60*	*3.48*
	(0.21)	(-0.30)	(-0.08)	(0.23)	(-0.05)	(0.00)	(-0.01)	(0.00)	(0.00)	(0.00)
	[1.59]	[-0.27]	[-0.10]	[0.17]	[-0.84]	[0.00]	[-0.16]	[0.05]	[0.00]	[0.00]
TRW	**0.00**	**0.01**	**0.16**	**0.17**	**0.00**	**0.06**	**0.17**	**0.00**	**0.57**	**0.40**
	0.01	*0.10*	*0.07*	*0.12*	*0.01*	*0.09*	*0.17*	*0.00*	*0.57*	*0.40*
	(-0.01)	(-0.09)	(0.09)	(0.05)	(0.00)	(-0.03)	(0.00)	(0.00)	(0.00)	(0.00)
	[-0.68]	[-0.92]	[1.27]	[0.41]	[-0.82]	[-0.34]	[0.00]	[-1.00]	[-0.01]	[-0.01]
WAT	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**1.04**	**1.11**	**0.07**
	0.00	*0.02*	*0.01*	*0.02*	*0.00*	*0.01*	*0.00*	*1.04*	*1.11*	*0.07*
	(0.01)	(-0.01)	(-0.01)	(-0.02)	(0.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)
	[3.29]	[-0.74]	[-0.92]	[-0.78]	[-1.00]	[2.68]	[-1.00]	[0.00]	[0.00]	[0.07]
Total 2012	**2.96**	**24.79**	**17.03**	**30.03**	**1.48**	**21.38**	**1.19**	**1.15**	**100.00**	**13.60**
	2.67	*27.46*	*16.91*	*29.80*	*1.50*	*20.02*	*0.38*	*1.25*	*99.99*	*13.59*
	(0.29)	(-2.67)	(0.12)	(0.22)	(-0.02)	(1.36)	(0.81)	(-0.10)	(0.01)	(0.01)
	[0.11]	[-0.10]	[0.01]	[0.01]	[-0.01]	[0.07]	[2.15]	[-0.08]	[0.00]	[0.00]
Gain	**0.82**	**1.29**	**2.82**	**3.05**	**0.24**	**4.26**	**1.02**	**0.10**	**13.60**	
	0.53	*3.96*	*2.70*	*2.82*	*0.26*	*2.90*	*0.21*	*0.21*	*13.59*	
	(0.29)	(-2.67)	(0.12)	(0.22)	(-0.02)	(1.36)	(0.81)	(-0.10)	(0.01)	
	[0.55]	[-0.67]	[0.05]	[0.08]	[-0.08]	[0.47]	[3.88]	[-0.50]	[0.00]	

Table 7. Systematic land cover change transition matrix for the whole region in terms of losses. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012									
	A	**ARA**	**FOR**	**GRSH**	**OPEN**	**PMF**	**TRW**	**WAT**	**Total 1990**	**Loss**
1990										
A	**0.41**	**0.00**	**0.01**	**0.02**	**0.02**	**0.00**	**0.01**	**0.00**	**0.47**	**0.06**
	0.41	*0.00*	*0.04*	*0.03*	*0.00*	*0.00*	*0.02*	*0.00*	*0.50*	*0.10*
	(0.00)	(0.00)	(-0.03)	(-0.02)	(0.02)	(0.00)	(-0.01)	(0.00)	(-0.03)	(-0.03)
	[0.00]	[7.36]	[-0.70]	[-0.51]	[5.55]	[-1.00]	[-0.62]	[-1.00]	[-0.07]	[-0.36]
ARA	**0.00**	**0.66**	**0.00**	**0.03**	**0.00**	**0.13**	**0.02**	**0.00**	**0.85**	**0.19**
	0.00	*0.66*	*0.07*	*0.06*	*0.01*	*0.00*	*0.03*	*0.00*	*0.83*	*0.17*
	(0.00)	(0.00)	(-0.07)	(-0.03)	(-0.01)	(0.13)	(-0.02)	(0.00)	(0.01)	(0.01)
	[3.56]	[0.00]	[-0.99]	[-0.49]	[-1.00]	[26.79]	[-0.54]	[43.76]	[0.02]	[0.08]
FOR	**0.01**	**0.00**	**46.32**	**2.59**	**0.09**	**0.03**	**3.35**	**0.01**	**52.39**	**6.07**
	0.04	*0.04*	*46.32*	*3.52*	*0.41*	*0.30*	*2.10*	*0.01*	*52.73*	*6.41*
	(-0.03)	(-0.04)	(0.00)	(-0.93)	(-0.32)	(-0.27)	(1.25)	(0.00)	(-0.34)	(-0.34)
	[-0.85]	[-0.99]	[0.00]	[-0.26]	[-0.78]	[-0.90]	[0.60]	[-0.01]	[-0.01]	[-0.05]
GRSH	**0.06**	**0.06**	**3.23**	**33.16**	**0.63**	**0.36**	**0.57**	**0.00**	**38.07**	**4.91**
	0.03	*0.03*	*3.10*	*33.16*	*0.30*	*0.22*	*1.53*	*0.00*	*38.36*	*5.20*
	(0.03)	(0.03)	(0.13)	(0.00)	(0.33)	(0.15)	(-0.96)	(0.00)	(-0.29)	(-0.29)
	[1.05]	[1.01]	[0.04]	[0.00]	[1.12]	[0.69]	[-0.63]	[-0.75]	[-0.01]	[-0.06]
OPEN	**0.00**	**0.00**	**0.12**	**0.78**	**3.76**	**0.01**	**0.01**	**0.00**	**4.69**	**0.93**
	0.00	*0.00*	*0.38*	*0.31*	*3.76*	*0.03*	*0.19*	*0.00*	*4.68*	*0.92*
	(0.00)	(0.00)	(-0.26)	(0.47)	(0.00)	(-0.01)	(-0.18)	(0.00)	(0.01)	(0.01)
	[-1.00]	[-1.00]	[-0.68]	[1.48]	[0.00]	[-0.44]	[-0.96]	[-1.00]	[0.00]	[0.01]
PMF	**0.00**	**0.01**	**0.36**	**0.24**	**0.00**	**1.41**	**0.02**	**0.00**	**2.05**	**0.64**
	0.00	*0.00*	*0.17*	*0.14*	*0.02*	*1.41*	*0.08*	*0.00*	*1.81*	*0.41*
	(0.00)	(0.01)	(0.19)	(0.10)	(-0.02)	(0.00)	(-0.06)	(0.00)	(0.24)	(0.24)
	[1.82]	[8.03]	[1.16]	[0.74]	[-1.00]	[0.00]	[-0.71]	[-1.00]	[0.13]	[0.58]
TRW	**0.00**	**0.00**	**0.15**	**0.51**	**0.00**	**0.01**	**0.15**	**0.00**	**0.82**	**0.67**
	0.00	*0.00*	*0.07*	*0.05*	*0.01*	*0.00*	*0.15*	*0.00*	*0.28*	*0.13*
	(0.00)	(0.00)	(0.09)	(0.45)	(-0.01)	(0.01)	(0.00)	(0.00)	(0.54)	(0.54)
	[-1.00]	[-1.00]	[1.29]	[8.24]	[-1.00]	[1.64]	[0.00]	[-1.00]	[1.93]	[4.02]
WAT	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.66**	**0.66**	**0.00**
	0.00	*0.00*	*0.05*	*0.04*	*0.01*	*0.00*	*0.03*	*0.66*	*0.80*	*0.14*
	(0.00)	(0.00)	(-0.05)	(-0.04)	(-0.01)	(0.00)	(-0.03)	(0.00)	(-0.13)	(-0.13)
	[4.62]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[0.00]	[-0.17]	[-0.98]
Total 2012	**0.48**	**0.73**	**50.20**	**37.32**	**4.51**	**1.96**	**4.13**	**0.67**	**100.00**	**13.47**
	0.48	*0.73*	*50.20*	*37.32*	*4.51*	*1.96*	*4.13*	*0.67*	*100.00*	*13.47*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	
Gain	**0.07**	**0.07**	**3.88**	**4.16**	**0.74**	**0.56**	**3.98**	**0.01**	**13.47**	
	0.07	*0.07*	*3.88*	*4.16*	*0.74*	*0.56*	*3.98*	*0.01*	*13.47*	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	

