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The perception of ecosystem services in the wooded pastures of the Swiss Franches-Montagnes: an assessment using public participation GIS

Alice Dind

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Abstract

Agroforestry has long proved itself to provide many ecosystem services, ranging from provision of biodiversity to climate mitigation. In Switzerland, the region of Les Franches-Montagnes is famous for its large areas of wooded pastures, which compose the typical mosaic structure of the landscape. Integrated management plans and typologies of the wooded pastures have been developed to better understand and manage these silvopastoral systems. However, few studies have considered their benefits to the local population and assessed their role in the landscape as an ecosystem services provider. This study aims to show how the people of the region perceive ecosystem services provision in their surrounding landscape and how the latter contributes to their well-being. To do so, a survey using public participation GIS developed for the AGFORWARD project, was answered by the inhabitants of Muriaux, one of the 13 municipalities of the district of Les Franches-Montagnes. In this survey, they were asked to map different ecosystem services indicators on web-based maps of the region. Their answers were analyzed and the relationship between the ecosystem services indicators and land cover types was assessed. The results show that the diversified landscape of Les Frances-Montagnes provide many ecosystems services. However, the wooded pastures do not seem to hold more importance than other elements of the landscape in the provision of the latter. Answers to additional question of the survey suggest that the contribution of the landscape to personal well-being is mainly based on people-landscape relationships, such as tranquility and space and on social interaction between the inhabitants. Because this study only assesses a small proportion of the population of the region, it can be regarded as an exploratory work on the perception of ecosystem services in the Franches-Montagnes.

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Introduction

1.1 Defining Agroforestry

Agroforestry (AF) can be defined as the deliberate combination of woody perennials and agricultural crops or livestock on the same unit of land (Nair, 1993). It is a land-use management practice offering many advantages to farmers, local population and nature. It is well known that agroforestry practices provide many useful ecosystem services. In a review by Rigueiro et al. (2009), improvement of soil nutrient use, carbon sequestration and soil conservation are described as some of the ecosystem services associated with agroforestry. Indeed, it is known that trees have a higher capacity to store carbon and thus, agroforestry systems can mitigate the climatic effect of deforestation by capturing some of the atmospheric carbon while providing useful products to humans (Montagnini and Nair, 2004). Preserving and enhancing biodiversity is an important concern in agriculture. AF has proven to achieve increased biodiversity by recreating semi-natural habitats that mimic natural ecosystems (Altieri, 1999). Indeed, AF provides habitat for a wide range of species, improves the connectivity between habitats through the creation of corridors and prevents habitat degradation (Jose, 2009). Other ecosystem services were discussed by Fagerholm et al. (2016b), the most assessed being provision of habitat and biodiversity, production of food, fiber, climate regulation and production of fuel.

Because of the great advantages AF present, systems are found all over the world. In the tropics, many systems are developed for the production of high-value crops such as cacao (*Theobroma cacao*), coffee (*Coffea*), tobacco (*Nicotiana*) and banana (*Musa*) (Alvim and Nair, 1986; Beer et al., 1990). Varying in their level of complexity, these systems range from basic two-crops cultures to complex agroforests (Schneider et al., 2014; Vebrova et al., 2014). In Europe, six basic types of AF systems are described: (1) silvoarable agroforestry (alley cropping, scattered trees, line belt), (2) forest farming, (3) riparian buffer strips, (4) improved fallow (leguminous), (5) multipurpose trees and (6) silvopasture (Mosquera-Losada et al., 2009).

1.2 The silvopastoral systems

Silvopastures are systems that deliberately combine wood, forage and/or livestock production (Klopfenstein et al., 1997). They are described as the oldest type of agroforestry systems (Etienne, 1996). These systems are man-made and require management. However, they resemble natural systems and result from complex interactions between their components. Etienne (1996) describes five main components: climate, soil, tree, sward and animal, which interact either positively, negatively or with mutual benefits. The climate defines the limiting factors, which can be the light, the temperature or the level of precipitation. These factors limit both the growth of grass and trees and influence the behavior of the animal. Grazing animals

keep the landscape open and cycle nutrients through their feces. The trees provide shade for the animals, nutrients for the understory vegetation, usable products for man and many other advantages (Etienne, 1996)

Many systems are found in different regions of the world. In Europe, they are mostly located in Mediterranean regions and Eastern European countries (Plieninger et al., 2015). Portugal and Spain possess the well-known silvopastoral systems, called *Montado* and *Dehesa* respectively. Together they represent one of the most widespread agrosilvopastoral system and occupy 2.3 million hectares in Spain and 0.7 million hectares in Portugal (Moreno Marcos et al., 2007). These systems combine the presence of grazing animals in pastures scattered by oak-trees. Studies have shown the benefits of these systems. Economically, *Dehesas* have proved to be one of the best ways to exploit pasture resources while preserving the environment (Gómez-Gutierrez and Pérez-Fernández, 1996). The tree component is very important as it improves soil fertility by increasing soil chemical parameters such as the amount of organic matter, nitrogen (N) and phosphorous (P) and cation-exchange capacity (Moreno Marcos et al., 2007). The shading effect is also important for the animals, as the climate is usually quite harsh, with hot temperatures. In temperate regions of Europe, traditional systems called *Streuobst* combine grasslands and fruit trees. Although not being economically profitable, these systems provide numerous ecological services (mainly biodiversity) and have strong cultural and aesthetic values (Herzog, 1998).

Biodiversity is one of the main ecosystem services provided by wooded pastures. Indeed, the trees in these systems create a gradient of light, moisture and fertility so that many different adapted species can colonize these microclimates (Mosquera-Losada et al., 2005). In addition, silvopastoral systems can act as ecological corridor, improving the connectivity of different habitats (Rois-Díaz et al., 2006). Silvopastoral systems can also help prevent forest fires by creating discontinuity of plant fuel in the landscape (Rigueiro-Rodríguez et al., 2005).

Despite all the benefits silvopastorism can offer, a reduction of area covered by silvopastures has been observed in some regions (Buttler et al., 2009; Plieninger and Wilbrand, 2001). This is mainly explained by the desire to increase productivity.

In order to preserve such systems, their aesthetics, socio-cultural values and ecosystem services are often brought forward, but the link between these services and human well-being is not always considered. Useful methods to assess the socio-cultural aspect of ecosystem services are participatory approaches. Such approaches enable to explore how stakeholders' perceptions, values, knowledge and preferences are related to ecosystem services (Villamor et al., 2014) and to understand the link between landscape and human well-being (Berbés-Blázquez, 2012; Bieling et al., 2014; Hausmann et al., 2016). Few case studies have researched this topic in agroforestry landscapes (eg. Pinto-Correia et al., 2011; Hartel et al., 2014). Public participation GIS (PPGIS) has been used in numerous studies analyzing

ecosystem services and social perspectives (Brown and Fagerholm, 2015). PPGIS uses Geographic Information System technology in a socially participative way in order to assess local knowledge. It is a tool used, among others, to involve the public into policymaking (Sieber, 2006). Recently, a study using PPGIS to assess the link between ecosystem services, land use and human well-being was developed for the Spanish *Dehesa* systems (Fagerholm et al., 2016a).

1.3 Silvopastoral agroforestry in Switzerland

Silvopastoral systems are encountered in some regions of Switzerland, usually located in alpine and sub-alpine areas. The Franco-Swiss Jura Mountains are well-known for the large areas of wooded pastures, which are emblematic of the region. They are typically composed of spruce (*Picea abies*) and herd of cattle (sometimes mixed with horses) grazing on a rich herbaceous layer. They cover a total area of 371km^2 that is 14% of the total area of the Jura Arc (Gallandat et al., 1995). Sixty-seven percent occur above 1000m and are usually found in the transition zone between the cultivated zones near the villages and the forest (Gallandat and Gillet, 1999). A typology of the wooded pastures, based on the work of Gallandat et al. (1995), was created as a part of an Integrated Management project (Barbezat and Boquet, 2008). The typology includes three types of wooded pastures, differentiated by their degree of afforestation: 1) Pastures with few trees, with a degree of afforestation comprised between 1 and 20% (type 2000), 2) Pastures with many trees (or simply wooded pastures) with a degree of afforestation between 20 and 70% (type 3000) and 3) Grazed woodlands, with a degree of afforestation higher than 70% (type 4000). The three types are silvopastoral systems but are considered as forest and are subject to forestry law.

The wooded pastures started to appear in the Middle Age, when monks colonized these isolated areas and started to remove trees in order to create more open landscape suitable for pasturing (Rieben, 1957). The opening of the forest was further enhanced by the glass and iron industries, which became important in the Jura. Between the 1950's and 1970's, a policy was created for the separation of forests and pastures in order to increase the productivity of both forestry and agriculture and to facilitate their management. Fortunately, the policy was not generalized and the wooded pastures of the Jura Mountains were spared (Perrenoud et al., 2003).

However, the wooded pastures are still subject to disappearance. Indeed, they are now following a dichotomous evolution: the closing of the forest in non-productive zones and the removal of the trees in zones which are more intensively managed (Barbezat and Boquet, 2008). Remote plots tend to be neglected and the number of livestock put in these wooded pastures is decreasing, which leads to signs of forest re-growth. On the contrary, closer pastures tend to be more intensively exploited and trees are often removed (Perrenoud et al.,

2003). The type of grazing system also influences the intensity of their use. There are two systems of grazing used in wooded pastures: free-range and rotational (Gillet and Gallandat, 1999). Free-range grazing consists of letting the cattle roam freely through the pastures the whole summer. On the other hand, in rotational grazing systems, the pastures are divided into parks and the animals pass from one to another through the season, according to the rotation plan. The latter system is more intensive and results in increased fertilization and higher stocking rate. Although free-range was the most widely used system (Gillet and Gallandat, 1999), rotation grazing system is becoming more and more popular (Buttler et al., 2009). The management of wooded pastures varies greatly according to the cantons and even to the different districts and the municipalities composing them[1].

1.3.1 Economical aspect

There are two main users who generate economic benefits from the wooded pastures: the foresters and the farmers.

The foresters are in charge of the management of the forest. The wood of the wooded pastures is generally of low quality and not intensively exploited (Buttler et al., 2009). The costs of management are usually higher than the benefits, which make logging a not very profitable activity. Thus, timber exploitation is usually quite low and varies a lot according to the canton and on the timber price on the market. In general, the economic interest of wooded pastures is more important for agriculture than forestry.

The farmers use the wooded pastures for animal grazing in summer, usually from May to October. Because of the strong heterogeneity of the system, the productivity and the pastoral value vary greatly among the wooded pastures. Also, for this reason, productivity of wooded pastures is hard to determine (Mosimann et al., 2012) and data is scarce. However, it has been demonstrated that the presence of trees tends to lower the productivity of the system (Rieben, 1957). Thus, in order to compensate for the lower fodder productivity of wooded pastures, subsidies have been established in the form of direct payments. The type of direct payments varies according to the status of the wooded pastures. In Switzerland, wooded pastures are either considered as UAA (Utilized Agriculture Area) or zones of summer pastures (Barbezat and Boquet, 2008). According to the handbook of Barbezat and Boquet (2008), zones included in UAA are closer to the farm and are sometimes private. On the other hand, zones of summer pastures are always communal. Both zones receive different kind of direct payments (Ordonnance du 23 octobre 2013 sur les paiements directs versés en agriculture, OPD 910.13, RO 2013 4145):

[1] Switzerland is composed of 26 cantons, which are composed of smaller political units called municipalities. There are about 2300 of them and they enjoy considerable autonomy in many domains.

- wooded pastures in UAA receive general direct payments for the non-wooded areas as surface contributions and can be registered as ecological focus areas for biodiversity conservation (level I payments, art. 56 al. 1). For parts with high ecological quality, biological quality bonus payments can be obtained (level II payments, art. 56 al. 2). Additional payments can also be obtained in the context of ecological network projects.
- wooded pastures in zones of summer pasturing receive ecological direct payment as summer pasturing contributions: “contributions d’estivage” and “contributions d’alpage”. The “contributions d’estivage” are usually given to the municipality, which must, as a general rule, give 80% to the farmers (Julien Berberat, personal communication). On the other hand the “contributions d’alpage” are directly received by the farmers. Payments for ecological focus areas are only accorded to the parts of the summer pasture with level II ecological quality.

Such subsidies permit a sustainable management of the wooded pastures while keeping them economically profitable (Barbezat and Boquet 2008).

In 2015, the new policy instrument of “landscape policy projects” was introduced. It allows the granting of direct payments for maintaining and restoring landscapes of particular value to society (aesthetic, cultural, historical). The wooded Jura pastures are a typical example of such landscapes and three landscape quality projects were initiated in 2015 in the canton. In the district of the Franches-Montagnes, the objectives of the projects were, among others, to have a better management of the wooded pastures, to improve the landscape mosaic structure and to maintain the presence of the animals outside (FRIJ, 2015). The range of action was applied to zones in UUA and zones of summer pasturing. Farmers who accepted the conditions and participated in this project could benefit of additional direct payments.

As a means to increase their income, some farmers have chosen to practice secondary activities. The wooded pastures attract tourists for outdoor activities such as hiking, horse riding, biking and mountain biking, cross-country skiing, snow shoeing… This represents an opportunity for farmers to generate additional income. Indeed, it is not rare to see farms offering accommodation such as rural gites or horse riding tours.

1.3.2 Ecological aspect

As mentioned before, biodiversity is strongly influenced by the structure of the wooded pastures and this is observed at different levels.

The vegetation is very rich in the wooded pastures of the Jura. Indeed, one sixth of the vascular flora of Switzerland is found there (Gallandat et al 1995). This richness is partly explained by the high variability of the soil and by the microclimates created by the mosaic structure of the wooded pastures (Buttler et al., 2012; Havlicek, 1999). The pastoral value of grasslands and the regeneration potential is strongly influenced by the composition and the structure of the

vegetation (Gallandat et al. 1995). As previously explained, wooded pastures can be divided in different types according to their degree of afforestation. A study on the typology of vegetation of the wooded pastures conducted by the University of Neuchâtel describes the different vegetation types found in these wooded pastures. The type 2000 (pastures with few trees) and the type 3000 (pastures with many trees) are the most diversified; species richness is the highest with values ranging from 68 to 294 species. However, in grazed woodlands, species richness is usually lower than 100 species.

Information and studies about the fauna of the wooded pastures are scarce. Some emblematic species found in the region are the Western Capercaillie (*Tetreao urogallus*) and the Hazel Grouse (*Tetrastes bonasia*). Also the different types of wooded pastures offer great niches for various animals: pastures with few and many trees are usually well appreciated by many invertebrate species while grazed woodlands offer a great habitat for the avifauna (Barbezat and Boquet, 2008).

1.3.3 Social-cultural aspect

The management and ownership of the wooded pastures vary from canton to canton and even from district to district. Usually wooded pastures belong to the municipality and are communally exploited. Farmers must be owners of cultivated lands in UAA in order to obtain the right to use the communal wooded pastures. Usually, 0,7 ha of UAA lands grants a grazing right of 1 UGB. UGB stands for “Unité de Gros Bétail”, which is a reference unit for livestock aggregation and is equivalent to one adult dairy cow (EUROSTAT, 2013). In the district of the Franches-Montagnes, which is famous for its wooded pastures, the principles of right to access the communal pastures are established according to ancient documents such as “l’Ordonnance du Prince-évêque Guillaume-Jacques”, “la Sentence des Commis de 1702” and “l’Acte de Classification de 1870” (Léon-André Maître, personal communication). In this case, the right of grazing in wooded pastures is also granted according to farmer’s properties, however, the district of the Franches-Montagnes has developed a specific UGB reference unit called “encranne”, which is equivalent to 0.7 UGB (Julien Berberat, personal communication). Farmers who have animals in wooded pastures must also perform chores to maintain the wooded pastures, such as the removing of weeds, setting up fences or removing stones.

It’s because of their historical origins and their important cultural value that the wooded pastures of the Swiss Jura Mountains have been spared until now. In order to preserve them, studies and management plans have been developed to better understand and mostly to better manage such systems (eg. Perrenoud et al., 2003; Barbezat and Boquet, 2008). One of the main issues is to reconcile agricultural, forestry, touristic and ecological interests. Indeed, farmers and foresters are not the only ones using the wooded pastures, more casual users such as hikers, bikers, horse riders, skiers, picnickers, hunters, berry and mushrooms pickers are taking more

and more importance (Gallandat et al. 1995). However, the role of these additional users and their relation with the landscape has not been much studied. One exception is the survey study by Miéville-Ott and Barbezat (2005), which asked for people's landscape preferences and features they value in the region of La Sagne. The results showed that the people, mainly people from the municipality or neighboring ones, valued the wooded pastures for their beauty and calm as well as for doing sports. The majority of the participants to the survey also showed a preference for wooded pasture areas over closing forest or open pasture with few trees.

1.4 Focus of the study

This master thesis is realized in the context of the AGFORWARD (AGroFORestry that Will Advance Rural Development) research project, which promotes agroforestry practices (www.agforward.eu).

