Orienteering and environment.
Consideration of the stakes, modelling of the spatial and temporal influence of an event and ground marking follow-up: back to the 2011 World Orienteering Championships in the Bauges Natural Regional Park (Savoie, France).

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Key words

Abstract
As an archetypal activity of "off-piste" sport, the practice of orienteering may cause impacts on the environment. The purpose is to bring a new experience feedback further to the public races during the 2011 World Orienteering Championship in Savoie. Three elements are approached: i) the steps realized before and during the event for the consideration of the ecological stakes, ii) the modelling, on the basis of the data of this event, the influence of an orienteering race event race on the ground relating to its duration and to the space, and iii) the results of the observation of the evolution of tracks left by the participants on the ground during the 3 years which followed. Results show that during an orienteering event we see less than half of the participants at the same time on the race ground, half of the runners on half of the map, with half of their route spent on paths. This work contributes to show the good environmental results shown in some previous studies, linked firstly to the actions and to the supervision of the practice, secondly to its intrinsic characteristics.

INTRODUCTION
Orienteering consists of checking through compulsory control points by chosen routes using a large-scale map (usually 1/10 000 scale). This practice had its origin in Scandinavia in the 19th century as military exercise; in the competition form, it appeared in Sweden in 1919. The sport was recognized by the IOC in 1977 and its rules are governed by an international federation (IOF). But orienteering is not a registered trademark and the activity is very widespread in countryside activities involving navigation. Most people associate it with untimed practices with maps.

Competitive orienteering is practised on a big variety of terrains. The most attractive are the ones that are the most complex for the competitors but these are often those with aesthetic and heritage value for public leisure. Such strong landscaped, heritage, touristic and ecological areas often have protected status.

Questionings and review of the knowledge
As an archetypal activity of "off-piste" sport, the practice of orienteering may cause impacts on the environments and on the animal and vegetable species (disturbance, damage to animal lairs, trampling of vegetation). Besides the global impacts inherent in all the natural activities and to the mass events (CO\(_2\) emissions, sorting of waste), the stakes concern the ecological impacts in the race areas. In terms of impact, we distinguish between damage (visible deteriorations of the flora, immediate or deferred) and disturbance (of the fauna), more complex to study (they are not harmful for an animal which goes away, but are in the case of nuisances connected with the movement or of destruction of a nest for example).

The first debates appear in 1987 in the New Forest National Park (UK) between persons practising orienteering and The New Forest Group (Parker, 2010). This debate, biased by the will of the NFG to
divert the attention to maintain the deer hunting by horse, was based on no proof from each of the parts, but had the advantage to raise the question, to launch the reflections within federations and to publish some studies (Parker, 2005a,b).

These studies, very few, approach the various aspects of the impacts on the environment. Regarding the space use, Laininen (1999) shows in Finland that, on approximately 5000 races organized on 1000 different sites, the average surface used is 400000 ha (that is to say 1.7% of the forest surface). By basing itself on the major event (Jukola, 13000 participants), the real surface for which tracks are observed after the competition represents 0.5% of the race area (tracks which disappear in 1 to 3 years).

The impacts on the vegetation and on the grounds are linked to the trampling and to the edaphic changes, in particular in the control zone. It is admitted in ecology that the environment resists in the short term to limited damages (fire, flood, occasional passing by), that the damaged flora quickly recover (1 season growth, sometimes 3). The ecologists consider that there is damage when the duration of “healing” exceeds 10 years. Studies carried out on this aspect stay however on the threshold of 3 years recovery. The visible signs of trampling after the Jukola race (marshes, lichens) concern 0.5% of the ground after the event, 0.1% after 1.5 year (Myllyvirta et al., 1998). Mendoza (2007) shows that after a race in Alberta with 1300 competitors, the damaged vegetation took 3 seasons to recover, but that forbidden control plots also show damages (big wild mammals). A study made in Germany (Breckle et al., 1989), on sandy grounds, leads to different rates but give evidence of a return in the initial state. In Sweden, sensitive plots of land were followed: one with 15000 spinets recently planted, crossed by 2400 runners, underwent no damage (Kardell, 1974); another one, in which all the routes of the runners were scrupulously studied around a sensitive environment (connected to a chablis) shows the absence of effect (Bader, 1998). A follow-up study in Ardèche, France (Mounet, 2004) illustrates that a sensitive damp environment saw itself degraded from the 1st passage, that the tracks of 25 passages in a wet meadow disappeared within 1 month and that a zone with sphagnums crossing by 130 people regenerated in one year. If we even believe a mathematical model of standing realized according to the weight, to the surface of the foot, the number of feet by time unit and contact time (Parker, 2009), a cow, during 1 year represents 15000 adults orienteers during 1:30 hour (in other words, 200 cows = 3 millions of orienteers). In summary, until events of 2500 people, the damage is low, the recovery fast (1 to 3 years), it can take one season furthermore for the biggest events, but never reaches the threshold of 10 years. However the studies focused on the trampling of the vegetation and none estimated the erosion of grounds, in particular on slopes, banks, in gullies…