Table 8. Systematic land cover change transition matrix in natural protected areas in terms of gains. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012 A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT	Total 1990	Loss
1990										
A	**0.41**	**0.00**	**0.01**	**0.02**	**0.02**	**0.00**	**0.01**	**0.00**	**0.47**	**0.06**
	0.41	*0.00*	*0.03*	*0.02*	*0.00*	*0.00*	*0.00*	*0.00*	*0.47*	*0.06*
	(0.00)	(0.00)	(-0.02)	(-0.01)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[5.35]	[-0.63]	[-0.32]	[7.66]	[-1.00]	[1.86]	[-1.00]	[0.00]	[0.00]
ARA	**0.00**	**0.66**	**0.00**	**0.03**	**0.00**	**0.13**	**0.02**	**0.00**	**0.85**	**0.19**
	0.00	*0.66*	*0.09*	*0.07*	*0.01*	*0.00*	*0.01*	*0.00*	*0.85*	*0.19*
	(0.00)	(0.00)	(-0.09)	(-0.04)	(-0.01)	(0.13)	(0.01)	(0.00)	(0.00)	(0.00)
	[2.16]	[0.00]	[-0.99]	[-0.59]	[-1.00]	[35.39]	[1.00]	[2.48]	[0.00]	[0.00]
FOR	**0.01**	**0.00**	**46.32**	**2.59**	**0.09**	**0.03**	**3.35**	**0.01**	**52.39**	**6.07**
	0.06	*0.09*	*46.32*	*4.55*	*0.55*	*0.24*	*0.50*	*0.08*	*52.39*	*6.07*
	(-0.05)	(-0.09)	(0.00)	(-1.96)	(-0.46)	(-0.21)	(2.85)	(-0.08)	(0.00)	(0.00)
	[-0.90]	[-1.00]	[0.00]	[-0.43]	[-0.84]	[-0.87]	[5.67]	[-0.93]	[0.00]	[0.00]
GRSH	**0.06**	**0.06**	**3.23**	**33.16**	**0.63**	**0.36**	**0.57**	**0.00**	**38.07**	**4.91**
	0.04	*0.06*	*3.94*	*33.16*	*0.35*	*0.15*	*0.32*	*0.05*	*38.07*	*4.91*
	(0.02)	(0.00)	(-0.70)	(0.00)	(0.28)	(0.21)	(0.25)	(-0.05)	(0.00)	(0.00)
	[0.52]	[-0.03]	[-0.18]	[0.00]	[0.79]	[1.37]	[0.77]	[-0.98]	[0.00]	[0.00]
OPEN	**0.00**	**0.00**	**0.12**	**0.78**	**3.76**	**0.01**	**0.01**	**0.00**	**4.69**	**0.93**
	0.00	*0.01*	*0.49*	*0.36*	*3.76*	*0.02*	*0.04*	*0.01*	*4.69*	*0.93*
	(0.00)	(-0.01)	(-0.36)	(0.42)	(0.00)	(0.00)	(-0.03)	(-0.01)	(0.00)	(0.00)
	[-1.00]	[-1.00]	[-0.75]	[1.16]	[0.00]	[-0.22]	[-0.80]	[-1.00]	[0.00]	[0.00]
PMF	**0.00**	**0.01**	**0.36**	**0.24**	**0.00**	**1.41**	**0.02**	**0.00**	**2.05**	**0.64**
	0.00	*0.00*	*0.33*	*0.24*	*0.03*	*1.41*	*0.03*	*0.00*	*2.05*	*0.64*
	(0.00)	(0.01)	(0.03)	(0.00)	(-0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.35]	[1.82]	[0.10]	[-0.02]	[-1.00]	[0.00]	[-0.13]	[-1.00]	[0.00]	[0.00]
TRW	**0.00**	**0.00**	**0.15**	**0.51**	**0.00**	**0.01**	**0.15**	**0.00**	**0.82**	**0.67**
	0.00	*0.01*	*0.35*	*0.26*	*0.03*	*0.01*	*0.15*	*0.00*	*0.82*	*0.67*
	(0.00)	(-0.01)	(-0.20)	(0.25)	(-0.03)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[-1.00]	[-1.00]	[-0.57]	[0.94]	[-1.00]	[-0.11]	[0.00]	[-1.00]	[0.00]	[0.00]
WAT	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.66**	**0.66**	**0.00**
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.66*	*0.66*	*0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[205.08]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[-1.00]	[0.00]	[0.00]	[0.00]
Total 2012	**0.48**	**0.73**	**50.20**	**37.32**	**4.51**	**1.96**	**4.13**	**0.67**	**100.00**	**13.47**
	0.52	*0.83*	*51.55*	*38.67*	*4.74*	*1.84*	*1.05*	*0.81*	*100.00*	*13.47*
	(-0.04)	(-0.09)	(-1.35)	(-1.35)	(-0.23)	(0.13)	(3.08)	(-0.14)	(0.00)	(0.00)
	[-0.07]	[-0.11]	[-0.03]	[-0.03]	[-0.05]	[0.07]	[2.93]	[-0.17]	[0.00]	[0.00]
Gain	**0.07**	**0.07**	**3.88**	**4.16**	**0.74**	**0.56**	**3.98**	**0.01**	**13.47**	
	0.11	*0.16*	*5.23*	*5.51*	*0.98*	*0.43*	*0.90*	*0.15*	*13.47*	
	(-0.04)	(-0.09)	(-1.35)	(-1.35)	(-0.23)	(0.13)	(3.08)	(-0.14)	(0.00)	
	[-0.33]	[-0.56]	[-0.26]	[-0.25]	[-0.24]	[0.29]	[3.40]	[-0.92]	[0.00]	