The aim of this study is to understand how local people use and perceive the landscape around them and to assess the contribution of ecosystem services of agroforestry to their well-being. The idea is to use public participation GIS (PPGIS) methods to consider human activities and values around ecosystem services in a spatially explicit way and make a comparison between agroforestry, open lands and forest. The study was carried out in the region of the Franches-Montagnes (CH), where wooded pastures are the predominant type of agroforestry systems.

The objectives of this thesis are:

1. To describe the relationship between local people and their surrounding landscape by identifying the ecosystem services valued and by mapping their spatial distribution
2. To compare these services and their relation to land cover
3. To identify how the landscape influence the well-being of the inhabitants of the region
4. To summarize the role of wooded pasture as ecosystem services provider

Material and methods

2.1 Study area

The study was carried out in the region of Les Franches-Montagnes in the Swiss Jura Mountains (Figure 1). The municipality of Muriaux was chosen from the four municipalities selected for the AGFORWARD project in this region (Muriaux, Le Noirmont, Les Breuleux and La Chaux-des-Breuleux). Although the questionnaire was exclusively answered by the inhabitants of the municipality, the study area was not delimited by the municipality borders and included the region in general.

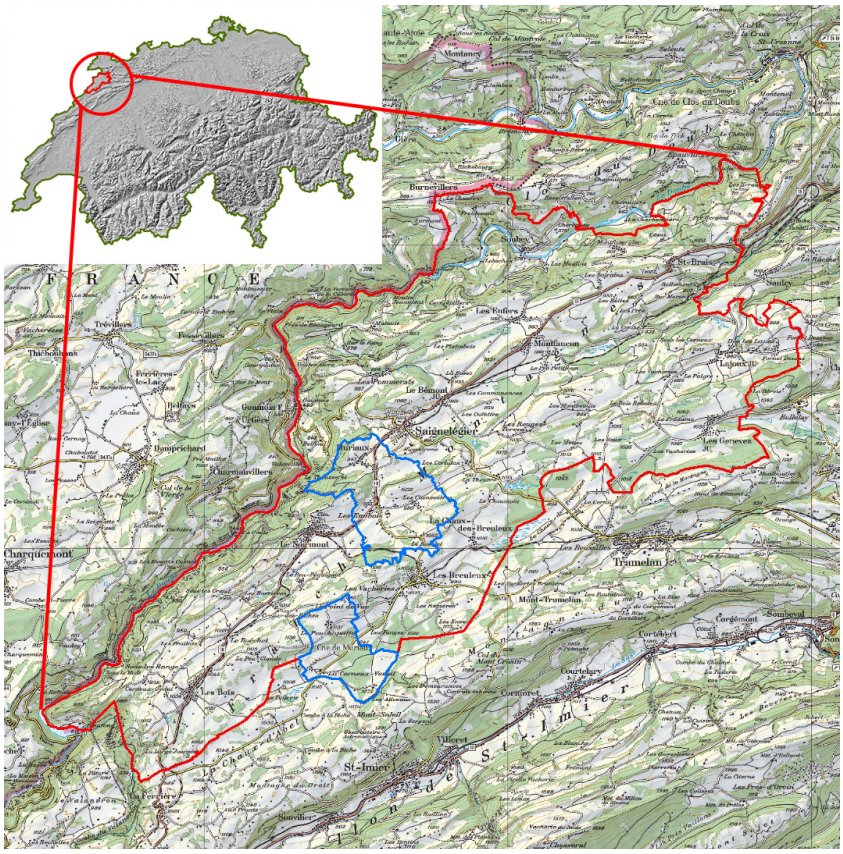

Figure 1: Map of the study region (in red: delimitation of the district of Franches-Montagnes, in blue: the delimitations of the municipality of Muriaux)

Les Franches-Montagnes are a district composed of 13 municipalities (including Muriaux), which territory extends on 20 028 ha (OFS, 2013). The region is particularly known for its local horse breed and typical landscapes of wooded pastures. In 2005, the wooded pastures covered a surface area of 3'824 ha (Eschmann and Kohler, 2006). Following the previously mentioned typology, pastures with few trees (type 2000) cover the largest surface area (2'025 ha), while pastures with many trees and grazed woodland are less dominant (surface area of 834 ha and 965 ha respectively).

In the municipality of Muriaux, the population density was 29.9 habitants per km^2 in 2014. The total surface is 16.9 km^2 and comprises 60.5 ha of agricultural land and 36.1 ha of wooded areas, forest and wooded pastures confounded (Office Fédéral de la Statistique [OFS], 2016). The climate is usually humid and rainy with long and harsh winter. The level of precipitation is high, especially in the summer and thunderstorms are frequent and can be violent (MétéoSuisse, 2013).

2.2 Data collection with PPGIS

The interview campaign was conducted during the month of April 2016 in the villages of Muriaux and Les Emibois. The informants were recruited by knocking at doors. The topic and purpose of the survey were explained to them and they were asked if they were interested in answering it. In order to have answers representative of the whole population, the number of interviews per age and gender was balanced. The calculation was made for the four municipalities selected for the AGFORWARD project, which decided on a total number of 170 informants. This covers about 5% of the total population of the four municipalities. For Muriaux, it resulted in 23 interviews in total, balanced in the different categories of age and gender (Table 1). This chosen number covered also about 5% of the total population. A tracking sheet was used to keep track of the number of questionnaires answered and by which category of age and gender.

Table 1: Population of Muriaux (OFS, 2010) and number of respondents per category of age and gender for 2014

		15-29	30-59	>60	All ages
Total population	Total	98	192	143	433
	Male	54	94	72	220
	Female	44	98	71	213
Population sampled	Total	5	10	8	23
	Male	3	5	4	12
	Female	2	5	4	11

The survey was on the form of an online web-based Public Participation GIS questionnaire (PPGIS) developed by Fagerholm (unpublished) for the AGFORWARD project (https://maptionnaire.com/en/881). It was translated in French and started with a welcome page explaining the aim of the survey and the approximate time to answer it. Then, the informants had to choose between the four different municipalities selected for the AGFORWARD project. In this case all the informants had to live or work in the municipality of Muriaux. Before the mapping task, basic information about their age and gender was asked. The first point to map was the home of the informant. Then followed the actual mapping task and the respondents were asked to map places where they practiced diverse activity or which they valued (Figure 2).

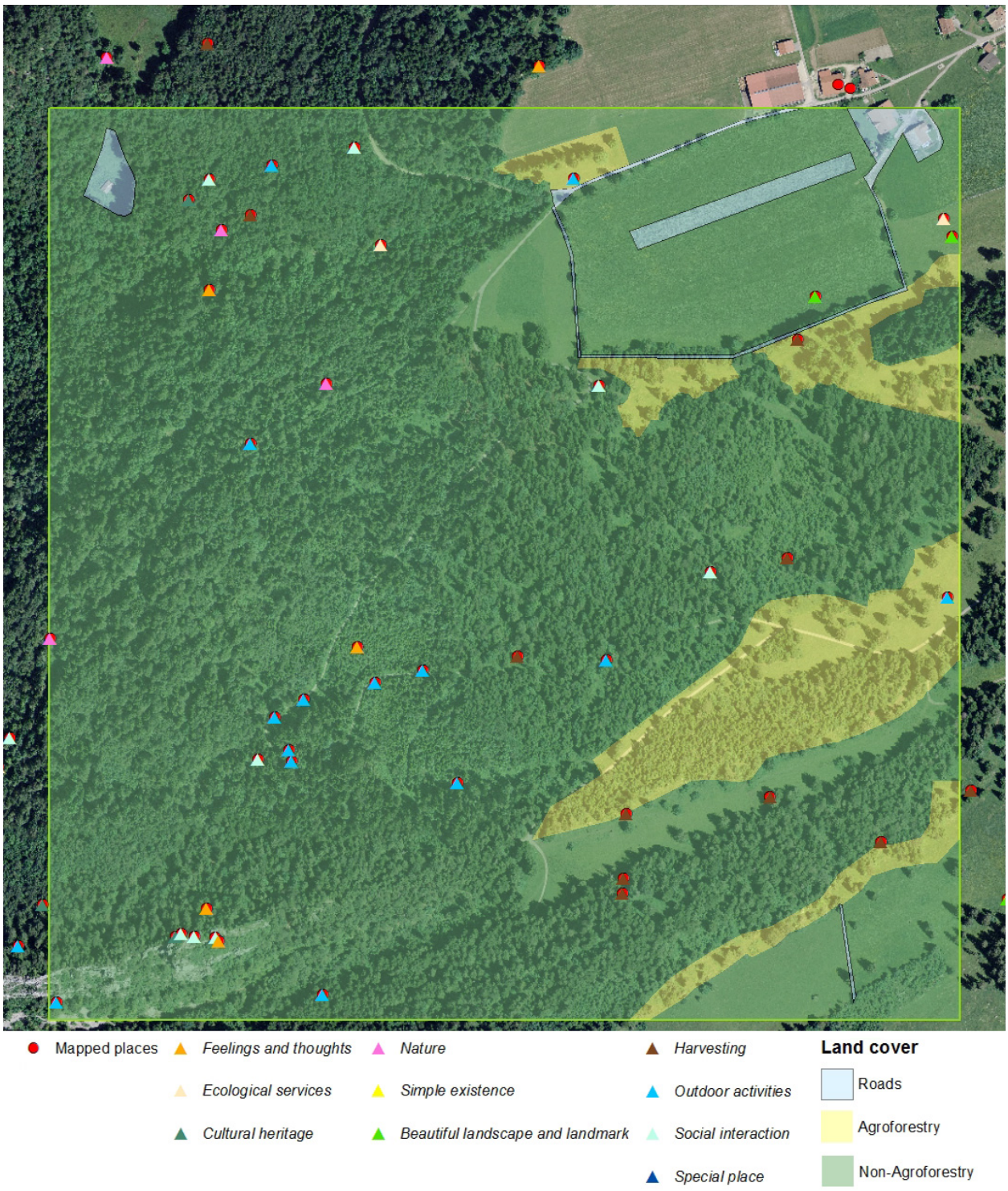

Figure 2: Extract of the results of points mapped on the landscape during the mapping task of the survey

Thus, the elements to map could be divided into “doing” and “valuing” and related to the following ecosystem services: provisioning, cultural and regulation/supporting services (Table 2). Respondents could map several points per categories.

Table 2: Summary of the mapping task of the PPGIS survey (ES = Ecosystem services, C = Cultural services, P = Provisioning services, R/S = Regulating/supporting services).

	Survey question	Choices	Related ES
Doing			
Outdoor activities	I practice outdoor sports, walking, hiking, biking, dog walking etc.	Sports, walking, hiking, dog walking, other	C
Harvesting	I harvest fruits, berries, flowers, mushrooms, asparagus, fish, game etc.	Fruits, berries, flowers, mushrooms, asparagus, fish, game, other	P
Farm products	I appreciate, produce or can buy farm products here	Appreciate, produce, buy: meat, eggs, dairy, honey, vegetables, garden products, other	P
Social interaction	I spend time together with other people	With: family, friends, other people of the municipality for: organized event or festivity, spontaneous gatherings, other reason	C
Valuing			
Landscape and landmark	I enjoy seeing this beautiful landscape or landmark	Beautiful landscape, beautiful landmark	C
Cultural heritage	I appreciate the local culture, cultural heritage or history	Historic remains or monuments, Local tradition, local memory, other	C
Feelings and thoughts	I am inspired by feelings, new thoughts, religious or spiritual meanings etc.	Feelings, thoughts, religious meanings, spiritual meaning, other	C
Simple existence	I appreciate this place just for its existence regardless of benefits for me or others		C
Appreciation of mature	I appreciate the plants, animals, ecosystems etc.	Plants, animals, ecosystems, something else	R/S
Environment regulating capacities	I appreciate the environmental capacity to produce, preserve, clean, and renew air, soil, and/or water	Air, soil, water	R/S
Other			
Special place	Other special place or area to me		-

During the mapping task, all the elements were mapped as points. Thus, some categories such as local products, social interaction, beautiful landmarks and cultural heritage could be mapped precisely. For some other categories (outdoor activities, harvesting, beautiful landscapes, nature and environment regulating capacities), the points were placed at the center of the activity or value, representing the area where the activity is practiced or which is valued. At the end of the mapping task, an open question about how the region contributes to personal well-being was asked. To help the informants, they were asked, for example, to cite the three most important elements for them. Then, additional background information about the informant was

asked and included: if they lived there full-time or part-time, for how long, their level of knowledge of the region, if they owned land and for which purpose, how many persons lived in the household and how many children, their level of education, their profession and the net income of the household. At the end of the questionnaire, questions about the attitude and level of understanding of the informant were to be answered by the person facilitating the interview. All data from the survey was automatically saved in a database. The surveys were answered on a computer with stable Internet connection and were mediated by a facilitator. Most of the time, the facilitator was in possession of the computer and mapped the places showed on the screen by the informant. Only in rare cases, the informants placed the points on the map themselves but always with the guidance of the facilitator.

2.3 Habitat mapping of Landscape Test Sites

In order to assess the relationship between the mapped points and the land cover, a mapping of the habitats of selected plots was carried out. For the AGFORWARD project, 12 Landscape Test Sites (LTS) of 1 km^2 each were randomly selected in the area of the four municipalities: four LTS for wooded pastures, four for open areas (including open pastures, artificial and semi-natural grasslands and arable lands) and four for forest (Figure 3).

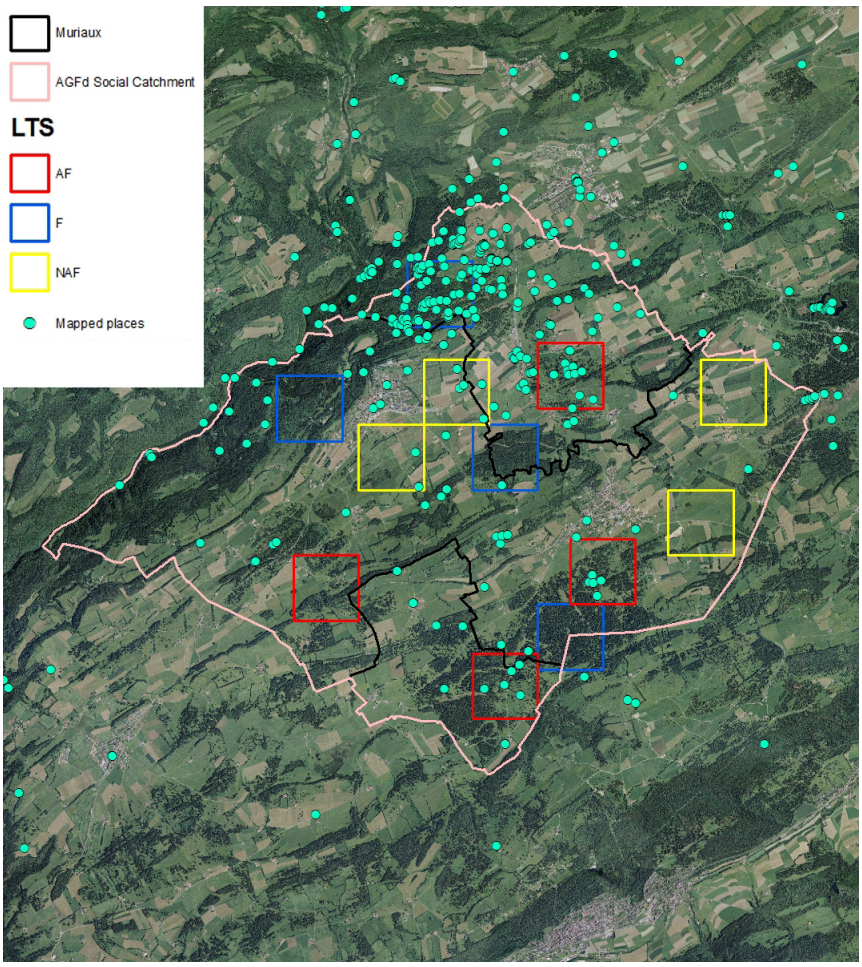

Figure 3: Spacial location of the LTS (in red: AF LTS, in blue: F LTS and in yellow: nAF LTS)

Among them, three plots (one of each land cover type) were located in the municipality of Muriaux. The selection of the LTS was previously done following the AGFORWARD protocol created by Moreno (unpublished).