The studies made on the fauna disturbance were interested in cervids (the small mammals take easily refuge underground) which move far from the disturbances or towards natural places of refuge (thickets, inaccessible zone). These movements may be harmful if they are made during the periods of birth and breeding (in May, June), in winter and if they lead to wounds. Follow-ups show that the flight is easy, that the big deer run away on long distances outside of the zone of race and that the smallest take seek refuges, and that animals quickly come back to a normal level of anxiety after the event (Cederlund et al., 1981; Douglas, 1989). Deer radio-marked during a race in Denmark returned in 24 to 48 hours (Jepperson, 1987).

Regarding the damages to nesting birds (destruction of nests situated on the ground and in undergrowth, remoteness of the adults from nests, disturbances from the season of courtship displays until the breeding season), the studies are more difficult and rare (Liddle, 1997).

A follow-up made during an event combining 500 people in the UK during the season of reproduction showed no damage on the 54 counted species (Goodall and Gregory 1991).

Another one, realized during an event combining 1000 people in the upland of Titterston Clee (UK) where is nesting on the ground the Wheatear Oenanthe, gives very precise cartographic results (localization of nests, passage and runners attendances compared with every nest) (Parker, 2005c): on 31 identified nests, 4 were destroyed, they were situated in the parking and arena areas (welcome, arrival, spectators), while 27 others, situated on the race area, showed a very strong tolerance (until more than 200 passages/hour 25 m far from the nest). Finally, the work made by
Brackenridge (1988) in Scotland (1000 competitors), based on an inventory over 3 months before and after the race, shows especially that the impacts of an episodic event remain particularly difficult to correlate to the methods of studies on the long term of the population of birds.

**Objective and case study: the WOC 2011 in Savoie**

The purpose of this work is to bring a new experience feedback further to the World Orienteering Championship (WOC) July 2011 in Savoie, organized on the Savoie Grand Revard mountain, in the Regional Natural reserve of Bauges (5°59'00''E-45°38'43''N; Figure 1). The Massif of Bauges is a Pre-alpine calcareous massif of the French Alps, a landscape modelled by the surface karstic forms (rocky chaos, lapiaz, abysses...), the mixed forest and human activities (forestry development, agriculture, tourism, leisure activities).

Three elements are approached: i) the steps realized before and during the event for the consideration of the ecological stakes, ii) the modelling, on the basis of the data of this event, the influence of an orienteering race event race on the ground relating to its duration and to the space (mapped surface), and iii) the results of the observation of the evolution of tracks left by the participants on the ground during the 3 years which followed.

It is necessary to specify we studied more specifically the organized public races during the WOC. This work thus leans on the 6 stages of the 2011 O’Festival Savoie Grand Revard. With 4865 runners coming from 41 countries, we can consider that the distribution of ages, categories and circuits on one hand, and races times between the best and the beginners on the other hand, are representative of a typical race, from an international, national and even regional level. To this, are added the drawings of experts, who exploited and respected at best the grounds and rules of the orientation. This work thus bases on the 3 Long Distance races (LD) and the 3 Middle Distance races (MD) of the O’ Festival, their 30 circuits and 46 categories of runners.