Table 9. Systematic land cover change transition matrix in natural protected areas in terms of losses. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012 A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT	Total 1990	Loss
1990										
A	**0.42**	**0.02**	**0.01**	**0.04**	**0.00**	**0.00**	**0.05**	**0.01**	**0.54**	**0.12**
	0.42	*0.01*	*0.02*	*0.03*	*0.00*	*0.04*	*0.01*	*0.00*	*0.53*	*0.11*
	(0.00)	(0.01)	(-0.02)	(0.00)	(0.00)	(-0.03)	(0.05)	(0.01)	(0.02)	(0.02)
	[0.00]	[2.01]	[-0.74]	[0.13]	[-0.90]	[-0.91]	[6.36]	[2.92]	[0.03]	[0.14]
ARA	**0.02**	**13.11**	**0.06**	**0.24**	**0.00**	**0.92**	**0.03**	**0.08**	**14.46**	**1.35**
	0.03	*13.11*	*0.56*	*0.84*	*0.05*	*1.02*	*0.20*	*0.06*	*15.88*	*2.77*
	(-0.01)	(0.00)	(-0.50)	(-0.60)	(-0.05)	(-0.10)	(-0.17)	(0.02)	(-1.42)	(-1.42)
	[-0.35]	[0.00]	[-0.89]	[-0.72]	[-1.00]	[-0.10]	[-0.86]	[0.39]	[-0.09]	[-0.51]
FOR	**0.05**	**0.00**	**15.79**	**1.13**	**0.05**	**0.04**	**0.63**	**0.01**	**17.69**	**1.90**
	0.04	*0.16*	*15.79*	*1.03*	*0.06*	*1.25*	*0.24*	*0.07*	*18.65*	*2.86*
	(0.00)	(-0.16)	(0.00)	(0.10)	(-0.02)	(-1.21)	(0.39)	(-0.06)	(-0.96)	(-0.96)
	[0.11]	[-0.99]	[0.00]	[0.09]	[-0.27]	[-0.97]	[1.59]	[-0.88]	[-0.05]	[-0.34]
GRSH	**0.07**	**0.24**	**2.43**	**37.00**	**0.29**	**4.86**	**0.64**	**0.06**	**45.59**	**8.59**
	0.11	*0.42*	*1.78*	*37.00*	*0.16*	*3.21*	*0.63*	*0.18*	*43.49*	*6.49*
	(-0.04)	(-0.18)	(0.65)	(0.00)	(0.13)	(1.65)	(0.01)	(-0.12)	(2.10)	(2.10)
	[-0.34]	[-0.42]	[0.37]	[0.00]	[0.79]	[0.51]	[0.01]	[-0.66]	[0.05]	[0.32]
OPEN	**0.00**	**0.00**	**0.03**	**0.30**	**3.26**	**0.01**	**0.00**	**0.00**	**3.60**	**0.35**
	0.01	*0.03*	*0.14*	*0.21*	*3.26*	*0.25*	*0.05*	*0.01*	*3.97*	*0.71*
	(0.00)	(-0.03)	(-0.11)	(0.09)	(0.00)	(-0.25)	(-0.05)	(-0.01)	(-0.36)	(-0.36)
	[-0.52]	[-0.96]	[-0.79]	[0.43]	[0.00]	[-0.97]	[-1.00]	[-0.90]	[-0.09]	[-0.51]
PMF	**0.08**	**0.52**	**0.62**	**1.24**	**0.01**	**9.79**	**0.02**	**0.22**	**12.49**	**2.71**
	0.03	*0.12*	*0.49*	*0.73*	*0.04*	*9.79*	*0.17*	*0.05*	*11.41*	*1.63*
	(0.05)	(0.41)	(0.13)	(0.51)	(-0.04)	(0.00)	(-0.15)	(0.17)	(1.08)	(1.08)
	[1.76]	[3.51]	[0.27]	[0.70]	[-0.87]	[0.00]	[-0.88]	[3.38]	[0.09]	[0.67]
TRW	**0.00**	**0.00**	**0.06**	**0.21**	**0.00**	**0.00**	**0.13**	**0.00**	**0.40**	**0.26**
	0.00	*0.00*	*0.02*	*0.02*	*0.00*	*0.03*	*0.13*	*0.00*	*0.20*	*0.07*
	(0.00)	(0.00)	(0.04)	(0.18)	(0.00)	(-0.03)	(0.00)	(0.00)	(0.19)	(0.19)
	[-1.00]	[-1.00]	[2.79]	[7.93]	[-1.00]	[-1.00]	[0.00]	[-1.00]	[0.93]	[2.58]
WAT	**0.01**	**0.01**	**0.00**	**0.02**	**0.00**	**0.34**	**0.00**	**4.85**	**5.24**	**0.38**
	0.01	*0.05*	*0.20*	*0.31*	*0.02*	*0.37*	*0.07*	*4.85*	*5.88*	*1.03*
	(0.00)	(-0.04)	(-0.20)	(-0.28)	(-0.02)	(-0.03)	(-0.07)	(0.00)	(-0.64)	(-0.64)
	[-0.21]	[-0.84]	[-0.98]	[-0.93]	[-1.00]	[-0.08]	[-1.00]	[0.00]	[-0.11]	[-0.63]
Total 2012	**0.65**	**13.90**	**19.00**	**40.18**	**3.59**	**15.96**	**1.50**	**5.23**	**100.00**	**15.66**
	0.65	*13.90*	*19.00*	*40.18*	*3.59*	*15.96*	*1.50*	*5.23*	*100.00*	*15.66*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Gain	**0.23**	**0.79**	**3.21**	**3.18**	**0.34**	**6.17**	**1.37**	**0.38**	**15.66**	
	0.23	*0.79*	*3.21*	*3.18*	*0.34*	*6.17*	*1.37*	*0.38*	*15.66*	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	