The habitat mapping was conducted following the AGFORWARD habitat mapping protocol (Szerencsits et al. unpublished). Prior to field mapping, working maps of the LTS were prepared in ArcGIS desktop 10.3 (ESRI, 2015) on SWISSIMAGE digital colour orthophotomosaic images with a ground resolution of 0.25 to 2.5 m (Office federal de topographie swisstopo). The large-scale topographic landscape model swissTLM3D (swisstopo) was used to delineate roads, urban areas, forest and forest patches. These elements were overlaid and mapped as polygons on the orthophotos. The maps used for the field mapping were printed version of the latter, at the scale of 1:3000. The field mapping was carried out during mid-May and the beginning of June 2016. The LTS were walked across and the habitat types were recorded on the prepared maps and assigned a number. The habitats were delineated according to the vegetation composition and structure; delimitation was drawn where changes were visible. For areal elements, only habitats with a minimal surface area of 100m^2 were mapped. As for linear elements, only habitats with a width ranging between 1m and 25m and with a minimum length of 50m were recorded. The corresponding numbers of the habitats were reported on a recording

sheet (Appendix A9), in which each of them was attributed a habitat type and was described as agroforestry or non-agroforestry habitat. The classification of the habitats was based on the typology of the European project EBONE (Bunce et al., 2010). Each habitat was described with different attributes according to their habitat type: open areas such as grasslands and pastures were described by the composition of the grass layer and the land use, forests and forest patches were described by their tree layer and wooded pastures were described by both grass and tree layers. The recording sheet with a detailed list of the descriptive criteria are attached in Appendix A.

Once the mapping of the habitats was completed, the information collected on the working maps was digitized in ArcGIS 10.3 on the orthophoto images. All the linear and areal habitats were reported and mapped as polygons. Elements already delineated in the preparatory step were reshaped or deleted if needed. Information on the recording sheet was reported on an attribute table for each LTS.

2.4 Data analysis

Data from the PPGIS surveys were transferred into Excel tables and the coordinates of the points were transformed from WGS84 to CH1903+ LV95 coordinate system and digitized in ArcGIS 10.3 software.

Background information on the informants and data on the mapped points collected during the surveys, were analyzed with descriptive statistics on Excel in order to obtain a general overview of the profile of the informants and of the categories of services mapped.

Then, an analysis of the habitats and the PPGIS points comprised in the LTS was carried out. First, the classification of the habitat types was simplified. Based on the results of the fieldwork on habitat mapping and the classification from the protocol (Appendix A), the simplified classification contained eight different habitat types including semi-natural habitats (agroforestry elements, woody elements, herbaceous elements and dry-stones walls), agricultural habitats (annual herbaceous crops, permanent grasslands), aquatic habitats and urban areas (Appendix B). These different habitats were identified and compared between the LTS. Then, the points comprised in the plots were identified and a comparison was made between the LTS types. The points inside the LTS were analyzed with descriptive statistics.

In order to analyze the points that were not mapped within the LTS boundaries, a land cover type was attributed to each point mapped during the surveys, using an overlay of collateral data. The databases used were the Swiss land use statistics with the standard nomenclature NOAS04 (OFS), the large-scale topographical landscape model swissTLM3D (swisstopo) and the map of Agricultural land zones (Office fédéral de l'agriculture OFAG). Each PPGIS point received an attribute from these databases. Information about distance from running and standing water as well as from high and low marsh zones were added. Concerning the Swiss

land use statistics, as the land use is assessed by points every 100m, the PPGIS points were attributed the land use type of the closest point. For each PPGIS point, information from the different databases was combined and a single simplified land cover categorization was decided. To increase accuracy, each point was visualized on orthophotoimages (swisstopo) in ArcGIS 10.3 and the category was confirmed and adapted if necessary. The main types of land cover corresponded to: wooded pastures, open lands and forest. Additional land categories (e.g. urban or forest border) were added according to the nature of the service mapped (for example, a picnic at the forest border). The relationship between the mapped points and the land cover type was then described using descriptive statistics and a comparison was made between open lands, wooded pastures and forest.

In order to identify additional elements of the landscape which influenced the well-being of the inhabitants, the responses to the open question at the end of the mapping task were analyzed. First the elements mentioned several times were grouped together and categorized according to the Cultural Values Model developed by Stephenson (2008). Thus, the landscape values were classified as forms (physical, tangible and measurable aspects), relationships (people-people interactions in the landscape and landscape-people interactions) and practices/processes (human practices and natural processes).

Results

3.1 Profile of the informants

A total of 23 persons were interviewed. Among them, 12 were men (52%) and 11 were women (48%). Their age ranged from 20 years old to 82 years old. All the informants lived full time in the municipality of Muriaux, either in the village of Les Emibois or in Muriaux. More than 82% have been living there for more than 10 years and only three persons (13%) less than six years. The latter were also the only ones who claimed to know the region quite poorly while the majority of the informants (86%) claimed to know the region either extremely well (39%) or quite well (48%). None of the respondents said that he or she knew the region extremely poorly. About half of the informants owned land in the area and mainly for residential purposes (46%). Other reasons were leisure, tourism or farming purposes (13%). Only two persons owned land for forest activity (7.7%) and only one for agroforestry, hunting and nature conservation purposes (3.8%).

The main occupation of the informants was quite diverse and among them, four were retired. The most represented domain of work involved either: agriculture, with five persons (21.7%, two for crop production and three for livestock production) or tourism and catering with three persons (13%). More than half of the informants (60%), mainly men, followed a vocational

training education. The size of the households varied from one person to seven people with an average of three persons per household. For more information on the respondents, refer to Appendix C.

3.2 Distribution of the points

A total of 409 points were recorded on the map during the survey campaign. Respondents mapped in average 17.78 places, with a minimum of nine and a maximum of 30 places (SD 6.4). The respondents with a high self-perceived knowledge mapped in average more points (18.85) than the ones who claimed a rather poor knowledge (10.67). Middle-aged respondents, ranging between 30 and 59 years old, mapped in average slightly more places (20.2) than younger people (14.8) and older (16.6).

Among the 409 places mapped, 23 were the home of the respondents, so a total of 386 sites were mapped for the indicators of ecosystem services. In general, more points were mapped for the category “doing” (223 points, 57.8%) than for the category “valuing” (154 points, 39.9%). Concerning the related ecosystem services, provisioning services totaled a number of 88 points (mean = 44.0), cultural services 231 (mean = 38.5) and regulation/supporting services 58 (mean =29.0).

The most mapped indicator was outdoor activities (Table 3). It was also the only element that all the informants assessed without exception and they mapped in average more points for this indicator than for the others. Among the different choices, walking was the most assessed (49 points, 40%), followed by hiking (23 points, 19%), biking (20 points, 16%), other activities (19 points, 15%), dog walking (9 points, 7%) and sports (3 points, 2%). As part of other activities, horse riding was frequently cited with a total of 12 points (10% of all outdoor activities). Other activities also included cross-country skiing (3 points, 2%), climbing (3 points, 2%) and swimming (1 point, 1%).

The categories harvesting, local products and social interaction were equally mapped by most of the informants (87%). Concerning harvesting, a total of 37 spots were mapped by 20 informants. The activity was mainly practiced for picking berries (20 points, 41,7%), but also mushrooms (13 points 27,1%), flowers (5 points, 10.4%) and fruits (2 points 4,2%). Only one informant mapped the activity of fishing and only one other practiced hunting and both mapped only one point for the activity. Some of the informants also harvested non-listed products such as cumin, linden, bears’ garlic, edible plants and healing plants. Social interaction totaled a relatively high number of points (Table 3). People usually met for independent gatherings (97%) with friends and family. Only one respondent mapped two places where he met people during organized events (by the municipality for instance). This same respondent was also the only person to map social interaction with people from the municipality.

In the general category “valuing”, the most mapped indicators were the appreciation of nature and landscape and landmark (Table 3). Almost all the informants (89%) mapped one or both of them. The respondents mapped more places for beautiful landscapes (89%) than for beautiful landmarks (11%). Concerning the mapping of appreciation of nature, the three choices were quite equally assessed: 39% for the animals, 33% for ecosystem and 27% for the plants.

Points for cultural heritage and feelings and thoughts were less often assessed than the previously mentioned indicators, however, still half of the informants mapped at least one point. The least mapped elements of the survey were: environment regulating capacities, special place and simple existence; less than half of the informants assessed these parameters (Table 3). Concerning the appreciation of the environment regulating capacities, the respondents usually liked places with clean air (61.5%) and good soil (53.8%) and few sites were assessed for clear water (30.8%).

Table 3: Summary of descriptive statistics on mapped ecosystem services indicators (number and relative proportion of the informants, number and relative proportion of the points, maximum and mean number of points per informants, general category D = doing and V = valuing).

		Informants		Points		Points per informant		
Ecosystem services	Indicator	n	n%(23)	n	n%(386)	max	mean	Category
Cultural services		**23**	**100.0**	**231**	**59.8**	**17**	**10**	**-**
	Outdoor activities	23	100.0	94	24.4	8	4.1	D
	Social Interaction	20	87.0	41	10.6	4	2.1	D
	Landscape and landmark	21	91.3	44	11.4	4	2.1	V
	Cultural heritage	12	52.2	17	4.4	3	1.4	V
	Feelings and thoughts	15	65.2	29	7.5	4	1.9	V
	Simple existence	5	21.7	6	1.6	2	1.2	V
Provisioning services		**22**	**95.7**	**88**	**22.8**	**8**	**4**	
	Local products	20	87.0	51	13.2	6	2.6	D
	Harvesting	20	87.0	37	9.6	4	1.9	D
Supporting and regulating services		**20**	**87.0**	**58**	**15.0**	**7**	**2.9**	**-**
	Appreciation of Nature	20	87.0	45	11.7	5	2.3	V
	Environment regulating capacities	9	39.1	13	3.4	2	1.4	V
Other	Special place	9	39.1	9	**2.3**	1	1	-

3.3 Habitat mapping of the LTS and the points comprised in them

The habitat mapping resulted in the digitalization of 12 maps of the LTS (Figure 4 and Appendix D). The LTS were composed of 31 to 92 polygons representing a range of 15 different habitat types. The simplified classification resulted in a number of eight habitat types (Appendix B).

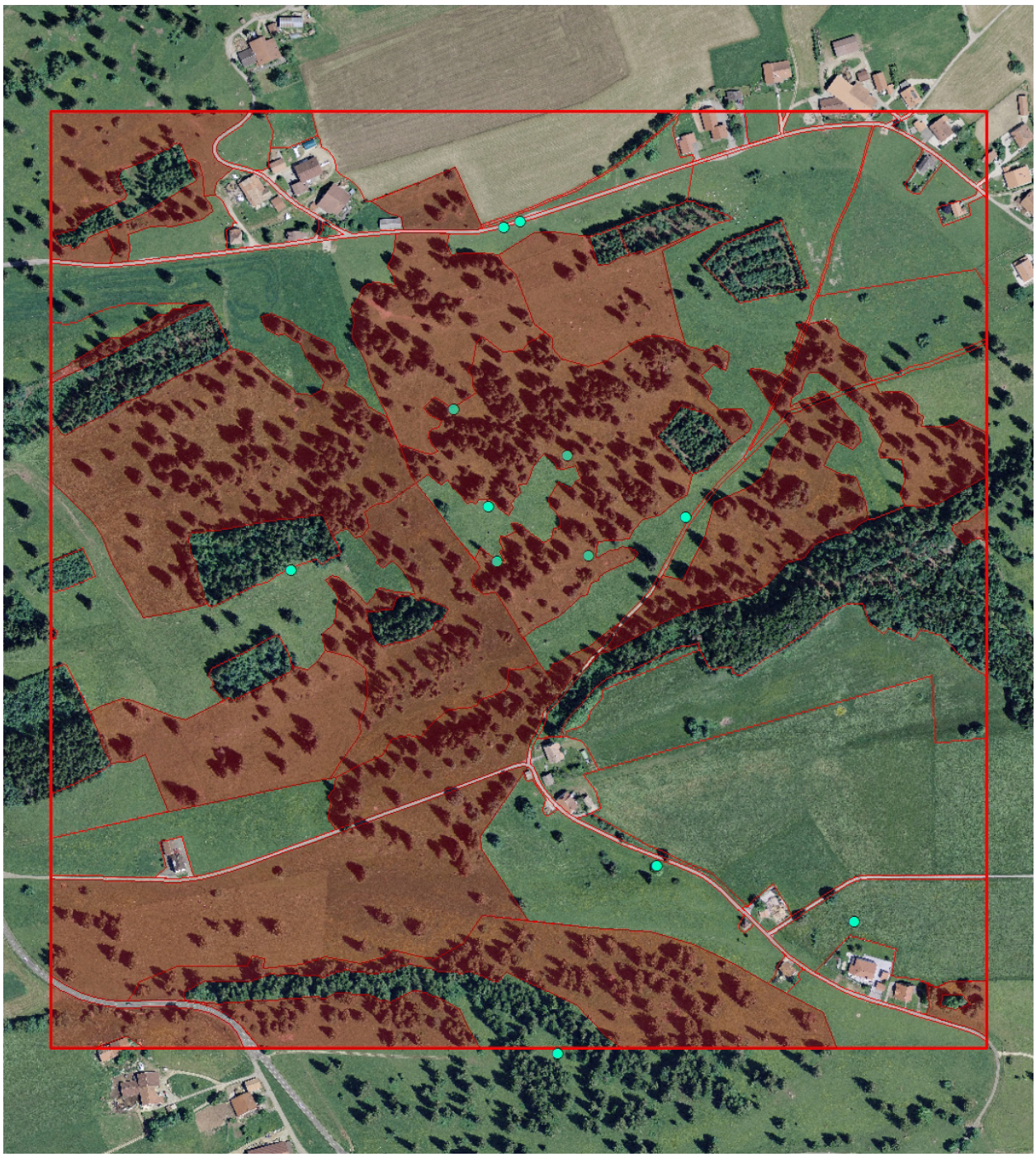

Figure 4: Example of the results of the habitat mapping of the LTS: AF LTS n°211. The different habitats are separated by a red line. Areas in transparent red correspond to AF habitats. The points represent the places mapped by the respondents of the PPGIS survey.

In general, the dominant habitat type was artificial permanent grassland: more than one quarter of the polygons mapped (27.1%) were permanent grasslands and they covered at total surface of 338.9 ha (28.5% of the total surface of the LTS). Together with non-AF woody elements (WE), they were the only two habitat types that were present in all of the LTS (Table 4). Urban areas (UA) were also always present, in the form of built up areas and traffic roads. Aquatic habitats (AQH) were only found in one LTS (206, nAF) and covered about 0.4 ha of the plot. The presence of dry-stone walls (DSW) was also observed in most of the LTS but less in the

forest plots. Agroforestry elements (AFE) were found in all of the LTS except two nAF plots (209 and 210). They covered 26.7% of the total surface of the LTS and were mostly present in AF LTS and more prevalent in F plots than nAF ones (Figure 5). Semi-natural herbaceous elements (HE) were mapped in almost all of the LTS but mainly in nAF plots. They usually covered a small area (14.7 ha in total) especially in the F plots (less than one hectare, Figure 5). Woody elements were found mainly in the F LTS, in which they covered a surface of 226.5 ha (56,6% of the F LTS) and were more prevalent in AF LTS than nAF ones (53.5 ha against 3.0 ha). The nAF plots usually included a high number of fields with annual herbaceous crops (AHC) and managed grasslands (APG). In term of surface, these habitats covered 36.6% and 42.3% of the plots respectively. Many of the permanent grasslands were also found in AF LTS. In general, nAF LTS contained a higher number of small habitats than AF and F LTS (Table 4). Also, the F parcels, were the least fractioned with a low number of habitats but which had generally a larger surface.