Each of the stages collected between 2965 to 3237 competitors, lasted (from the 1st departure to the last arrival) between 6:05 hour s to 6:35 hours for the LD and between 5:28 hours to 6:00 hours for the MD, and required between 90 to 101 controls for the LD and between 89 to 96 for the MD, on maps from 3,2 to 7,1 km² for the LD and from 2 to 3,6 km² for the MD (Figure1). This event remains, on an international scale, of exceptional magnitude. The practice of orienteering race is indeed characterized rather by numerous small events. For example in Finland, we count every year approximately 4600 events, from which only around thirty of them had more than 1000 participants and 90% which had less than 100. In France, they are approximately 1000 races organized each year and only about ten grouping between 1000 to 1500 participants.

Finally, this work is focused only in the race area itself, the vastest and the most sensitive. The parking and the arena areas (welcome, services, arrivals...), where during several hours the spectators and competitors are concentrated, are not considered, these being anthropic matters where the environmental challenges concern rather the stakes connected to sustainable development.

**THE CONSIDERATION OF THE ECOLOGICAL STAKES**

**At the level of the federal practice**

The environmental protection is registered in the policy of the IOF and of the national federations as well as in the codes of the practice (standards for the organizer, regulations for the follower), whatever is the level and the frame (competition, leisure, school). THE IOF Environmental Policy (http://orienteering.org/resources/environment/) so promulgates 6 objectives from which the "Environmental protection" (measures planned in association with the local actors; sensitive / forbidden areas identified from environmental databases) and plans an evaluation of the major events via environmental performance indicators (Laininen, 2003; Parker and Viti, 2005).

The follower has to respect animals, all the vegetations and the trees essences, the restricted zones by the organizer, to use the compulsory passages, to circumvent the zones of swamps... Every runner who breaks this code is disqualified and exposes himself to penalties. The organizer has to
answer certain standards from the mapping by taking into account the sensitive ecological areas (swamps, peat bogs, natural reserves, zones with biotope order, Natura 2000 Areas).

Levers are also important from the point of view of the technical organization of the race. First of all, departures are individual and spread in time. Then, the disturbance of animals and the damages on the vegetation can be taken into account at the time of the drawing of courses: (i) identification (in the running area and periphery) of refuges or of flight areas (that courses avoid), (ii) unidirectional routes (identical direction of rotation and convergence of all the courses to avoid that the runners evolve in all directions) to allow the flight of animals, (iii) total number of competitors passing by a point not exceeding a reasonable limit, and (iv) avoidance of the sensitive zones (controls positioning outside of these areas so that the choices routes do not pass there - tacit avoidance-, by their marking on maps - red vertical stripes and even marks on the ground – ribbons. All this comes along more generally by raising awareness and putting to knowledge of the competitors on site.

Measures before and during the WOC 2011

Within the framework of the WOC 2011, the objective fixed by the sustainable development policy was "to minimize the environmental impacts of the event". The total surface of forest and open spaces susceptible to be frequented during the event was about 2000 ha for the competitions. The main environmental sensibilities identified in the races scope were the Creusates Peat bog (Natura 2000 area being also the object of an order for the biotope protection) and several wet zones (in particular the peaty zones of La Féclaz and the peat bogs of Plainpalais) (Figure 1). These wet zones and especially the acid peat bogs are very rare in the Bauges massif, and remarkable in the calcareous context of the Revard mountain.

The consideration of the stakes associated with the natural environment requirements before the event leaned on: (i) the creation of a Department of Durable Development in the Organizing Committee, (ii) the collection and the analysis of data linked to the environment (inventory of wet areas, documents related to the purposes of Natura 2000, inventory of the Natural Zones from an ecological, animal, fauna and flora interest ZNIEFF), the communication with the local administrators (Regional Natural Reserve of Bauges, Forest National Office, Gets League for the Protection of the Birds in Savoie, Regional Preservation of the countryside in Savoie, National Office of the Hunting and the Wild Fauna, Academy of the Natural Patrimony of Savoie) and services of the country (Direction Départementale des Territoires de Savoie), (iii) the dialogue with other teams of the organization (course planners), and (iv) the editorial staff of the parliamentary report regarding the evaluation of the incidences Natura 2000. The chronology of the work was the following: (Until 1 year before the event) data collection and realization of a map synthesis; (less 8 months) meeting of information and dialogue with the administrators: presentation of the event, of the potential impacts, synthesis of environmental stakes, precision and sharing of the modalities (total avoidance of the perimeter of the Creusates peat bog, avoidance of the wet areas of major interest already listed, complete establishment of the logistic areas and arenas in sectors already strongly fitted out by the village and by the nordic area), distribution to the mappers of the modalities; (less 6 months) data collection of additional sorts of birds (Gelinotte) with the hunting unions and Galliformes mountain observatory post; (less 4 months) editorial staff of Natura 2000 consequences report (70 pages), deposit into the Prefecture, instruction and obtaining of the receipt (without any observation from the Administration).