Table 10. Systematic land cover change transition matrix in Natura 2000 sites in terms of gains. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012 **A**	**ARA**	**FOR**	**GRSH**	**OPEN**	**PMF**	**TRW**	**WAT**	**Total 1990**	**Loss**
1990										
A	**0.42**	**0.02**	**0.01**	**0.04**	**0.00**	**0.00**	**0.05**	**0.01**	**0.54**	**0.12**
	0.42	*0.02*	*0.02*	*0.05*	*0.00*	*0.02*	*0.00*	*0.01*	*0.54*	*0.12*
	(0.00)	(0.00)	(-0.02)	(-0.01)	(0.00)	(-0.02)	(0.05)	(0.00)	(0.00)	(0.00)
	[0.00]	[-0.12]	[-0.77]	[-0.28]	[-0.96]	[-0.83]	[28.53]	[0.31]	[0.00]	[0.00]
ARA	**0.02**	**13.11**	**0.06**	**0.24**	**0.00**	**0.92**	**0.03**	**0.08**	**14.46**	**1.35**
	0.01	*13.11*	*0.30*	*0.63*	*0.06*	*0.25*	*0.02*	*0.08*	*14.46*	*1.35*
	(0.01)	(0.00)	(-0.24)	(-0.39)	(-0.06)	(0.67)	(0.01)	(0.00)	(0.00)	(0.00)
	[1.13]	[0.00]	[-0.79]	[-0.62]	[-1.00]	[2.67]	[0.22]	[-0.02]	[0.00]	[0.00]
FOR	**0.05**	**0.00**	**15.79**	**1.13**	**0.05**	**0.04**	**0.63**	**0.01**	**17.69**	**1.90**
	0.02	*0.33*	*15.79*	*0.94*	*0.08*	*0.37*	*0.04*	*0.12*	*17.69*	*1.90*
	(0.03)	(-0.32)	(0.00)	(0.19)	(-0.04)	(-0.34)	(0.59)	(-0.11)	(0.00)	(0.00)
	[1.98]	[-0.99]	[0.00]	[0.20]	[-0.46]	[-0.90]	[16.91]	[-0.93]	[0.00]	[0.00]
GRSH	**0.07**	**0.24**	**2.43**	**37.00**	**0.29**	**4.86**	**0.64**	**0.06**	**45.59**	**8.59**
	0.09	*1.99*	*2.73*	*37.00*	*0.52*	*2.29*	*0.22*	*0.75*	*45.59*	*8.59*
	(-0.02)	(-1.75)	(-0.30)	(0.00)	(-0.23)	(2.57)	(0.42)	(-0.69)	(0.00)	(0.00)
	[-0.25]	[-0.88]	[-0.11]	[0.00]	[-0.44]	[1.12]	[1.95]	[-0.92]	[0.00]	[0.00]
OPEN	**0.00**	**0.00**	**0.03**	**0.30**	**3.26**	**0.01**	**0.00**	**0.00**	**3.60**	**0.35**
	0.00	*0.05*	*0.07*	*0.14*	*3.26*	*0.06*	*0.01*	*0.02*	*3.60*	*0.35*
	(0.00)	(-0.05)	(-0.04)	(0.16)	(0.00)	(-0.05)	(-0.01)	(-0.02)	(0.00)	(0.00)
	[0.69]	[-0.97]	[-0.56]	[1.09]	[0.00]	[-0.85]	[-1.00]	[-0.92]	[0.00]	[0.00]
PMF	**0.08**	**0.52**	**0.62**	**1.24**	**0.01**	**9.79**	**0.02**	**0.22**	**12.49**	**2.71**
	0.02	*0.45*	*0.61*	*1.29*	*0.12*	*9.79*	*0.05*	*0.17*	*12.49*	*2.71*
	(0.06)	(0.07)	(0.01)	(-0.05)	(-0.11)	(0.00)	(-0.03)	(0.05)	(0.00)	(0.00)
	[2.81]	[0.16]	[0.01]	[-0.04]	[-0.95]	[0.00]	[-0.57]	[0.30]	[0.00]	[0.00]
TRW	**0.00**	**0.00**	**0.06**	**0.21**	**0.00**	**0.00**	**0.13**	**0.00**	**0.40**	**0.26**
	0.00	*0.04*	*0.05*	*0.11*	*0.01*	*0.04*	*0.13*	*0.01*	*0.40*	*0.26*
	(0.00)	(-0.04)	(0.01)	(0.10)	(-0.01)	(-0.04)	(0.00)	(-0.01)	(0.00)	(0.00)
	[-1.00]	[-1.00]	[0.14]	[0.91]	[-1.00]	[-1.00]	[0.00]	[-1.00]	[0.00]	[0.00]
WAT	**0.01**	**0.01**	**0.00**	**0.02**	**0.00**	**0.34**	**0.00**	**4.85**	**5.24**	**0.38**
	0.00	*0.06*	*0.08*	*0.16*	*0.01*	*0.06*	*0.01*	*4.85*	*5.24*	*0.38*
	(0.01)	(-0.05)	(-0.07)	(-0.14)	(-0.01)	(0.28)	(-0.01)	(0.00)	(0.00)	(0.00)
	[2.65]	[-0.86]	[-0.95]	[-0.86]	[-1.00]	[4.26]	[-1.00]	[0.00]	[0.00]	[0.00]
Total 2012	**0.65**	**13.90**	**19.00**	**40.18**	**3.59**	**15.96**	**1.50**	**5.23**	**100.00**	**15.66**
	0.57	*16.04*	*19.64*	*40.33*	*4.06*	*12.88*	*0.47*	*6.01*	*100.00*	*15.66*
	(0.08)	(-2.14)	(-0.65)	(-0.15)	(-0.46)	(3.07)	(1.03)	(-0.78)	(0.00)	(0.00)
	[0.15]	[-0.13]	[-0.03]	[0.00]	[-0.11]	[0.24]	[2.22]	[-0.13]	[0.00]	[0.00]
Gain	**0.23**	**0.79**	**3.21**	**3.18**	**0.34**	**6.17**	**1.37**	**0.38**	**15.66**	
	0.15	*2.93*	*3.86*	*3.33*	*0.80*	*3.10*	*0.34*	*1.16*	*15.66*	
	(0.08)	(-2.14)	(-0.65)	(-0.15)	(-0.46)	(3.07)	(1.03)	(-0.78)	(0.00)	
	[0.57]	[-0.73]	[-0.17]	[-0.05]	[-0.58]	[0.99]	[3.08]	[-0.67]	[0.00]	