Table 4: Number of polygons of the different habitats in each LTS (SNH = semi-natural habitats, AH = artificial habitats, AFE = agroforestry elements, WE = woody elements, HE = herbaceous elements, DSW = dry-stone walls, AHC = annual herbaceous crops, APG = artificial permanent grasslands, AQH = aquatic habitats and UA = Urban areas)

		SNH				AH							
	LTS	AFE	WE	HE	DSW	AHC	APG	AQH	UA	Total number of habitats	Mean number of habitats	Number of different habitats	Mean number of habitat types
AF	201	10	20	4	6	4	35	-	13	92	70.5	7	6.5
	204	23	4	1	1	-	10	-	6	45		6	
	205	34	3	-	4	2	11	-	9	63		6	
	211	21	15	1	4	1	23	-	17	82		7	
nAF	206	4	15	5	8	12	27	2	11	84	82.3	8	6.8
	208	15	18	6	8	1	21	-	5	74		7	
	209	-	27	7	2	22	24	-	7	89		6	
	210	-	18	9	2	34	10	-	9	82		6	
F	202	3	7	-	3	7	15	-	1	36	37.3	6	5.8
	203	19	5	1	-	-	12	-	4	41		5	
	207	7	8	1	3	1	9	-	2	31		7	
	212	3	14	-	-	4	9	-	11	41		5	
In all LTS		**139**	**154**	**35**	**41**	**41**	**206**	**2**	**96**	**760**	**63.3**	**8**	**-**

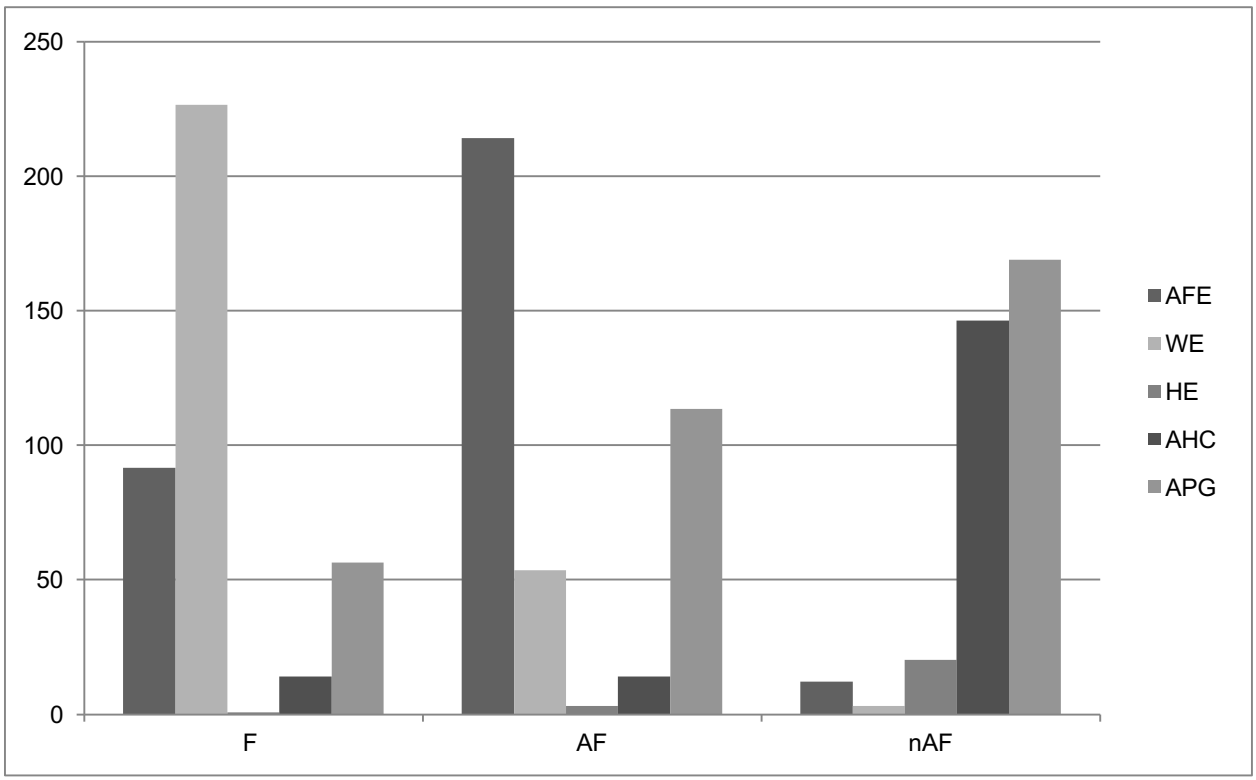

Figure 5: Surface area (ha) covered by the different habitat types (AFE = agroforestry elements, WE = (semi-natural) woody elements, HE = (semi-natural) herbaceous elements, AHC = annual herbaceous crops and APG = artificial permanent grasslands) in the F, AF and nAF LTS

There were, in general, only few points mapped in the LTS: 72 points in total, which represents 18.7% of all the mapped points (without the respondents' residence). There were slightly more points mapped in AF plots than in nAF plots (Table 5). Concerning the forest LTS, three of them had a very low number of points (0 or 1 point), while a single one (LTS 207) totalized a number of 43 points (59,7% of the total number of points mapped in the LTS), which represent 11.1% of all the mapped points (inside and outside the LTS). In this LTS, most of the points were for outdoor activities, harvesting and social interaction. This tendency was generally observed: one third of the points were for outdoor activities (33.3%), followed by harvesting (18.1%) and social interaction (12.5%). These indicators were also placed more often in AF LTS than in nAF ones. This was also the case for all others indicators except feelings and thoughts (equal number of points) and landscape and landmark (one more point). The least mapped indicator was simple existence and no points were mapped for local products. Special places and simple existence were exclusively mapped in AF plots and cultural heritage was only mapped in the forest. Also no place for social gathering, harvesting, appreciation of nature and environment regulating capacities were mapped in non-AF test sites. In term of ecosystem services, all the different services (cultural, provisioning and regulating/supporting), were more assessed in AF plots than nAF plots, and because of the high number of points in LTS 207, they were even more assessed in the F ones.

Table 5: Number of points per indicator mapped in the different LTS

		Cultural services						Provisioning services		Regulating/supporting services			
	LTS	Outdoor activities	Social Interaction	Landscape and landmark	Cultural heritage	Feelings and thoughts	Simple existence	Local products	Harvesting	Appreciation of nature	Environment regulating capacities	Special place	Total number of points
AF	201	0	0	0	0	0	0	0	0	0	0	0	0
	204	1	0	0	0	0	0	0	1	1	0	2	5
	205	1	1	1	0	0	0	0	1	0	1	0	5
	211	5	0	0	0	1	1	0	1	1	0	2	11
nAF	206	0	0	0	0	0	0	0	0	0	0	0	0
	208	0	0	0	0	0	0	0	0	0	0	0	0
	209	1	0	1	0	0	0	0	0	0	0	0	2
	210	3	0	1	0	1	0	0	0	0	0	0	5
F	202	0	0	0	0	0	0	0	1	0	0	0	1
	203	0	0	0	0	0	0	0	0	0	0	0	0
	207	13	8	2	2	4	0	0	9	3	2	0	43
	212	0	0	0	0	0	0	0	0	0	0	0	0
In all LTS		**24**	**9**	**5**	**2**	**6**	**1**	**0**	**13**	**5**	**3**	**4**	**72**

3.3 Spatial location of the points and their relation to land cover

The points were located at an average distance of 2.8 km from the respondents' homes, within a range from 0 to 14km. The points were mostly placed within the municipality boundaries and almost all were placed within the district boundaries (Figure 6). Because of the small number of points mapped, all of them were analyzed, including those placed across the French border.

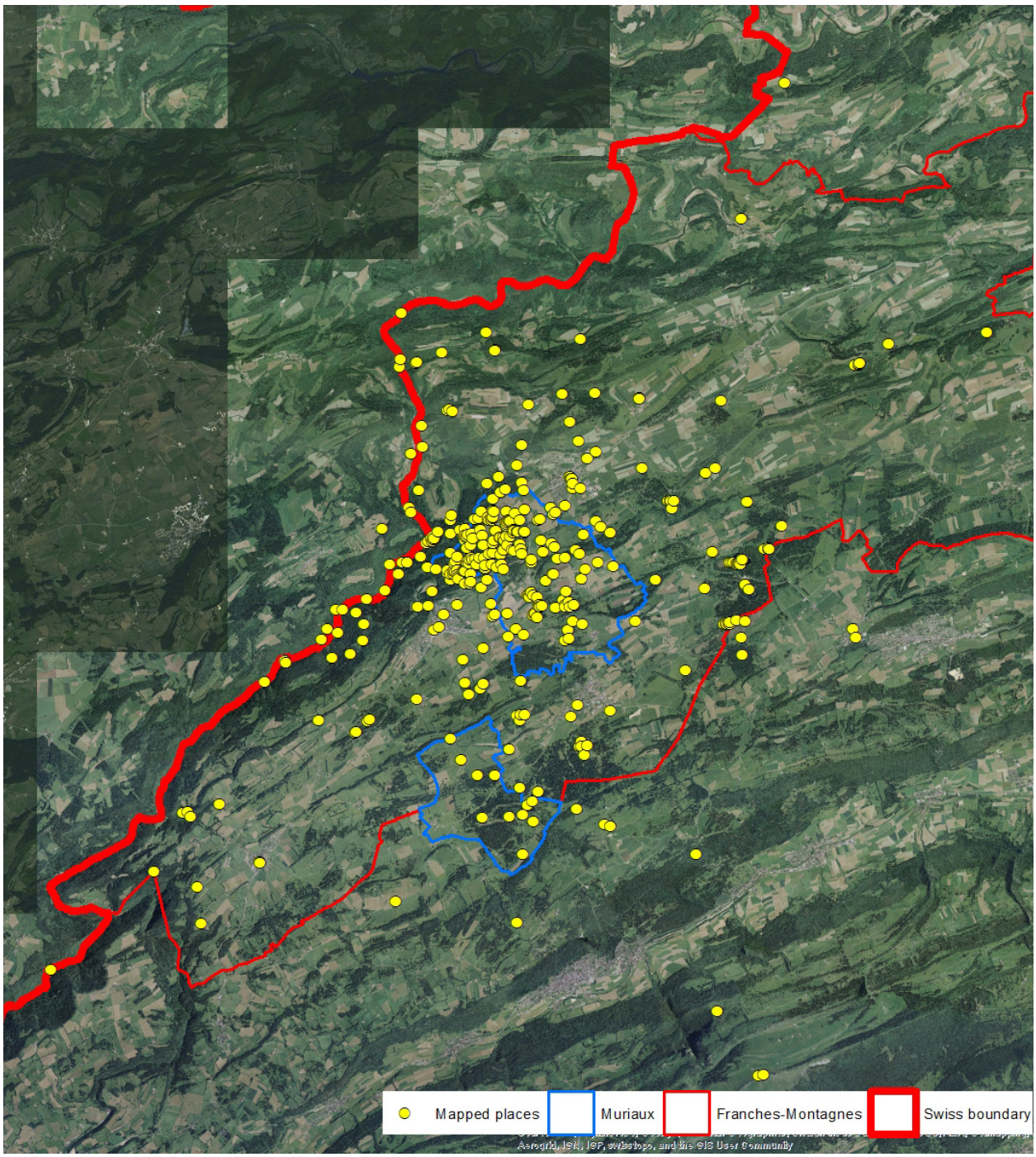

Figure 6: Spatial representation of all the points mapped during the mapping task of the PPGIS survey

In general, most of the points were mapped in urban areas and in the forest (Table 6). Many were also found in open lands, in wooded pastures and in near water bodies.

For the general category “doing”, the same pattern was observed: the majority of the points were mapped in urban areas (26.9%) and in the forest (30.0%). Many were also found in open areas (17.5%) and in wooded pastures (16.1%), fewer points were mapped in water and in the other land cover categories. Concerning the category “valuing”, fewer points were mapped in urban areas than for “doing”. Most of the points were mapped in the forest (32.5%), followed by

open lands and water (18.2% each), wooded pastures (11.7%) and urban areas (10.4%). Few points were also attributed to rocks, wetlands and forest borders.

Sites for cultural services were most prevalent in the forest (35.1%) and in open areas (23.4%) but were also represented in wooded pastures (13.9%), urban areas (10.4%) and near a water source (10.0%). The other land cover categories were less represented. Places for outdoor activities were mainly mapped in the forest and open lands and some sites were also placed in wooded pasture areas (Table 6). Few points were mapped in other land cover categories; those in rocky areas usually corresponded to climbing spots. People usually held gatherings in the forest. However, some spots were also mapped in urban areas (usually the respondent's house), in wooded pastures and near a water source. Very few points (one or two) were mapped in open areas and other land cover categories. Points for beautiful landscapes were mostly placed in open areas, in river courses, in wooded pastures and forest areas. All the places for beautiful landmarks were mapped in urban areas. Places valued for their cultural heritage aspect were mainly mapped in urban areas but also in the forest and few other categories. None were mapped in wooded pastures. Half of the places that inspire feelings and thoughts were mapped in the forest. Few were also placed in wooded pastures, open areas, urban areas, near a source of water and rocks. Only few points were mapped for simple existence and they were quite equally spread in the following land cover categories: forest, open lands, wooded pastures, forest borders and water.

For provisioning services, the majority (58%) of the points were placed in urban areas. It corresponded to the points mapped for the places to buy or produce farm products, which were exclusively mapped in urban areas. The vast majority of harvesting spots were found in wooded pastures or in the forest. Still few were mapped in open lands, in forest borders, near isolated trees and small clusters of trees and in wetlands.

Finally, supporting and regulating services were mostly mapped in the forest (37.9%) and for water spots (24.1%). Open areas and wooded pastures were also relatively well represented (19% and 10.3% respectively). The value of nature was mostly assessed in the forest and in aquatic habitats. Some points were mapped in open areas and few in wooded pastures. In aquatic habitats, the respondents seemed to equally appreciate the plants and the animals but showed a slight preference for ecosystems. In the forest, animals and ecosystems were more appreciated than plants. However in open areas, the plants were more often mentioned. The appreciation of the environment regulating capacities was mainly mapped in the forest (5 points), open lands and wooded pastures (3 points each). One point was also mapped in wetlands and aquatic habitat.

Finally, the respondents mapped special places that did not correspond to the previous categories. The few points mapped were found in wooded pastures, open areas, urban areas and aquatic habitat.

Table 6: Number (n) and percentage (%[a]) of points mapped per ecosystem services indicators for the different land cover types.

	Urban		Open lands		Wooded pastures		Forest		Forest borders		Trees		Wetlands		Rocks		Water	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Cultural services	**24**	**10.4**	**54**	**23.4**	**32**	**13.9**	**81**	**35.1**	**4**	**1.7**	**1**	**0.4**	**4**	**1.7**	**8**	**3.5**	**23**	**10.0**
Outdoor activities	2	2.1	35	37.2	14	14.9	36	38.3	0	0.0	0	0.0	1	1.1	3	3.2	3	3.2
Social interaction	7	17.1	2	4.9	6	14.6	17	41.5	2	4.9	1	2.4	0	0.0	0	0.0	6	14.6
Landscape and landmark	5	11.4	11	25.0	7	15.9	8	18.2	0	0.0	0	0.0	1	2.3	2	4.5	10	22.7
Cultural heritage	7	41.2	1	5.9	0	0.0	4	23.5	0	0.0	0	0.0	2	11.8	2	11.8	1	5.9
Feelings and thoughts	3	10.3	4	13.8	4	13.8	15	51.7	0	0.0	0	0.0	0	0.0	1	3.4	2	6.9
Simple existence	0	0.0	1	16.7	1	16.7	1	16.7	2	33.3	0	0.0	0	0.0	0	0.0	1	16.7
Provisioning services	**51**	**58.0**	**2**	**2.3**	**16**	**18.2**	**14**	**15.9**	**1**	**1.1**	**3**	**3.4**	**1**	**1.1**	**0**	**0.0**	**0**	**0.0**
Local products	51	100.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Harvesting	0	0.0	2	5.4	16	43.2	14	37.8	1	2.7	3	8.1	1	2.7	0	0.0	0	0.0
Supporting/regulating services	**1**	**1.7**	**11**	**19.0**	**6**	**10.3**	**22**	**37.9**	**1**	**1.7**	**0**	**0.0**	**2**	**3.4**	**1**	**1.7**	**14**	**24.1**
Appreciation of nature	1	2.2	8	17.8	3	6.7	17	37.8	1	2.2	0	0.0	1	2.2	1	2.2	13	28.9
Environment regulating capacities	0	0.0	3	23.1	3	23.1	5	38.5	0	0.0	0	0.0	1	7.7	0	0.0	1	7.7
Other																		
Special place	1	11.1	3	33.3	4	44.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	11.1

[a] the percentage is calculated with the total number of points for each category of services (cultural services = 231, provisioning services = 88 and supporting/regulating services = 58)

In general, the land category with the highest number of points was the forest (117 points, 29%) followed by urban areas (100 points, 24%), open lands (70 points, 17%), wooded pastures (58 points, 14%) and water (38 points, 10%).

In the forest, many points were mapped for different categories (Figure 7A). The most assessed was outdoor activities with 36 points. Then followed appreciation of nature and social interaction with 17 points each, feelings and thoughts with 15 points, harvesting with 14 points. Less assessed categories included: beautiful landscape with 8 points, environment regulating capacities with 5 points, cultural heritage with 4 points and simple existence with a single point. No points were mapped as special place and sites to buy local products.

In open lands, the most assessed category was outdoor activities with 35 points mapped (Figure 7B), for which the main activities were walking and hiking. Beautiful landscape and value of nature were also well mapped in open areas, with 11 and 8 points respectively. The remaining indicators only scored one to four points. No places for local products were mapped.

In wooded pastures, more than half of the points were either mapped for harvesting spots and outdoor activities (Figure 7C). Beautiful landscape and social interaction were also quite well mapped, with 7 and 6 points respectively. Feelings and thoughts as well as special place totalized a number of four points, environment regulating capacities and appreciation of nature three and simple existence one. No points were mapped for local products and cultural heritage.

The land category water was mainly assessed for nature and landscape with 13 and 10 points respectively (Figure 7D). Respondents also mapped some places for social gathering (6 points) and few points (1-3) for outdoor activities, feelings and thoughts, cultural heritage, environment regulating capacities, simple existence and special place.