During the races, the exclusion of the Creusates Peat bog area (the area was widened on its NW part with regard to the perimeter Natura 2000 at the request of the Conservatory of the Natural Patrimony of Savoie, administrator) was formalized by the installation of a 1 km ribbons on the ground to materialize the restricted zone, by the printing of a red hatchings on the runners maps which clarifies the restricted zone (IOF standards, Figure 2) and by the site supervision by the Organizing committee staffs, by the PNR of Bauges and National Forest Office. Besides, an information about the environmental requirements, reminding the stakes and the behaviour to be adopted, was present on the documents of communication published for the occasion (from which running notebook) and on the Durable Development stand.
MODELLING OF THE SPATIAL AND TEMPORAL INFLUENCE OF AN EVENT

The work on the data of each of the 6 public races of the WOC 2011 (departure times and runners races durations, circuits maps, localization the controls and the number of overpassing) give a very fine analysis of the real influence, in the space (running area) and in the time (from the 1st departure to the last arrival), of the races. These data, then brought back on the surface of the mapped area and on the duration of the event, allow then to build a model of quantification of these influences, applicable to all races, the indispensable stage for the evaluation of the impacts on the environment and the concrete tool of communication between the organizers and the territories actors.

Three indicators are built, clearly for the LD and MD races: (i) the number of runners effectively present on the running site during all the duration of the event, (ii) the spatial influence of the race compared to the mapped surface and (iii) the proportions of the runners route spent on and outside the paths. The Figure 3 represents, with the example of the stage 2, the quantifications realized for every stage. To build the models (Figure 4), the results are given in percentage of the registered runners and in percentage of the race duration, then averaged on the 3 LD and 3 MD races respectively.

Number of runners present in the running area

To calculate the number of present runners in the race area during all the duration of the event, the presence of every competitor on the ground, time per minute, is recorded (taking as basis the departure time and the running time). Then, the presences per minute are accumulated, from the 1st runner to the last one at his arriving. The results (Figure 5a) show that, for a LD race, no more than 53% of the runners are at the same time running on the terrain, that, for example, during more than a third part of the duration of the event (36%), there is less than 10% of the participants on the terrain, and that during half of the time there is less than a quarter part and during the 82% of the time, less than half runners. For a MD race, there is no more than 38% of the runners at the same time on the terrain, also less than 10% of the participants during more than a third part of the duration of the event (37%), less than a quarter part during more than half part (54%) of the time, and even less than 30% during 93% of the race. These results precise those obtained by Anderson (1990) and Goodall & Gregory (1991).

Spatial influence of the race compared with the mapped surface

All the race area is not entirely used by all the competitors. This influence is estimated, for every stage, by the quantification of the number of runners crossing by control, all courses mixed, and by the spatial partition of the mapped space crossed according to the number of runners by course (Figure 3).

The results made on the controls crossing show that all the controls set up on the ground (with the exception of the arrival) don’t see more than 50% of the runners, and that a third part of them (36% for a LD, 35% for a MD) only see 10 to 25% of the runners. Besides, 32% of the controls set up for a LD race (22% for a MD) see only 5% or fewer runners, 57% of the controls (46% for a MD) see at the most 10% of the runners and 6% of the controls (16% for a MD) more than a quarter.