Table 11. Systematic land cover change transition matrix in Natura 2000 sites in terms of losses. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012 A	ARA	FOR	GRSH	OPEN	PMF	TRW	WAT	Total 1990	Loss
1990										
A	**1.66**	**0.03**	**0.01**	**0.03**	**0.00**	**0.03**	**0.01**	**0.00**	**1.76**	**0.11**
	1.66	*0.04*	*0.05*	*0.07*	*0.00*	*0.10*	*0.01*	*0.00*	*1.93*	*0.28*
	(0.00)	(-0.01)	(-0.05)	(-0.04)	(0.00)	(-0.07)	(0.00)	(0.00)	(-0.17)	(-0.17)
	[0.00]	[-0.27]	[-0.90]	[-0.51]	[-1.00]	[-0.72]	[-0.05]	[-1.00]	[-0.09]	[-0.62]
ARA	**0.41**	**29.65**	**0.12**	**0.20**	**0.00**	**0.75**	**0.06**	**0.01**	**31.19**	**1.54**
	0.26	*29.65*	*0.94*	*1.23*	*0.03*	*1.84*	*0.18*	*0.03*	*34.15*	*4.50*
	(0.14)	(0.00)	(-0.82)	(-1.03)	(-0.03)	(-1.09)	(-0.12)	(-0.02)	(-2.96)	(-2.96)
	[0.54]	[0.00]	[-0.87]	[-0.84]	[-1.00]	[-0.59]	[-0.66]	[-0.70]	[-0.09]	[-0.66]
FOR	**0.00**	**0.07**	**10.15**	**0.47**	**0.01**	**0.26**	**0.34**	**0.00**	**11.31**	**1.15**
	0.10	*0.25*	*10.15*	*0.44*	*0.01*	*0.67*	*0.06*	*0.01*	*11.69*	*1.54*
	(-0.09)	(-0.18)	(0.00)	(0.03)	(-0.01)	(-0.40)	(0.28)	(-0.01)	(-0.38)	(-0.38)
	[-0.95]	[-0.73]	[0.00]	[0.06]	[-0.57]	[-0.61]	[4.36]	[-0.77]	[-0.03]	[-0.25]
GRSH	**0.09**	**0.50**	**1.62**	**23.00**	**0.09**	**3.25**	**0.08**	**0.03**	**28.66**	**5.66**
	0.24	*0.63*	*0.86*	*23.00*	*0.03*	*1.69*	*0.16*	*0.02*	*26.63*	*3.63*
	(-0.15)	(-0.13)	(0.75)	(0.00)	(0.06)	(1.56)	(-0.08)	(0.01)	(2.02)	(2.02)
	[-0.64]	[-0.21]	[0.88]	[0.00]	[2.02]	[0.93]	[-0.48]	[0.27]	[0.08]	[0.56]
OPEN	**0.00**	**0.00**	**0.00**	**0.07**	**0.36**	**0.00**	**0.00**	**0.00**	**0.43**	**0.07**
	0.00	*0.01*	*0.01*	*0.02*	*0.36*	*0.03*	*0.00*	*0.00*	*0.43*	*0.07*
	(0.00)	(-0.01)	(-0.01)	(0.05)	(0.00)	(-0.03)	(0.00)	(0.00)	(0.00)	(0.00)
	[-1.00]	[-1.00]	[-0.95]	[3.08]	[0.00]	[-1.00]	[0.17]	[-1.00]	[0.00]	[0.02]
PMF	**0.33**	**0.89**	**0.77**	**1.94**	**0.01**	**21.64**	**0.06**	**0.04**	**25.68**	**4.04**
	0.22	*0.56*	*0.77*	*1.01*	*0.03*	*21.64*	*0.15*	*0.02*	*24.39*	*2.75*
	(0.11)	(0.33)	(0.00)	(0.93)	(-0.02)	(0.00)	(-0.08)	(0.02)	(1.29)	(1.29)
	[0.51]	[0.59]	[0.00]	[0.92]	[-0.72]	[0.00]	[-0.56]	[0.99]	[0.05]	[0.47]
TRW	**0.00**	**0.01**	**0.15**	**0.09**	**0.00**	**0.09**	**0.21**	**0.00**	**0.56**	**0.35**
	0.00	*0.01*	*0.02*	*0.02*	*0.00*	*0.03*	*0.21*	*0.00*	*0.30*	*0.09*
	(0.00)	(0.00)	(0.14)	(0.07)	(0.00)	(0.05)	(0.00)	(0.00)	(0.26)	(0.26)
	[-0.73]	[0.03]	[8.19]	[3.13]	[0.80]	[1.64]	[0.00]	[-1.00]	[0.85]	[2.87]
WAT	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.40**	**0.41**	**0.01**
	0.00	*0.01*	*0.01*	*0.02*	*0.00*	*0.02*	*0.00*	*0.40*	*0.47*	*0.07*
	(0.00)	(0.00)	(-0.01)	(-0.01)	(0.00)	(-0.02)	(0.00)	(0.00)	(-0.06)	(-0.06)
	[-1.00]	[-0.29]	[-0.98]	[-0.89]	[-1.00]	[-0.98]	[-1.00]	[0.00]	[-0.13]	[-0.87]
Total 2012	**2.49**	**31.16**	**12.82**	**25.80**	**0.47**	**26.01**	**0.77**	**0.48**	**100.00**	**12.93**
	2.49	*31.16*	*12.82*	*25.80*	*0.47*	*26.01*	*0.77*	*0.48*	*100.00*	*12.93*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Gain	**0.83**	**1.51**	**2.67**	**2.80**	**0.11**	**4.38**	**0.56**	**0.08**	**12.93**	
	0.83	*1.51*	*2.67*	*2.80*	*0.11*	*4.38*	*0.56*	*0.08*	*12.93*	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	