As for the other land cover categories, forest border and isolated and cluster of trees, only six and four points were mapped respectively. Forest borders include two points for simple existence and social interaction and one point for harvesting and appreciation of nature. Isolated trees and cluster had mainly points for harvesting (3) and one for social interaction. Only seven points were mapped in wetlands: two for cultural heritage and one for environment regulating capacities, harvesting, appreciation of nature, landscape and landmark and outdoor activities. In urban areas, in addition to the residences of the respondents, points were in majority mapped for local products. Points were also mapped for cultural heritage (7), social interaction (7), beautiful landmark (5), feelings and thoughts (3), outdoor sports (2), nature (1) and other special place (1).

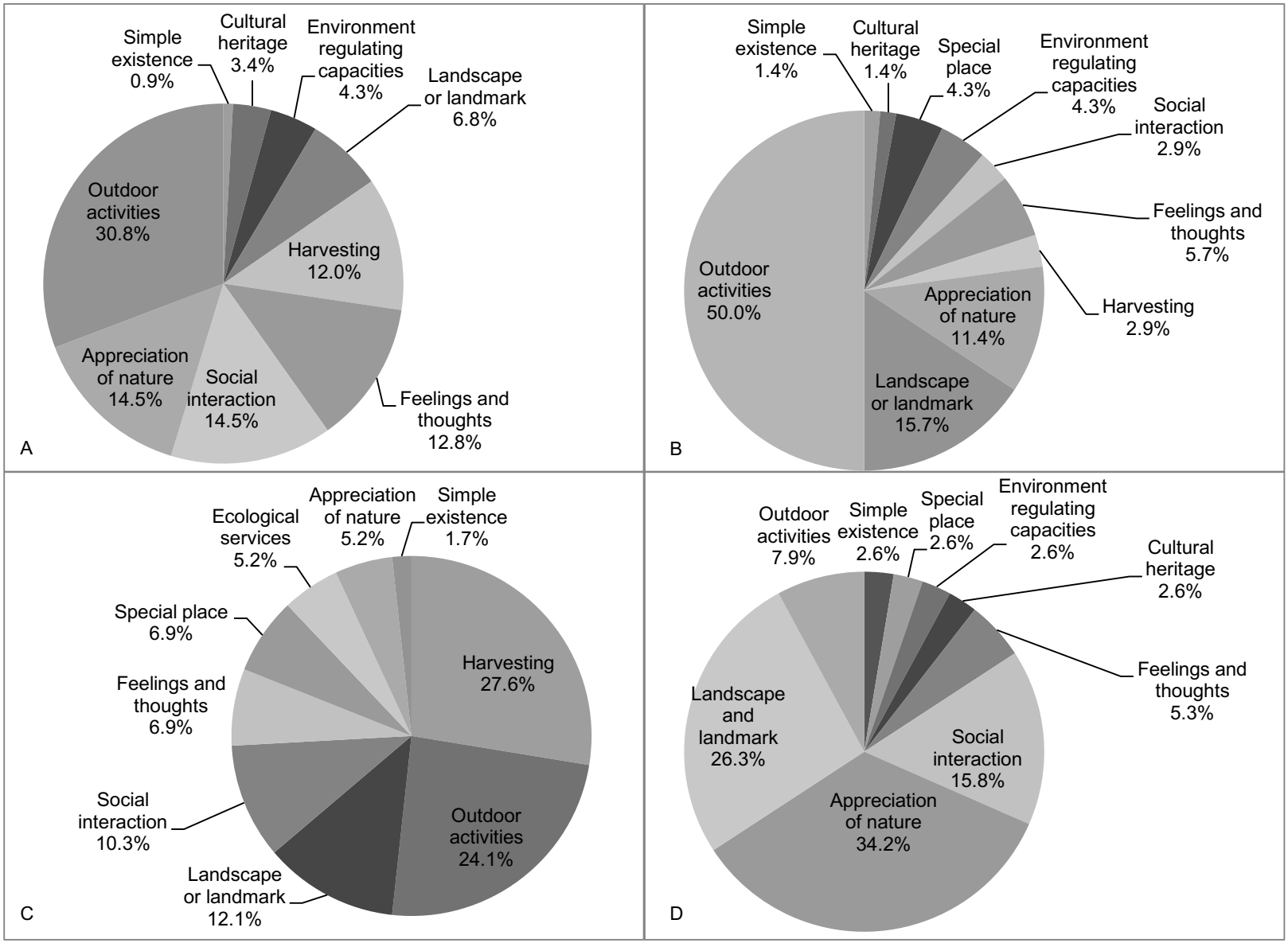

Figure 7: Proportion of ecosystem services indicators mapped in the forest (A), open lands (B), in wooded pastures (C) and in aquatic habitats (D).

3.4. Comparison between wooded pastures, forest and open lands

In general, the forest totalized the highest number of points and was the dominant land category for the majority of the indicators with the exception of harvesting spots and beautiful landscape, which were slightly more represented in wooded pastures and open areas respectively (Figure 8). Also, the number of points for outdoor activities in open areas was very close to the one of the forest and the value of landscape was equally mapped in wooded pastures and the forest. For the value of nature, beautiful landscapes, and outdoor activities, more points were mapped in open lands than in wooded pastures. On the other hand, places for social gatherings and for harvesting wild products were most prevalent in wooded pastures than in open areas. However, social gatherings were still more commonly held in the forest than in wooded pastures.

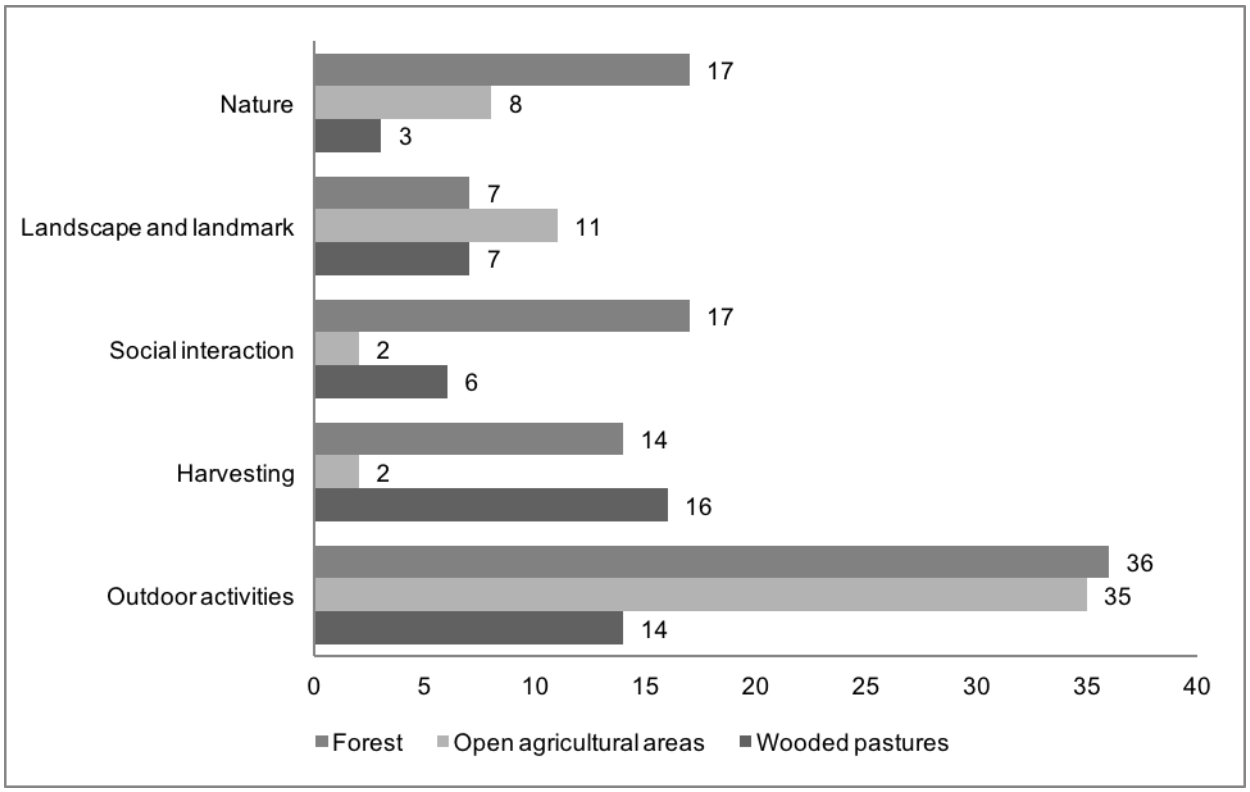

Figure 8 : Number of points of the five most assessed indicators for the three main land cover types.

3.5 Landscape values contributing to subjective well being

The open question at the end of the survey resulted in a list of 27 elements of the landscape which influenced the personal well being of the respondents (Table 7). In general, relationships were more frequently brought up, followed by forms and practices and processes. Tranquility was the most often mentioned. In addition, about 20% also mentioned nature, people's mentality and place attachment. The respondent also showed an appreciation of the climate, the free roaming livestock, the space and the conviviality/friendship. Some elements were only

mentioned once or twice, such as specific elements of the fauna and flora and the conservation of traditional practices.

Table 7: Number and percentage of informants mentioning landscape values categorized as forms, relationships and practices/processes

	Number of informants	Percentage of informants
Forms		
Nature	5	21.7
Trees	3	13.0
Birds	1	4.3
Ponds	1	4.3
Climate	4	17.4
Wooded pastures	1	4.3
Free livestock	4	17.4
Landscape	2	8.7
Diversity of landscapes	2	8.7
Relationships		
Tranquility	7	30.4
Conviviality/Friendship	4	17.4
People's mentality	5	21.7
Relationship with nature	3	13.0
Family	1	4.3
Preserving agriculture	1	4.3
Preserving craftmanship	1	4.3
Way of living	1	4.3
Place attachment	5	21.7
Rural aspect	3	13.0
Stimulation of the five senses	1	4.3
Practices and processes		
Greeness	1	4.3
Clean air	2	8.7
Silence	1	4.3
Space	4	17.4
Agriculture	2	8.7
Quality of life	1	4.3

Discussion

4.1 Methods used

4.1.1.PPGIS

Overall, the PPGIS was a useful method to assess the use and perception of ecosystem services in the landscape, as it was already successfully demonstrated in some other studies (e.g. Fagerholm et al., 2012; Plieninger et al, 2013). Most of the respondents (especially the younger ones) were at ease with the web-based format and could easily find the desired places on the map. However, some points were harder to map than others. Indeed, some of the indicators involved a dynamic activity or a large area, which were challenging to map as static points. This was the case for outdoor activities and beautiful landscape and landmark. Landscapes are rarely composed of a single land cover type but rather of a combination of different ones. Concerning outdoor activities, as most of them involve a travel through the

landscape, mapping several points for one activity (one point for each land cover type) on its path, could give more precise results.

Another point to take into account is the contribution of the facilitator. Often, his or her role was to stimulate the respondent's mind to think about places to map, especially for aspects that were less concrete than, for example, outdoor activities. This stimulation could induce a bias in the way people mapped the places and in which location. At least in this study, there was only one facilitator in charge of the interviews, which means that data collection was usually carried out in a consistent way.

Ringing at doors was a quite successful way to find respondents and resulted in very few refusals. The inhabitants were usually very welcoming. It was harder to find young people (15-29yrs old) and middle-aged (30-59yrs old) as they usually were at school or working during the day. Nevertheless, it was still possible to interview them by scheduling an appointment or by campaigning during the weekend. The 4G Internet connection worked usually well, except in most remote areas and inside some building with very thick walls. In these cases, it was easy to move closer to urban areas or to ask for the respondent's Wi-Fi.

4.1.2 Habitat mapping

The fieldwork on habitat mapping went rather smoothly although going through the LTS was sometimes challenging, as some areas were fenced and hard to access. It was also quite difficult to find the LTS with the orthophotos and delimit them.

Several mappers (four in total) carried out the habitat mapping. This could lead to less homogenous results, as the delineation of the habitats could be quite subjective. The four mappers started mapping together then in pairs in order to standardize the data collection.

The protocol followed was not always adapted to the situation and had to be modified, for instance a number had to be added for the dry-stone walls (123), which are common in the area and represent a remarkable biotope (Jacquat et al., 2009).

The fieldwork was carried out a bit too early in the season and some annual crops could be identified. For this reason, it was necessary to come back few weeks later. However it resulted not being very important for data analysis as the categorization of habitat was revised.

Another problem was that the difference between artificial permanent grasslands and temporary grasslands (part of the rotational plan) was hard to assess on the field. Personal communication from a local farmer led us to think that the rotational grasslands were overrepresented.

Following the AGFORWARD protocol and filling the attribute table, the habitat mapping provided additional information that could be used for further analysis about different ES such as pollination and biodiversity.

4.1.3 Important issues

The original ideas was to analyze the points mapped in the LTS and identify their relationship with the habitats (defined by the habitat mapping) in order to make a comparison of the types of indicators found for the different land cover types. However, most of the points mapped by the informants were not located inside the LTS. Therefore, in order to analyze their relationship to land cover, an overlay of collateral data on land use and land cover was needed and thus a land cover type was attributed to each of the mapped points. The resulting land cover classification may contain some errors, particularly in the differentiation between forest areas and wooded pastures, as the proportion of grazed woodland may have been underestimated (surface area of 965 ha in 2005); some zones mapped as forest should in fact be areas of grazed woodland (type 4000). Maps and data from Geoportail of the canton of Jura (https://geo.jura.ch) could provide more precise information on the spatial distribution of the different kind of wooded pastures.

Another issue was that the habitat classification provided by the AGFORWARD protocol (Appendix A) was not entirely adapted to the data analysis. This can be explained by the fact that the purpose of protocol used was to collect information and data for different aspects of the AGFORWARD project and was not created for the sole purpose of this study. Thus, as explained in the methodology, a simplified classification of the habitats was developed.

4.2 Distribution of the points

Points were mapped for all the indicators, which show a general appreciation of the local community for the three categories of ecosystem services. The results show a better assessment of cultural services and provisioning services, compared to supporting and regulating services. This tendency was also observed in a similar study carried out in Spain by Fagerholm et al. (2016a). However, in the present study one of the supporting/regulating services, the appreciation of nature, was also quite well assessed.

In general, the respondents mapped more easily indicators that represented activities or concrete elements. Indeed, all those classified in the category “doing” (outdoor activities, local products, harvesting and social interaction) were particularly well mapped. Concerning the category “valuing”, the two dominant indicators were beautiful landscape and landmark and the appreciation of nature. Both are quite tangible. The few number of points mapped for simple existence, environment regulating capacities and special place show that the respondents were less inclined to assess these aspects. Their definitions were more abstract and people’s understanding of them more subjective. During the interviews, the respondents expressed their difficulties to map such aspects.

Points for outdoor activities were particularly numerous and this shows that such practices are quite common for local people. This result is not a surprise as the importance of recreational

services has been observed in other similar studies (Fagerholm et al. 2016a, Plieninger et al., 2013). This result was also observed in the survey study by Miéville-Ott and Barbezat (2005), in which respondents mentioned their appreciation of the wooded pastures for practicing outdoor sports. Furthermore, the majority of the informants self-estimated to have a good knowledge of the region, meaning that they have been and have walked/run/hiked/cycled in several areas.

People also showed a strong appreciation for provisioning services, especially for places to produce and buy local products. The difference of number of points between the two indicators of this service may be explained by the fact that harvesting wild products is more considered a hobby than a necessity. Indeed, in this region, food is very accessible and easily found in local and farm shops and people do not need to collect it from the wild. Nevertheless, the results of Fagerholm et al. (2016a) show slightly more mapped points for harvested products than for farm products.

Social interaction is important for the local people; a high number of points were mapped as sites to hold gatherings. To confirm this tendency, the respondents often mentioned their appreciation of the local people's mentality and the importance of human relationship.

The reason why beautiful landmarks were less mapped than beautiful landscapes lies in the fact that the Franches-Montagnes is a rural region and is mainly known for its typical landscapes.

So far the results of this study were quite similar to the ones of Fagerholm et al. (2016a). One of the differences lies in the fact that the appreciation of a nature totaled a relatively high amount of points.

4.3 Habitat composition of the LTS and the points mapped in them

The results of the habitat mapping reflect the mosaic structure of the landscape, typical of the area. Indeed, the LTS were composed of a quite high number of parcels (between 31 and 92) representing several habitat types.

The LTS chosen were quite representative of their main habitat type (AF, nAF and F). Figure 8 shows that the majority of the surface is covered by agroforestry, croplands and grasslands and forest respectively.