Table 12. Systematic land cover change transition matrix unprotected areas in terms of gains. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

	2012									
	A	**ARA**	**FOR**	**GRSH**	**OPEN**	**PMF**	**TRW**	**WAT**	**Total 1990**	**Loss**
1990										
A	**1.66**	**0.03**	**0.01**	**0.03**	**0.00**	**0.03**	**0.01**	**0.00**	**1.76**	**0.11**
	1.66	*0.03*	*0.01*	*0.03*	*0.00*	*0.03*	*0.00*	*0.00*	*1.76*	*0.11*
	(0.00)	(-0.01)	(-0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
	[0.00]	[-0.17]	[-0.62]	[0.21]	[-1.00]	[0.03]	[10.23]	[-1.00]	[0.00]	[0.00]
ARA	**0.41**	**29.65**	**0.12**	**0.20**	**0.00**	**0.75**	**0.06**	**0.01**	**31.19**	**1.54**
	0.06	*29.65*	*0.29*	*0.58*	*0.01*	*0.58*	*0.02*	*0.01*	*31.19*	*1.54*
	(0.35)	(0.00)	(-0.16)	(-0.38)	(-0.01)	(0.17)	(0.04)	(0.00)	(0.00)	(0.00)
	[6.30]	[0.00]	[-0.57]	[-0.66]	[-1.00]	[0.29]	[2.44]	[-0.30]	[0.00]	[0.00]
FOR	**0.00**	**0.07**	**10.15**	**0.47**	**0.01**	**0.26**	**0.34**	**0.00**	**11.31**	**1.15**
	0.03	*0.41*	*10.15*	*0.34*	*0.01*	*0.34*	*0.01*	*0.01*	*11.31*	*1.15*
	(-0.03)	(-0.35)	(0.00)	(0.13)	(0.00)	(-0.08)	(0.33)	(0.00)	(0.00)	(0.00)
	[-0.85]	[-0.84]	[0.00]	[0.38]	[-0.16]	[-0.24]	[32.43]	[-0.68]	[0.00]	[0.00]
GRSH	**0.09**	**0.50**	**1.62**	**23.00**	**0.09**	**3.25**	**0.08**	**0.03**	**28.66**	**5.66**
	0.19	*2.38*	*0.98*	*23.00*	*0.04*	*1.98*	*0.06*	*0.04*	*28.66*	*5.66*
	(-0.10)	(-1.88)	(0.64)	(0.00)	(0.06)	(1.26)	(0.02)	(-0.01)	(0.00)	(0.00)
	[-0.54]	[-0.79]	[0.65]	[0.00]	[1.61]	[0.64]	[0.42]	[-0.20]	[0.00]	[0.00]
OPEN	**0.00**	**0.00**	**0.00**	**0.07**	**0.36**	**0.00**	**0.00**	**0.00**	**0.43**	**0.07**
	0.00	*0.02*	*0.01*	*0.02*	*0.36*	*0.02*	*0.00*	*0.00*	*0.43*	*0.07*
	(0.00)	(-0.02)	(-0.01)	(0.05)	(0.00)	(-0.02)	(0.00)	(0.00)	(0.00)	(0.00)
	[-1.00]	[-1.00]	[-0.94]	[2.67]	[0.00]	[-1.00]	[4.06]	[-1.00]	[0.00]	[0.00]
PMF	**0.33**	**0.89**	**0.77**	**1.94**	**0.01**	**21.64**	**0.06**	**0.04**	**25.68**	**4.04**
	0.14	*1.70*	*0.70*	*1.41*	*0.03*	*21.64*	*0.04*	*0.03*	*25.68*	*4.04*
	(0.19)	(-0.81)	(0.07)	(0.53)	(-0.02)	(0.00)	(0.02)	(0.01)	(0.00)	(0.00)
	[1.42]	[-0.48]	[0.10]	[0.38]	[-0.70]	[0.00]	[0.51]	[0.56]	[0.00]	[0.00]
TRW	**0.00**	**0.01**	**0.15**	**0.09**	**0.00**	**0.09**	**0.21**	**0.00**	**0.56**	**0.35**
	0.01	*0.11*	*0.04*	*0.09*	*0.00*	*0.09*	*0.21*	*0.00*	*0.56*	*0.35*
	(-0.01)	(-0.10)	(0.11)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[-0.85]	[-0.88]	[2.44]	[0.01]	[-0.34]	[-0.04]	[0.00]	[-1.00]	[0.00]	[0.00]
WAT	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.40**	**0.41**	**0.01**
	0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.40*	*0.41*	*0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	[-1.00]	[1.26]	[-0.83]	[-0.21]	[-1.00]	[-0.75]	[-1.00]	[0.00]	[0.00]	[0.00]
Total 2012	**2.49**	**31.16**	**12.82**	**25.80**	**0.47**	**26.01**	**0.77**	**0.48**	**100.00**	**12.93**
	2.08	*34.31*	*12.18*	*25.47*	*0.44*	*24.69*	*0.34*	*0.48*	*100.00*	*12.93*
	(0.40)	(-3.15)	(0.63)	(0.34)	(0.03)	(1.33)	(0.43)	(0.00)	(0.00)	(0.00)
	[0.19]	[-0.09]	[0.05]	[0.01]	[0.06]	[0.05]	[1.27]	[-0.01]	[0.00]	[0.00]
Gain	**0.83**	**1.51**	**2.67**	**2.80**	**0.11**	**4.38**	**0.56**	**0.08**	**12.93**	
	0.42	*4.66*	*2.03*	*2.47*	*0.08*	*3.05*	*0.13*	*0.08*	*12.93*	
	(0.40)	(-3.15)	(0.63)	(0.34)	(0.03)	(1.33)	(0.43)	(0.00)	(0.00)	
	[0.95]	[-0.68]	[0.31]	[0.14]	[0.34]	[0.43]	[3.32]	[-0.03]	[0.00]	

Table13. Systematic land cover change transition matrix unprotected areas in terms of losses. 1. Number in bold: actual land-cover change (in percent) in the region. 2. Number in italics: percent of the area that would be expected if land-cover change were random. 3. Number in round parentheses: actual minus expected percent. 4. Number in square brackets: number in round parentheses divided by the number in italics.

APPENDIX 2

		Natural protected areas		Natura 2000 sites		Unprotected areas	
		gain	**loss**	**gain**	**loss**	**gain**	**loss**
111	ARA-A	0.00	0.00	-0.01	0.01	0.14	0.35
	PMF-A	0.00	0.00	0.05	0.06	0.11	0.19
112	FOR-A	-0.03	-0.05	0.00	0.03	-0.09	-0.03
	TRW-A	0.00	0.00	0.00	0.00	0.00	-0.01
	GRSH-A	0.03	0.02	-0.04	-0.02	-0.15	-0.10
	OPEN-A	0.00	0.00	0.00	0.00	0.00	0.00
	WAT-A	0.00	0.00	0.00	0.01	0.00	0.00
121	FOR-ARA	-0.04	-0.09	-0.16	-0.32	-0.18	-0.35
	TRW-ARA	0.00	-0.01	0.00	-0.04	0.00	-0.10
	GRSH-ARA	0.03	0.00	-0.18	-1.75	-0.13	-1.88
	OPEN-ARA	0.00	-0.01	-0.03	-0.05	-0.01	-0.02
	WAT-ARA	0.00	0.00	-0.04	-0.05	0.00	0.00
122	FOR-PMF	-0.27	-0.21	-1.21	-0.34	-0.40	-0.08
	TRW-PMF	0.01	0.00	-0.03	-0.04	0.05	0.00
	GRSH-PMF	0.15	0.21	1.65	2.57	1.56	1.26
	OPEN-PMF	-0.01	0.00	-0.25	-0.05	-0.03	-0.02
	WAT-PMF	0.00	0.00	-0.03	0.28	-0.02	0.00
13	PMF-ARA	0.01	0.01	0.41	0.07	0.33	-0.81
211	A-ARA	0.00	0.00	0.01	0.00	-0.01	-0.01
212	A-PMF	0.00	0.00	-0.03	-0.02	-0.07	0.00
213	A-FOR	-0.03	-0.02	-0.02	-0.02	-0.05	-0.01
	A-TRW	-0.01	0.00	0.05	0.05	0.00	0.01
	A-GRSH	-0.02	-0.01	0.00	-0.01	-0.04	0.01
	A-OPEN	0.02	0.02	0.00	0.00	0.00	0.00
22	ARA-PMF	0.13	0.13	-0.10	0.67	-1.09	0.17
231	ARA-FOR	-0.07	-0.09	-0.50	-0.24	-0.82	-0.16
	ARA-TRW	-0.02	0.01	-0.17	0.01	-0.12	0.04
	ARA-GRSH	-0.03	-0.04	-0.60	-0.39	-1.03	-0.38
	ARA-OPEN	-0.01	-0.01	-0.05	-0.06	-0.03	-0.01
232	PMF-FOR	0.19	0.03	0.13	0.01	0.00	0.07
	PMF-TRW	-0.06	0.00	-0.15	-0.03	-0.08	0.02
	PMF-GRSH	0.10	0.00	0.51	-0.05	0.93	0.53
	PMF-OPEN	-0.02	-0.03	-0.04	-0.11	-0.02	-0.02
31	TRW-FOR	0.09	-0.20	0.04	0.01	0.14	0.11
	GRSH-FOR	0.13	-0.70	0.65	-0.30	0.75	0.64
	OPEN-FOR	-0.26	-0.36	-0.11	-0.04	-0.01	-0.01
	WAT-FOR	-0.05	0.00	-0.20	-0.07	-0.01	0.00
	GRSH-TRW	-0.96	0.25	0.01	0.42	-0.08	0.02
	OPEN-TRW	-0.18	-0.03	-0.05	-0.01	0.00	0.00

		Natural protected areas		Natura 2000 sites		Unprotected areas	
		gain	loss	gain	loss	gain	loss
	WAT-TRW	-0.03	0.00	-0.07	-0.01	0.00	0.00
	OPEN-GRSH	0.47	0.42	0.09	0.16	0.05	0.05
	WAT-GRSH	-0.04	0.00	-0.28	-0.14	-0.01	0.00
	WAT-OPEN	-0.01	0.00	-0.02	-0.01	0.00	0.00
32	FOR-TRW	1.25	2.85	0.39	0.59	0.28	0.33
	FOR-GRSH	-0.93	-1.96	0.10	0.19	0.03	0.13
	FOR-OPEN	-0.32	-0.46	-0.02	-0.04	-0.01	0.00
	TRW-GRSH	0.45	0.25	0.18	0.10	0.07	0.00
	TRW-OPEN	-0.01	-0.03	0.00	-0.01	0.00	0.00
	GRSH-OPEN	0.33	0.28	0.13	-0.23	0.06	0.06
4	A-WAT	0.00	0.00	0.01	0.00	0.00	0.00
	ARA-WAT	0.00	0.00	0.02	0.00	-0.02	0.00
	FOR-WAT	0.00	-0.08	-0.06	-0.11	-0.01	0.00
	GRSH-WAT	0.00	-0.05	-0.12	-0.69	0.01	-0.01
	OPEN-WAT	0.00	-0.01	-0.01	-0.02	0.00	0.00
	PMF-WAT	0.00	0.00	0.17	0.05	0.02	0.01
	TRW-WAT	0.00	0.00	0.00	-0.01	0.00	0.00

Table14. Land cover transitions in terms of gains and losses analyzed using the "D" value (D: actual value minus expected value) for each protection level.