When we compare the results of the habitat mapping of the LTS with the Swiss land use statistics (NOAS04) of the district of the Franches-Montagnes, some differences in the proportion of the habitat types are visible. For example, (semi-) natural grasslands cover only 2.0% (24 ha) of the total surface of the LTS and yet in the region in general they cover 4'991 ha, corresponding to 24.9% of the total surface area of the Franches-Montagnes. On the other hand, annual herbaceous crops cover a total surface of 174 ha in the LTS (14.6%) and only 1081 ha in the entire district of the Franches-Montagnes (5.4% of the total surface area). These differences can simply be explained by the heterogeneous distribution of the different habitats in the landscape, but it could also show that natural grasslands and croplands may be respectively

under- and overrepresented in the LTS. This result may come from misidentification during the field mapping, as it can be difficult to differentiate semi-natural grasslands from artificial permanent grasslands and artificial permanent grasslands from artificial grasslands which are part of the rotational plan. However, this potential error did not interfere too much with the analysis of the PPGIS points and their relationship to land cover, as these habitats were all categorized under open lands. Concerning agroforestry elements, it is hard to compare the results of the habitat mapping with NOAS04 nomenclature, as the latter does not include a class for wooded pastures. The important presence of dry-stones walls is easily explicable are these structures are very typical of the region (Jacquat et al., 2009).

The small amount of points mapped inside the LTS, makes it difficult to draw any conclusion. A tendency showed that people potentially appreciate more agroforestry and forest areas than open agricultural areas. However, the results for the F LTS show that the appreciation of a specific land cover type actually varies a lot according to the location of the place. The popularity of the F LTS 207 is that it is close to the village of Muriaux and comprises the "Rochers des Sommêtres" a rocky ridge overlooking the village of the Noirmont. The edge holds a refuge accessible to the hikers and the place is quite popular with the tourists.

The information collected during the habitat mapping could be used for further research. For example, the presence of rocks, bare ground and dead wooded was reported. These features are typical habitats of many invertebrate species and thus such information could be useful to study biodiversity. Also, for the herbaceous layer, the cover of grass, herbs and legumes was recorded. This could be used to calculate the potential for pollination service. These analysis will be, to some extent, carried out as part as the AGFORWARD project.

4.4 Spatial location of the points and their relation to land cover

All of the principal land cover types (forest, open lands, wooded pastures and urban areas) were quite well represented. Urban areas totalized a relatively high number of points and some categories were directly related to urban zones. Indeed, points for the provision of farm products were exclusively mapped in these areas, as they indicated local or farm shops and home gardens. Also sites of beautiful landmarks were related to buildings and monuments (e.g. church) and thus were mapped in urban areas. Overall, the forest seems to be the dominant location to practice most of the activities, followed by open lands. This tendency could be explained by the presence of many country roads and hiking paths in the forest and along the main roads near fields and open pastures. Water spots were also quite popular with local people. This tendency has also been observed in the study of Brown (2013), which shows that many ecosystem services values were related to water bodies. In addition, other studies have highlighted the attractiveness of water spots in a landscape (e.g. Dramstad et al. 2006,

Kaltenborn and Bjerke 2002). Many ecosystem indicators were also mapped in wooded pastures, which showed that the local people enjoy this typical feature of their region.
As explained in the first part of the discussion, some indicators were hard to map as a single point as they usually involved more than one land cover types. For this reason, there may have over- and under representation of some land cover categories as the points mapped could only represent a single land cover. This was especially the case for outdoor activities and beautiful landscapes. Indeed the points for such activities and values were usually mapped at the center of the activity on the most representative land cover type, and thus, other areas were the activity might also take place were excluded.
A bias was also observed for mapping beautiful landscapes. A landscape is usually a large area, which often includes a variety of features and represents a combination of different land covers. Thus, a point can hardly be representative of an entire landscape. This may have led to underrepresentation of certain land cover types. Respondents also struggled with this task and often emitted the opinion (including in the open question about how the landscape contributes to their personal well-being) that what they liked in a landscape was its heterogeneity. This reinforces the idea that heterogeneous landscapes are more attractive to people.

4.5 The contribution of the landscape to subjective well-being

The results on the assessment of the contribution of the landscape to human well-being, were quite similar to the results obtained by Fagerholm et al. (2016a). Indeed, relationships were often mentioned, especially tranquility. Also, it seems like the people are quite attached to the place itself (the village, their house, the inhabitants) and that the social aspect contributes greatly to their well-being, as people frequently mentioned the importance of people's mentality and conviviality. Nature was also often mentioned and specific aspects of it were sometimes brought up. It is interesting to note that the appreciation of seeing the livestock roam (more or less) freely in the landscape was mentioned several times. Together with the diversity of landscapes, they represent typical traits of the region. Because of the small number of informants, it is hard to draw any conclusion, however it seems like the openness (space) and the structure of the landscape (landscape, landscape diversity), as well as human interaction are especially important for the people's well-being.

4.6 The role of the wooded pastures

One of the hypotheses of this study was that wooded pastures played an important role in providing ecosystem services. This cannot be denied, as almost all of the ES indicators were present in the wooded pastures. The two missing indicators were provision of local products and cultural heritage. The absence of the first one is easily explainable as this indicator was exclusively mapped in urban areas (as shops and home gardens). However, it is more

surprising that none of the respondents regarded the wooded pastures as a part of the history or the culture of the region. Indeed, because of their long history, the wooded pastures are considered as an emblematic symbol of the region. An explanation could lie in the fact the respondents usually associated history and culture with old monuments, which explains that most of the points (41%) were mapped in urban areas. As for the other indicators, their mapping intensity was usually not higher than in other land cover categories (such as forest and open lands). One exception was for harvesting spots, which were most prevalent in wooded pastures. This could be explained, by the presence of many kinds of edible mushrooms, such as boletus and agarics and berry-bearing bushed, such as *Vaccinium myrtillis*, *Rubus fructicosus* and *Rosa canina* in wooded pastures (Freléchoux, 2003; Gallandat et al., 1995). Although, many kinds of mushrooms and berries can be found in the forest, their accessibility may be facilitated in the wooded pastures. Some answers to the question about well-being reinforce the idea that the wooded pastures provide many cultural services and contribute to people's well being. Indeed, four of the respondents mentioned the appreciation of seeing the livestock move freely in the nature and another informant even mentioned the wooded pastures themselves.

Overall, it seems that the wooded pastures hold an important role in the provision of ecosystem services but not more important than other surrounding artificial or semi-natural habitats.

Conclusion

The region of the Franches-Montagnes provides many ecosystem services (ES), including cultural, provisioning, and regulating/supporting services. The PPGIS method was a successful way to visualize how people interact with their environment by mapping indicators of these ecosystem services. The use of the LTS to determine the relationships between the habitat types and the ES indicators, didn't allow to obtain enough results. However, it could suggest that the appreciation of a habitat in influence by its special location and special features. The relationships between the points and the land cover were successfully assessed by using an overlay of correlated data on the points mapped. The results show that the ES indicators were found in diverse habitat types, mainly in forest, urban areas, open lands, wooded pastures and near water spots. Although, many indicators were found in wooded pastures, they do not seem to hold any specific importance in providing ecosystem services compared to other land cover types.

The region of Les Franches-Montagnes also provides additional benefits to the inhabitants of Muriaux which were not assessed during the mapping task of the PPGIS. Indeed, people seem to hold a particular attachment to social relationships between the inhabitants, as well as to the openness and the structure of the landscape and its tranquility.

Given the number of data collected with the PPGIS surveys and the small proportion of the population assessed, it is hard to draw any conclusions on how the people of the Franches-Montagnes perceive the provision of ecosystem services in their region. However, the results of this study show a tendency on how they use and value of the landscape. Thus, this master thesis could represent a first step in the analysis of the perception of ecosystem services in the region of Les Franches-Montagnes. Indeed, additional data from PPGIS interviews will be collected in the remaining municipalities selected for the AGFORWARD project (Le Noirmont, Les Breuleux and La Chaux-des-Breuleux) and the results of the analysis could be compared to the tendencies observed in this study.

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Appendices

Appendix A. Documents used for the fieldwork on habitat mapping adapted from Szerencsits et al. (unpublished).

Table A1. Habitat definitions and codes for the map attribute table

Habitat type	Definition	Habitat
1. Semi-natural habitat (SNH)		
WA: woody **areal** elements	any type of natural or semi-natural areal structure, including abandoned fields, with more than 30% shrub/tree canopy cover.	101
WL: woody **linear** elements	any type of semi-natural linear structure with more than 30% tree/shrub canopy cover. If the WL are part of the AF system (e.g. bocage), the hedgerows are mapped according another table.	102
HA: herbaceous **areal** elements	areal structure with less than 30% shrub/tree canopy cover which falls into one of these categories: - Fields abandoned or set aside. - Semi-natural grassland: low input. [permanent, no or low fertiliser input, max. 2 times mowing /year] - Herbaceous vegetation can be sown for environmental protection or biodiversity promotion (flower or grass mixtures).	103
HL: herbaceous **linear** elements	linear element with less than 30% tree/shrub cover; herbaceous strip. Herbaceous vegetation can also be sown (flower or grass mixtures).	104
AF areas with closed tree canopy	AF with closed tree canopy; e.g. grazing in closed forest,	105
FA: Temporary in-field SNH, **areal**	fallow, cover crops, not-marketable intercrops as long as the management categorized as “relatively undisturbed”	121
IP: Inert Ground	E.g., Rock, Gravel	122
Dry-stones walls		123
2. Forest	Forest (Intensive, non-agroforestry, introduced species)	201
3. Woody crops		
Vitis vinifera	Vine	301
Olea europea	Olive	302
Chestnut	Maroni	303
Prunus avium	Cherry	311
Prunus amygdalus	Apricot	312
Prunus persica	Peach/Nectarine	313
Prunus domestica	Prune plum	314
Prunus amygdalus	Almond	315
Malus spp.	Apple	316
Pyrus spp.	Pear	317
Citrus spp.	Citrus fruit	318
Juglans spp.	Walnut	321
Corylus avellana	Hazelnut	322
Pistacia sativa	Pistachio nut	331
Quercus ilex	Holm Oak	341
Quercus suber	Cork Oak	342
Quercus robur	Pedunculate Oak (English Oak)	343
Quercus spec.	other Oak species	344
Abies alba	Silver fir	351
Picea abies	Norway spruce	352
Pinus spp.	Pine species	353
Opuntia spp.	Prickly pear	354
Other non-AF-tree		355
4. Annual herbaceous crops		
Cultivated Bare Ground	unclear which crop but not fallow	401
Cover crop	Intermediate crop (will not be harvested)	402
Flowers		403
Orysa sativa	Rice	404
Triticum aestivum & associated sp.	Wheat	411
Hordeum sativum	Barley	412
Avena sativa	Oats	413

Secale cereale	Rye	414
Triticale	Hybrids between wheat & rye	415
Commercial horticulture	Vegetables	421
Zea mays	Maize	422
Beta oleracea	Sugar beet	423
Solanum tuberosum	Potato	424
Cucurbita sp.	Pumpkin (all types)	425
Helianthus annuus	Sunflower	426
Vicia faba	Field beans	427
Pisum spp	Peas (all types)	428
Brassica hybrid	Oilseed rape	429
Rotational (artificial) grassland	Seed < 5 years old	441
Fabaceae (Medicago, Trifolium)	Clover species (Legume)	442
Brassica sp.	Rape (Forage)	442
Forage crop.	Other forage crops	449
5. Perennial herbaceous crops		
Permanent grassland, intensive	(NOT SNH) >= 3 use cycles/year, frequently fertilised	501
Asparagus sp.	Asparagus	502
Permanent grassland, med. int.	(NOT SNH) 2-3 use cycles/year,	503
6. Urban areas	Classify traffic areas (inside settlements)	
Built up areas	Houses incl. gardens, parks	601
Traffic areas	Roads, railway lines	602
7. Open water		
Standing water	lakes, ponds	701
Running water	rivers, streams, canals, ditches, >1m wide	702

Table A2. Grazing animal species

Cow/Cattle	801
Pig	802
Sheep	803
Goat	804
Horse	806
Chicken	807

Table A3. Grassmanagement

1	Mown
2	Grazed
3	Mixed
4	Mulch

Table A4. WoodStru

1	> 80 % shrub cover	Trees < 2 m height are counted as shrubs
2	> 80 % tree cover	
3	shrubs and trees	

Table A5. WoodClass

1	Winter deciduous / in summer green
3	Coniferous
4	Non-leafy evergreen
6	Combinations

Table A6. WoodDead / Veteran Tree

1	Yes
2	No

Table A7. WoodReg

1	tree regeneration visible (age heterogeneity in the tree canopy)
2	most trees of the same age

Table A8. Tree crown diameter classes. (Egg Switzerland, to be specifically defined for each case study region)

Semi-standard tree (crown diameter < 2m)	901
Young standard tree (crown diameter < 5m)	902
Adult standard tree (crown diameter > 5m	903
Dead standard tree (dead tree still standing)	904

Table A9. Extract of the recording sheet

	All		Woody habitats * and ***					Grassland ** and ***				Grass and SNH	
Habitat Nr	Habitat	AF Hab	Wood Hgt	Wood Stru	Wood Class	Wood Dead	Wood Reg	Gra Manag	Gra Grass	Gra Clover	Gra Herb	Gra Bare	Gra Inert
	habitat type (Tab 5)	Af Habitat 1=yes, 2=no	mean height upper tree layer (m)	1= >80%shrub cover, 2= >80%tree cover, 3=mixed	1=winter decidous, 2=evergreen, 3=coniferous, 6=mixed	high biodiversity wood or standing dead wood 1=yes, 2=no	1= tree regeneration visible, 2= most trees of the same age	1= mown, 2= grazed, 3= mixed, 4= mulch	grass % cover	clover (legumes) % cover	herbs % cover	% bare ground	% inert ground, rocks, gravel
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													

Appendix B. Simplified habitat classification with code used in the text and corresponding codes to the classification used during the habitat mapping

Habitat type	Code	Corresponding code
Semi-natural habitat	**SNH**	
Woody elements	WA	101, 102
Herbaceous elements	HA	103, 104
Agroforestry elements	AFE	*All habitats described as AF*
Dry-stone walls	DSW	123
Artificial habitats		
Annual herbaceous crops	AHC	401-449
Permanent grasslands	PG	501, 503
Urban areas	**UA**	**601,602**
Aquatic habitats	**AQH**	**701, 702**

Appendix C. Additional information on the informants

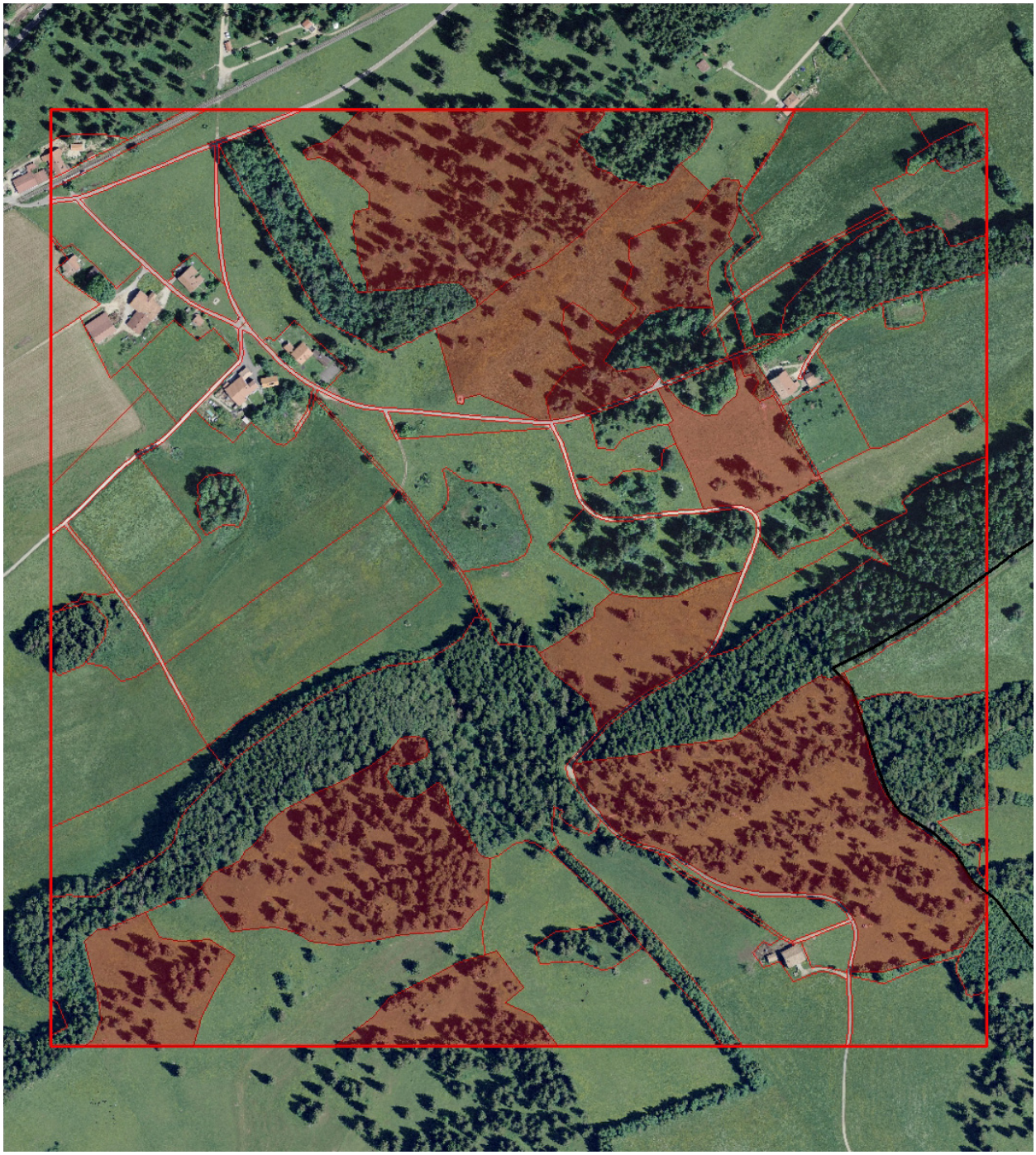
	n	%
Gender		
Female	11	47.8
Male	12	52.2
	23	100.0
Age category		
>60	8	34.8
15-29	5	21.7
30-59	10	43.5
	23	100.0
Relationship with area		
I live here full time	23	100.0
Number of years of residence		
1-5	3	13.0
11-15	1	4.3
16-20	5	21.7
21-25	1	4.3
31-35	2	8.7
36-40	1	4.3
41-45	3	13.0
46-50	3	13.0
51-55	1	4.3
6-10	1	4.3
61-65	1	4.3
66-70	1	4.3
	23	100.0
Self estimated knowledge of the region		
Extremely well	9	39.1
Quite well	11	47.8
Quite poorly	3	13.0
Extremely poorly	0	0.0
	23	100.0
Land owners		
No	12	52.2
Yes	11	47.8
	23	100.0
Purpose of ownership		
Farming	3	20.0
Residential	6	40.0
Leisure	3	20.0
Business	3	20.0
	15	100.0
Houshold size		
1	6	26.1