		Natural protected areas		Natura 2000 sites		Unprotected areas	
		gain	loss	gain	loss	gain	loss
111	ARA-A	3.56	2,16	-0.35	1,13	0.54	6,30
	PMF-A	1.82	0,35	1.76	2,81	0.51	1,42
112	FOR-A	-0.85	-0,90	0.11	1,98	-0.95	-0,85
	TRW-A	-1.00	-1,00	-1.00	-1,00	-0.73	-0,85
	GRSH-A	1.05	0,52	-0.34	-0,25	-0.64	-0,54
	OPEN-A	-1.00	-1,00	-0.52	0,69	-1.00	-1,00
	WAT-A	4.62	205,08	-0.21	2,65	-1.00	-1,00
121	FOR-ARA	-0.99	-1,00	-0.99	-0,99	-0.73	-0,84
	TRW-ARA	-1.00	-1,00	-1.00	-1,00	0.03	-0,88
	GRSH-ARA	1.01	-0,03	-0.42	-0,88	-0.21	-0,79
	OPEN-ARA	-1.00	-1,00	-0.96	-0,97	-1.00	-1,00
	WAT-ARA	-1.00	-1,00	-0.84	-0,86	-0.29	1,26
122	FOR-PMF	-0.90	-0,87	-0.97	-0,90	-0.61	-0,24
	TRW-PMF	1.64	-0,11	-1.00	-1,00	1.64	-0,04
	GRSH-PMF	0.69	1,37	0.51	1,12	0.93	0,64
	OPEN-PMF	-0.44	-0,22	-0.97	-0,85	-1.00	-1,00
	WAT-PMF	-1.00	-1,00	-0.08	4,26	-0.98	-0,75
13	PMF-ARA	8.03	1,82	3.51	0,16	0.59	-0,48
211	A-ARA	7.36	5,35	2.01	-0,12	-0.27	-0,17
212	A-PMF	-1.00	-1,00	-0.91	-0,83	-0.72	0,03
213	A-FOR	-0.70	-0,63	-0.74	-0,77	-0.90	-0,62
	A-TRW	-0.62	1,86	6.36	28,53	-0.05	10,23
	A-GRSH	-0.51	-0,32	0.13	-0,28	-0.51	0,21
	A-OPEN	5.55	7,66	-0.90	-0,96	-1.00	-1,00
22	ARA-PMF	26.79	35,39	-0.10	2,67	-0.59	0,29
231	ARA-FOR	-0.99	-0,99	-0.89	-0,79	-0.87	-0,57
	ARA-TRW	-0.54	1,00	-0.86	0,22	-0.66	2,44
	ARA-GRSH	-0.49	-0,59	-0.72	-0,62	-0.84	-0,66
	ARA-OPEN	-1.00	-1,00	-1.00	-1,00	-1.00	-1,00
232	PMF-FOR	1.16	0,10	0.27	0,01	0.00	0,10
	PMF-TRW	-0.71	-0,13	-0.88	-0,57	-0.56	0,51
	PMF-GRSH	0.74	-0,02	0.70	-0,04	0.92	0,38
	PMF-OPEN	-1.00	-1,00	-0.87	-0,95	-0.72	-0,70
31	TRW-FOR	1.29	-0,57	2.79	0,14	8.19	2,44
	GRSH-FOR	0.04	-0,18	0.37	-0,11	0.88	0,65
	OPEN-FOR	-0.68	-0,75	-0.79	-0,56	-0.95	-0,94
	WAT-FOR	-1.00	-1,00	-0.98	-0,95	-0.98	-0,83
	GRSH-TRW	-0.63	0,77	0.01	1,95	-0.48	0,42
	OPEN-TRW	-0.96	-0,80	-1.00	-1,00	0.17	4,06

		Natural protected areas		Natura 2000 sites		Unprotected areas	
		gain	loss	gain	loss	gain	loss
	WAT-TRW	-1.00	-1,00	-1.00	-1,00	-1.00	-1,00
	OPEN-GRSH	1.48	1,16	0.43	1,09	3.08	2,67
	WAT-GRSH	-1.00	-1,00	-0.93	-0,86	-0.89	-0,21
	WAT-OPEN	-1.00	-1,00	-1.00	-1,00	-1.00	-1,00
32	FOR-TRW	0.60	5,67	1.59	16,91	4.36	32,43
	FOR-GRSH	-0.26	-0,43	0.09	0,20	0.06	0,38
	FOR-OPEN	-0.78	-0,84	-0.27	-0,46	-0.57	-0,16
	TRW-GRSH	8.24	0,94	7.93	0,91	3.13	0,01
	TRW-OPEN	-1.00	-1,00	-1.00	-1,00	0.80	-0,34
	GRSH-OPEN	1.12	0,79	0.79	-0,44	2.02	1,61
4	A-WAT	-1.00	-1,00	2.92	0,31	-1.00	-1,00
	ARA-WAT	43.76	2,48	0.39	-0,02	-0.70	-0,30
	FOR-WAT	-0.01	-0,93	-0.88	-0,93	-0.77	-0,68
	GRSH-WAT	-0.75	-0,98	-0.66	-0,92	0.27	-0,20
	OPEN-WAT	-1.00	-1,00	-0.90	-0,92	-1.00	-1,00
	PMF-WAT	-1.00	-1,00	3.38	0,30	0.99	0,56
	TRW-WAT	-1.00	-1,00	-1.00	-1,00	-1.00	-1,00

Table 15. Land cover transitions in terms of gains and losses analyzed using the "R" value (R: ratio difference actual value minus expected value to expected value) for each protection level.