(continued)

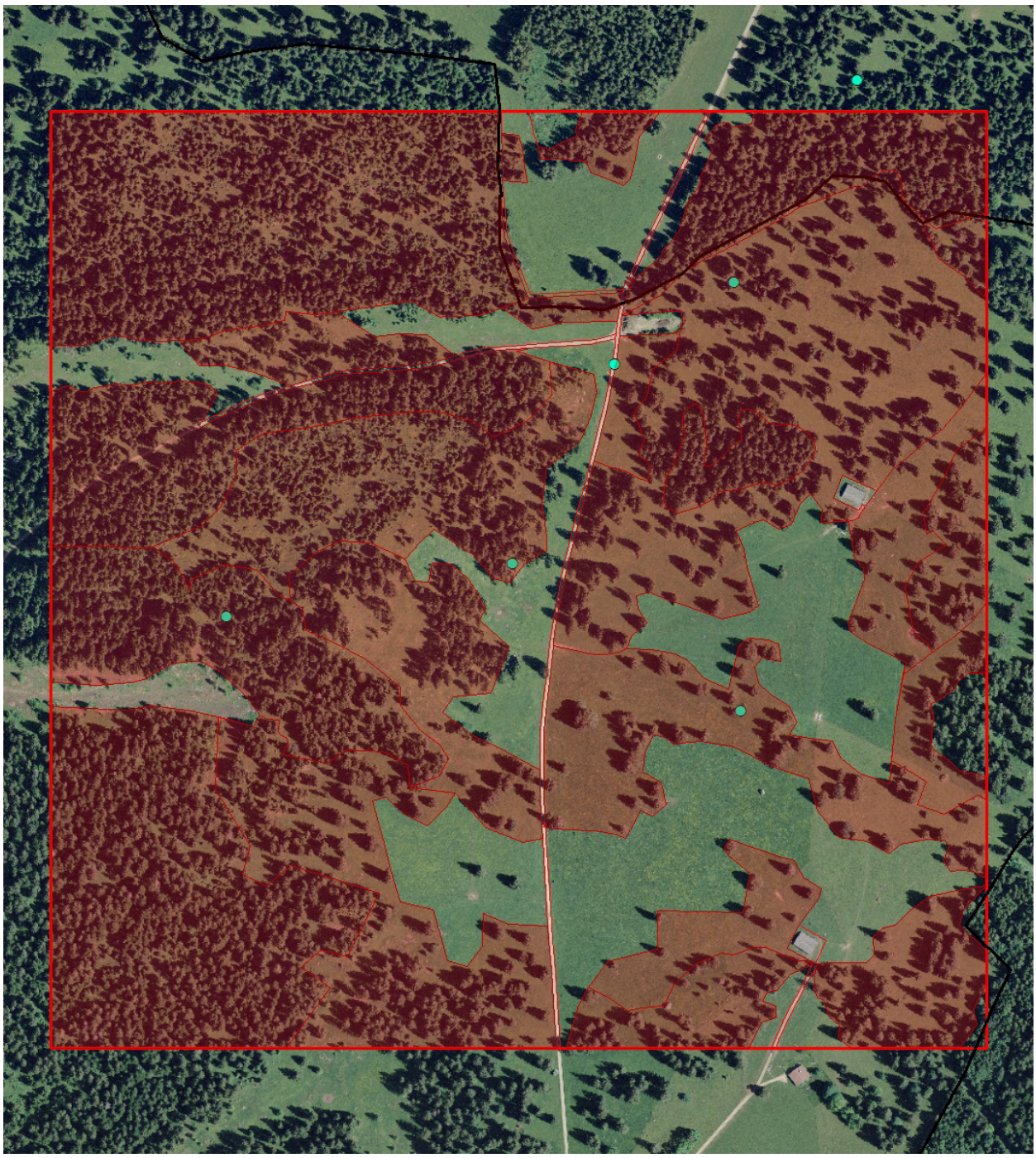
2	7	30.4
3	2	8.7
4	1	4.3
5	5	21.7
6	1	4.3
7	1	4.3
	23	100.0
Children in household		
0	16	69.6
1	1	4.3
2	5	21.7
3	1	4.3
	23	100.0
Level of education		
Higher university degree	2	9.1
Polytechnic or lower university degree	2	9.1
Primary or secondary school	3	13.6
Upper secondary school / college	1	4.5
Vocational training	14	63.6
	22	100.0
Main occupation		
Work in relation to agriculture or forestry	5	21.7
Others	18	78.3
	23	100.0
Household annual income		
Less than 62'000 CHF	13	72.2
More than 62'000 CHF	5	27.8
	18	100.0

Appendix D. Additional images of the results of the habitat mapping of the LTS

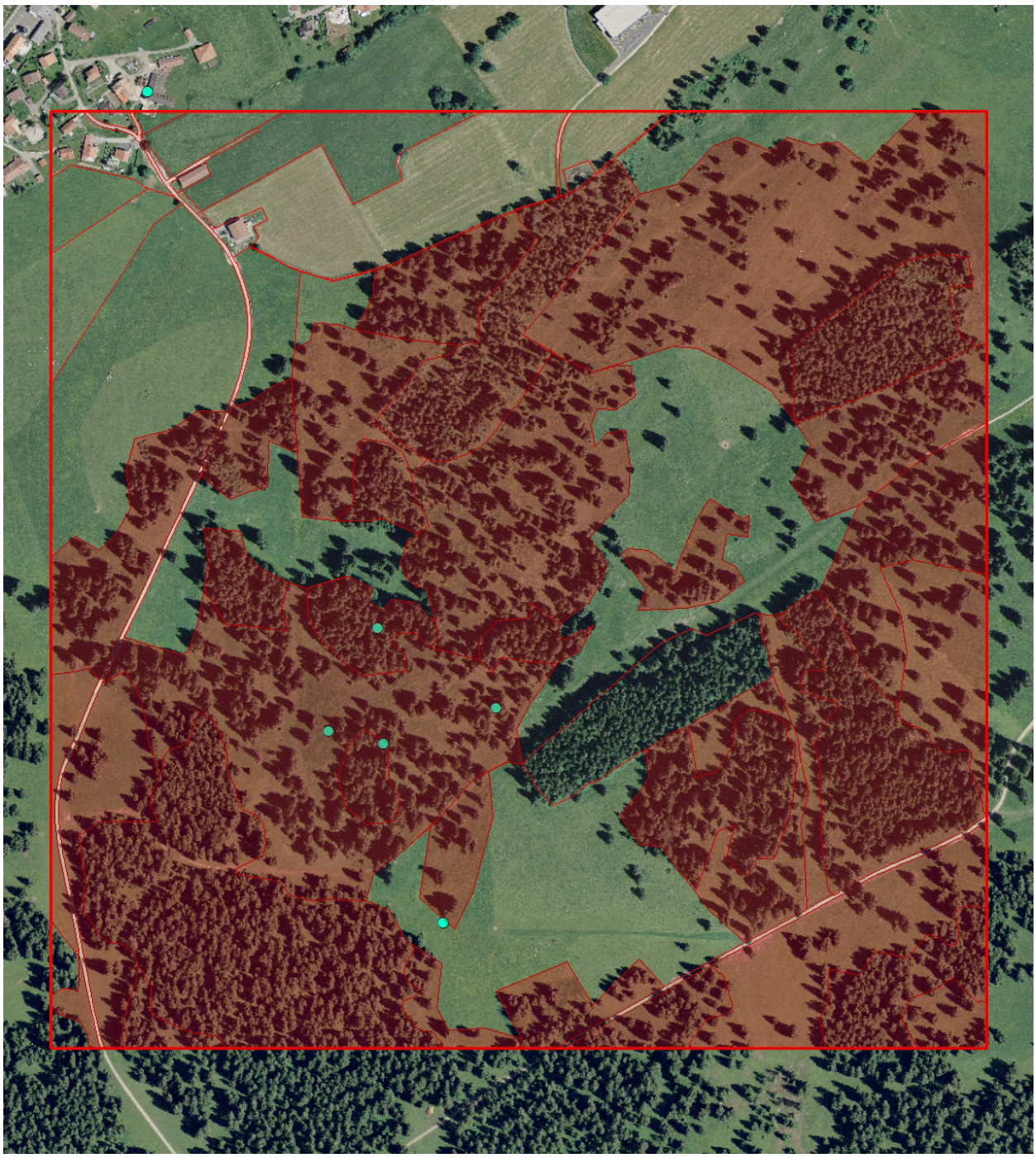
Appendix D1. Habitat mapping of AF LTS



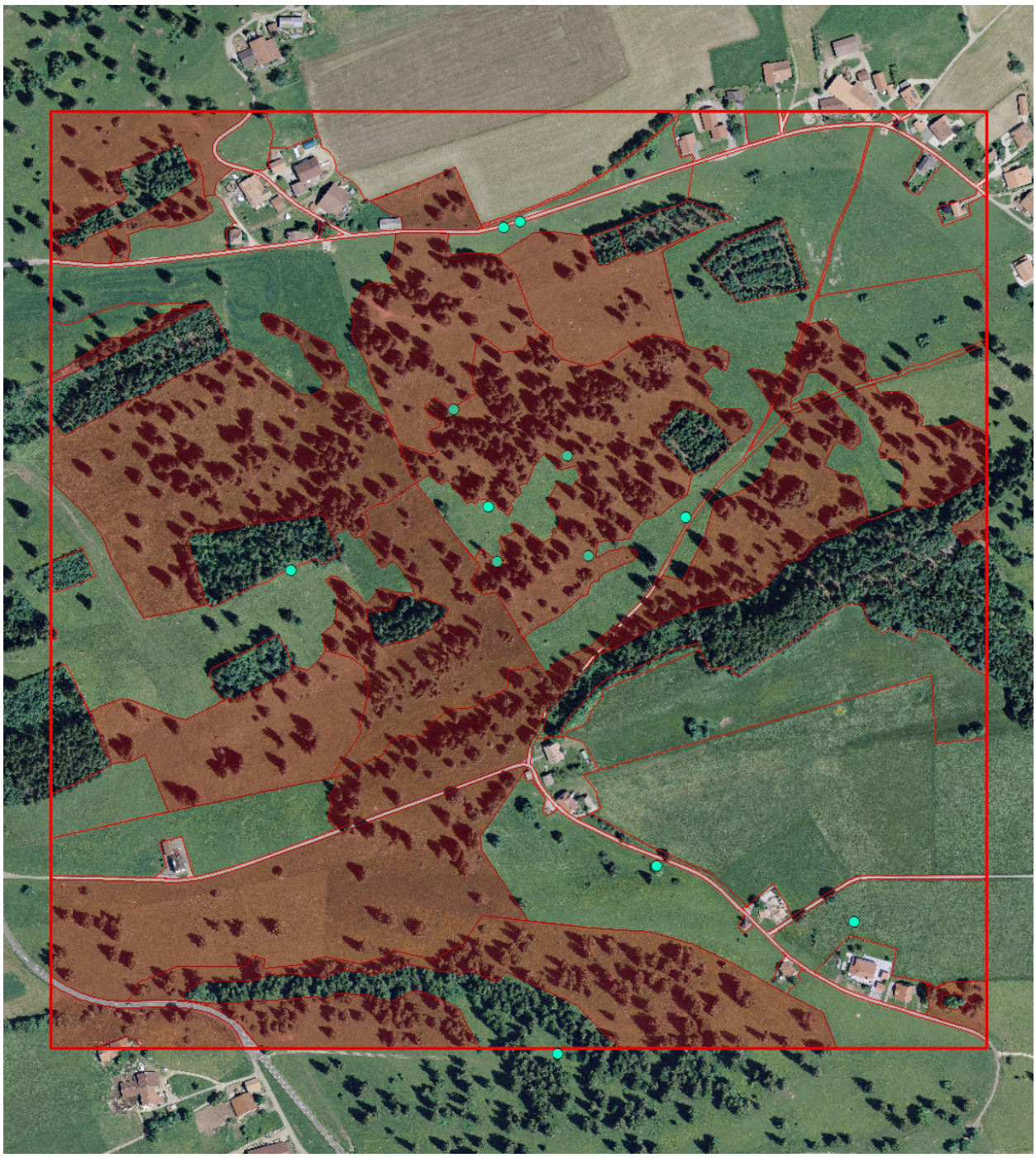
Map 1: LTS n°201



Map 2: LTS n°204

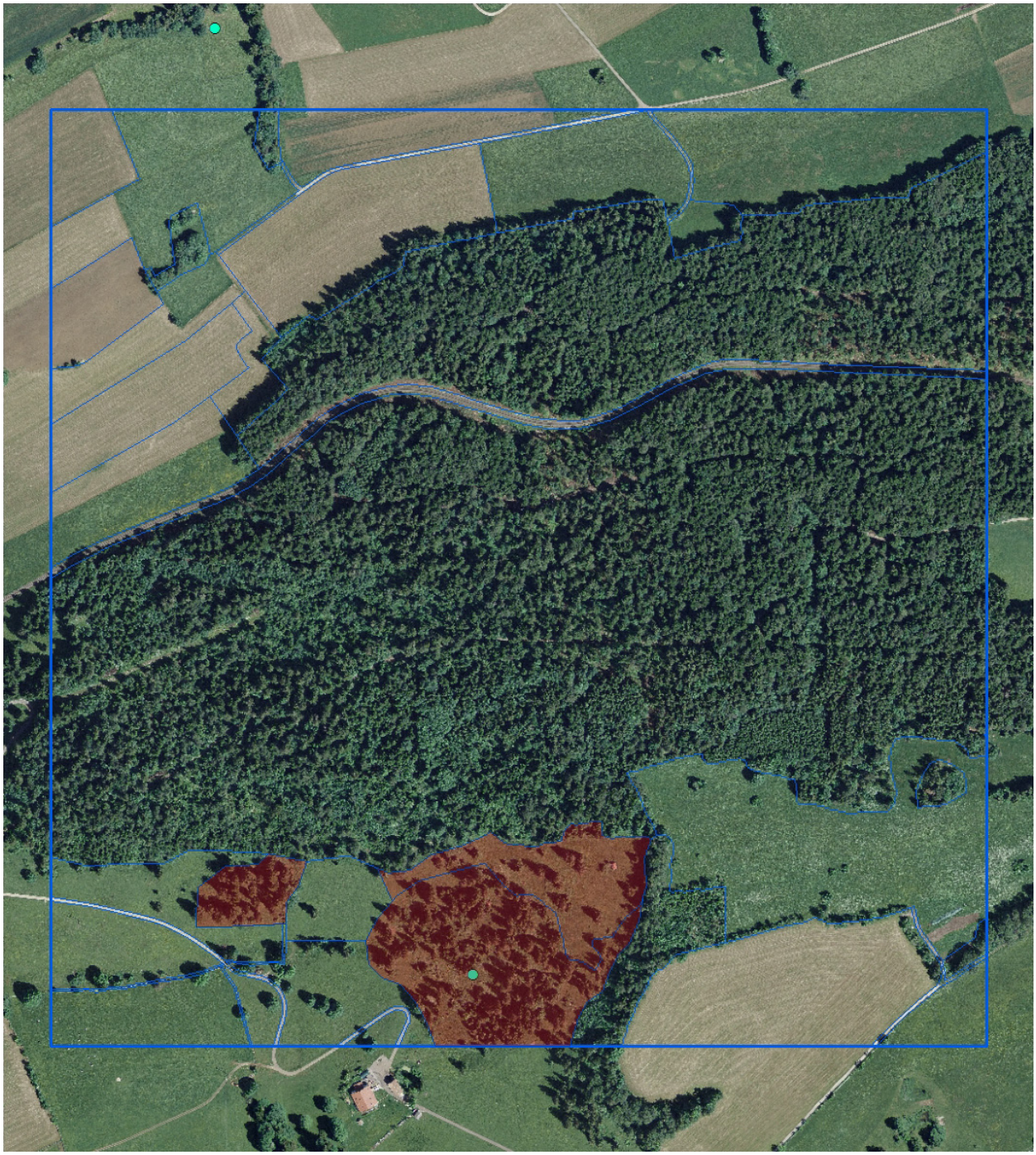


Map 3: LTS n°205

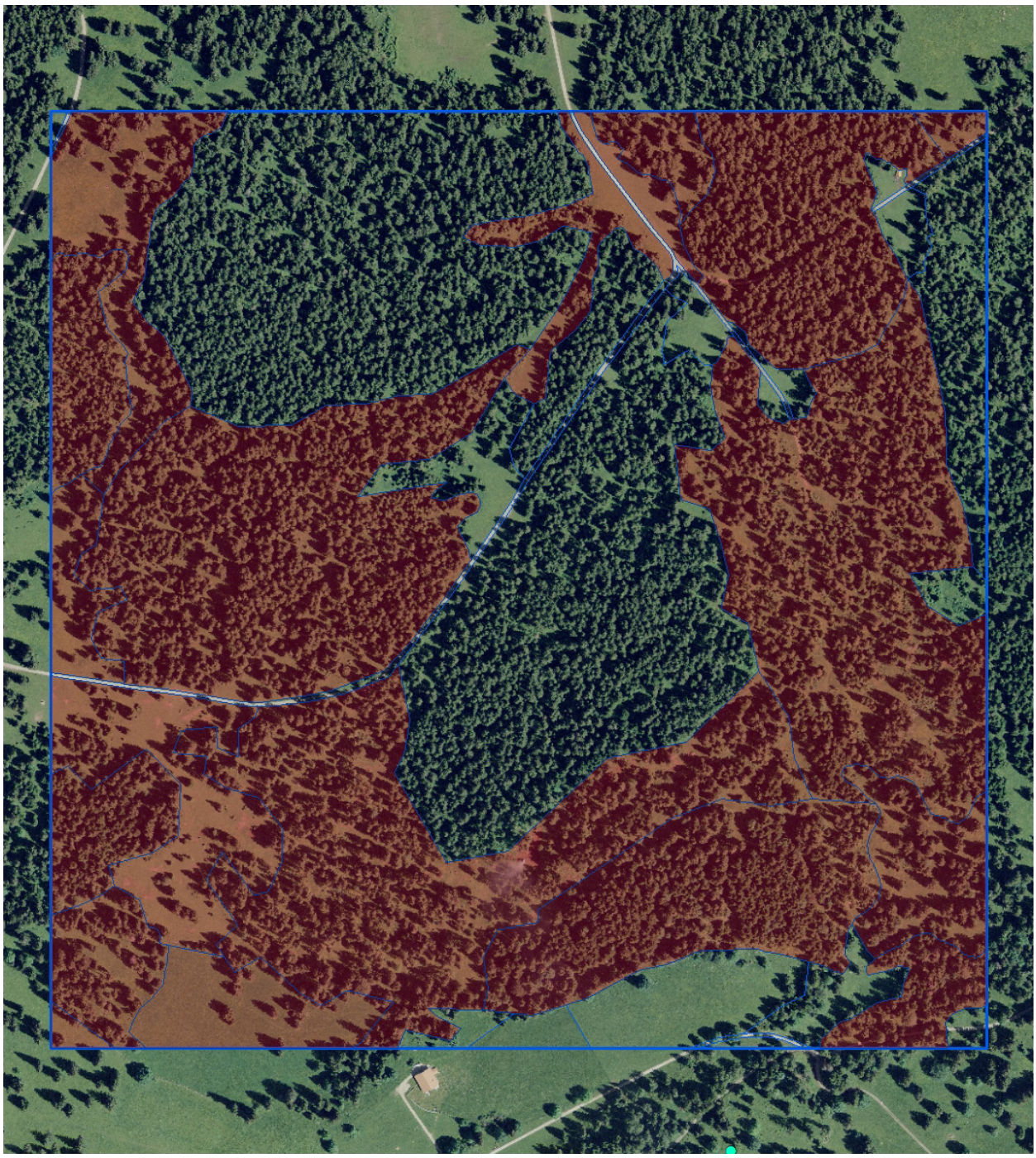


Map 4: LTS n°211

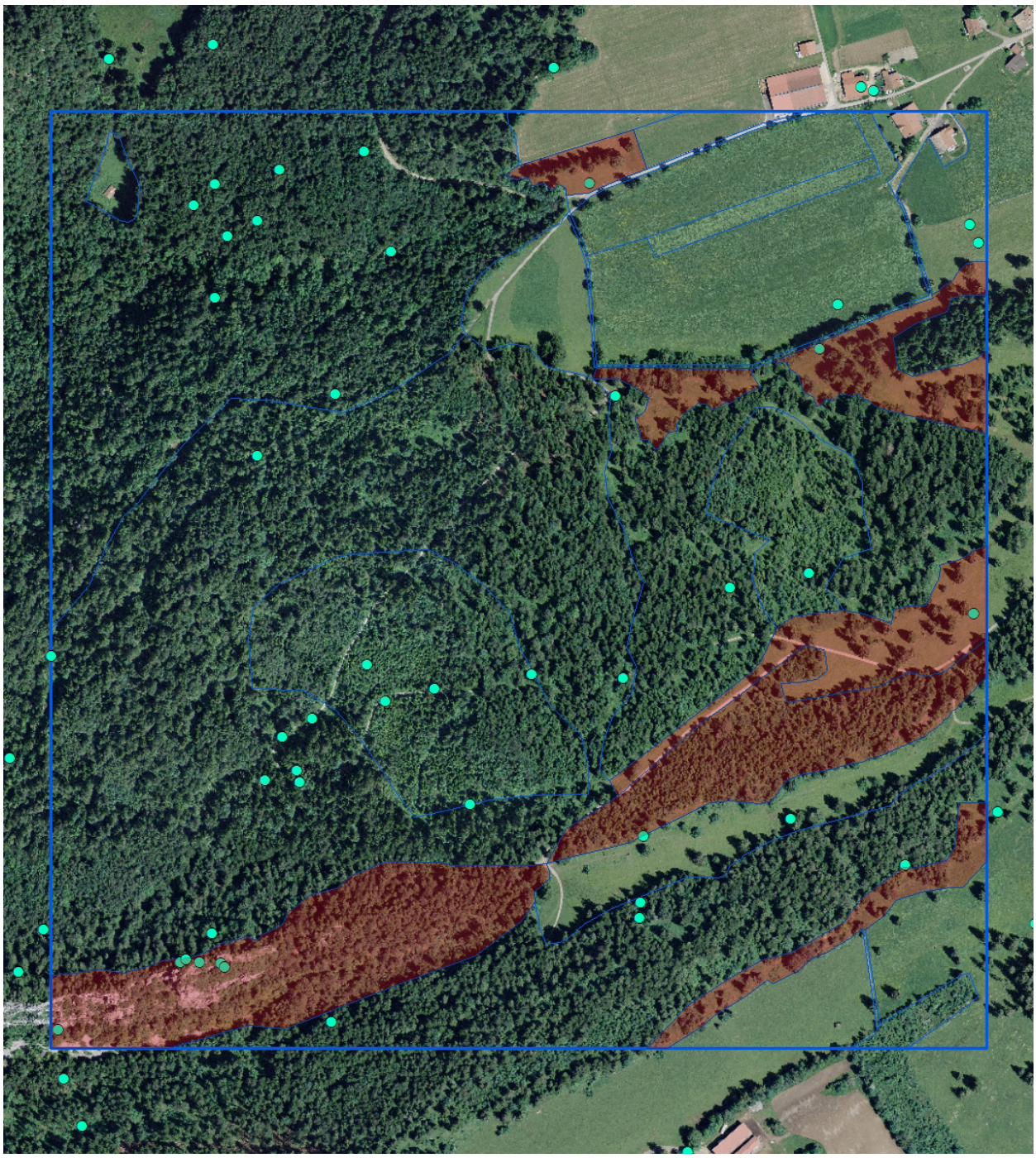
Appendix D2. Habitat mapping of F LTS



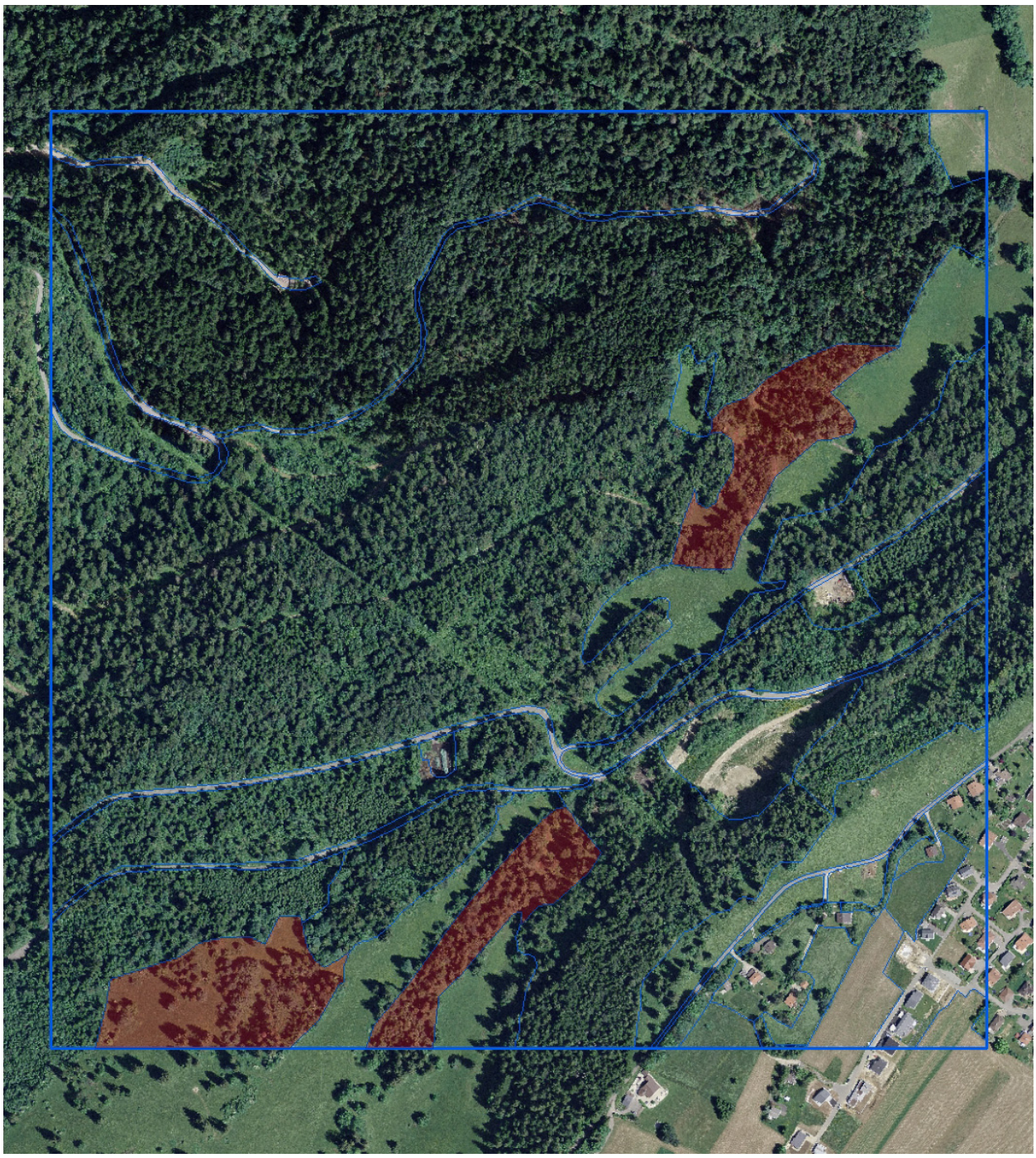
Map 5: LTS n°202



Map 6: LTS n°203

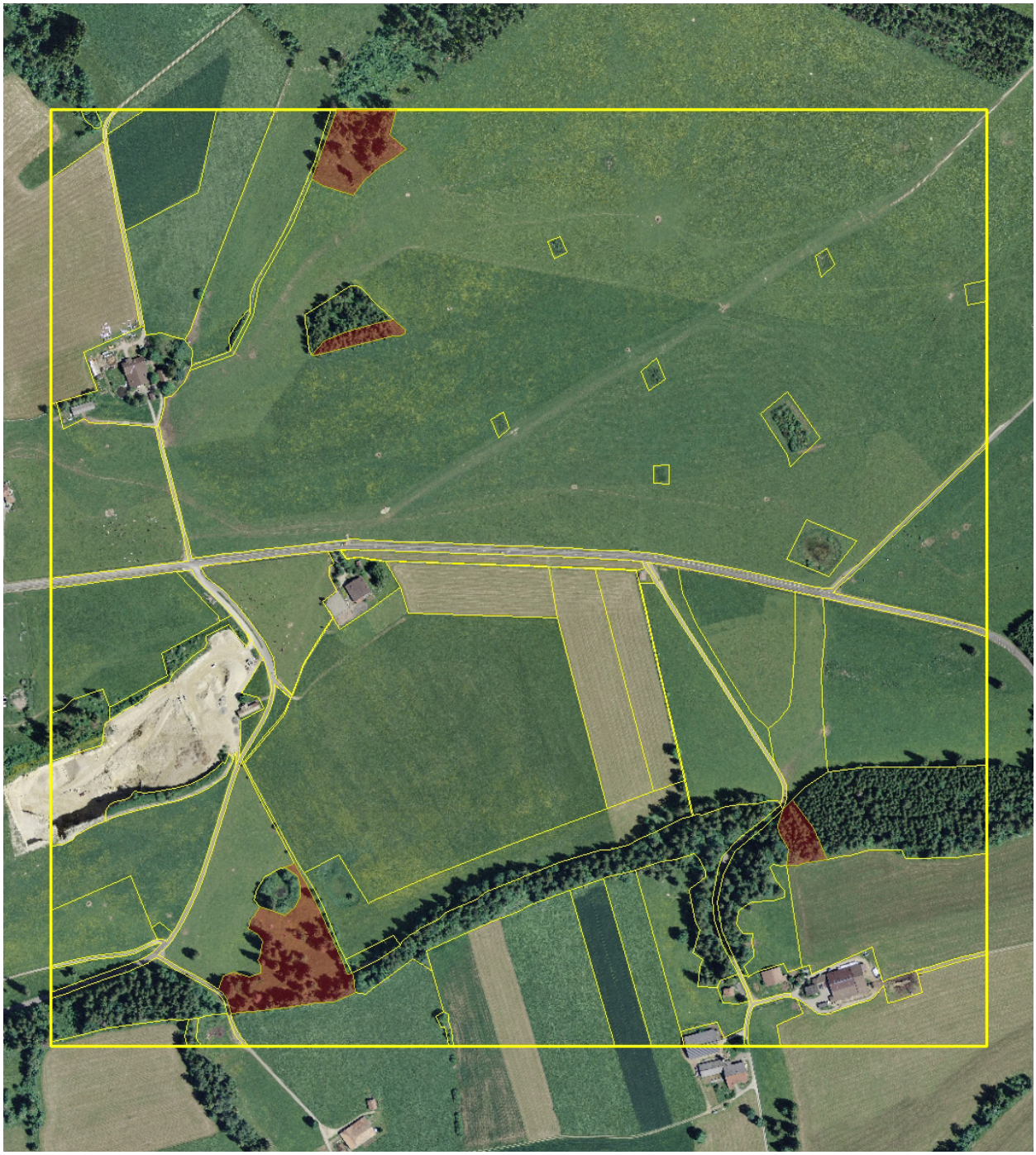


Map 7: LTS n°207



Map 8: LTS n°212

Appendix D1. Habitat mapping of AF LTS

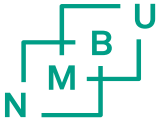


Map 9: LTS n°206

Map 10: LTS n°208

Map 11: LTS n°209

Map 12: LTS n°210



Norwegian University
of Life Sciences

Postboks 5003
NO-1432 Ås, Norway
+47 67 23 00 00
www.nmbu.no