The results found on the real use of the mapped space illustrate first of all the fact that the map is never used in its entirety: between 62% of the map at least (stage 3, MD race) and 87% (stage 5, MD) at the most. We then observe that the courses of every stage can be grouped in 8 groups for the LD race, 7 groups for the MD race, for which the influence is practically identical, to which is then associated the number of competitors (Figure 3c). The accumulation of surfaces and number of runners shows that, for example (Figure 4b), 10 % of the runners use an average of 70% of the surface mapped in a LD race (75% of that in a MD race), that a quarter of the runners use 60% of the LD map (72% of a MD), which half of the runners use 45% of the map in a LD (60% of the map in a MD), which three quarters of the runners use 30% of the map in a LD (50% of map in a MD), and finally that all of the runners find themselves only on 10 to 15 % of the map.
Proportions of the runners route on and outside the paths

This variable is interesting to estimate the real use of the off-track field, but its evaluation is difficult (the strategies of the runners vary, as well as the density of the paths from a ground to another one); the results thus are to be taken with reserves.

The ideal routes were drawn and measured on the software Ocad, by circuit and by stage, then we calculated the percentage of the routes spent on a path, road... The results (Figure 4c) show that the runners spend on average circuits of LD 49% of their route on tracks (between 40% for the courses W20 W35 and 81 % for the MW10) and 40% for the courses of MD (between 25% for the W45 and 73% for marked course). We find the most important proportions for the short courses (veterans, young people, beginners), but the increase is not linear with the difficulty, the very long control to control of the high level courses bring more often the runners on the paths. For the LD races, a third part of the runners is on the paths during 50 to 80% of their route, half of the runners during a little less than 50% and 15% during 40% as an average. For the MD races, 70% of the runners are using the paths on 25 to 30% of their route, the rest of the runners up to 70% of their route. These results are similar to those made by Goodall and Gregory (1991), Parker (2010) and by Andersen et al. (1986) who estimated during an event in Denmark that the participants spend 50% of their route off-track (and less than 0.5% cross the very dense forest).

Finally, by simplifying (and without taking into account the participants who get lost), these results show that during an orienteering event we see less than half of the participants at the same time on the race ground, half of the runners on half of the map, with half of their route spent on paths.

FOLLOW-UP OF THE EVOLUTION OF THE TRACKS LEFT BY THE RUNNERS ON THE GROUND

After the WOC 2011, a work was made to estimate the impact of the event on the grounds, by using a simple indicator of potential disturbances: the tracks left on the ground by the participants (only in the races areas) and their evolutions during the 3 years which followed.

Methods

The first step consisted in choosing the most representative sectors regarding the use of grounds by the participants and the ecological stakes. So we retained the routes and controls the most frequented and those situated in the wet prairies, that is to say 12 areas, 40 controls and between 362 runners (11% of the subscribers) to 3202 runners (93%) (Figure 5a). The second step is the implementation of a typology to allow the description and the classification of the tracks. The first observation of the dimension puts in evidence the uselessness to proceed to a quantitative analysis (erosion of the ground, the trampled shelf space, the intensity of the standing about); the chosen typology is thus qualitative, according to the following criteria: (0) no visible track, (1) visible tracks (slept spices), (2) visible tracks (trampled spices, vegetation and litter destroyed) being able to be likened to a path (but not suffisant to be report on a CO map), (3) erosion of the ground on a distance (forming a flowpath), (4) erosion exceeding a flowpath.

The selected areas were visited, photographed, described and classified in several dates to follow the evolution: October 2011 (+2 months), June 2012 (+11 months), October 2012 (+14 months) and June 2014 (+3 years).

Results

This follow-up gave an exhaustive photographic and descriptive document of which only the key elements are listed hereafter.

Tracks observed in October 2011 (Figure 5b), just after the event, are numerous but very localized in the immediate approach of the controls (about ten meters). The classification gives in very big majority the tracks of types 1 and 2; those of types 3 and 4 are exceptional (5 controls) but spectacular, concentrated on the strong clayey slopes. The grounds of the stage 1 (zone E1-2) are
especially marked at the level of the series of the controls at the end of the race of all the circuits (types 1 and 2). The wet zones of the stage 2 (E2-2) show very visible standings about through tall grass but without soil erosion. On the other hand, very marked erosions are observed on certain slopes (E2-6, E2-3). The dense grounds in vegetation of the stage 3 and very rocky of the stages 4 and 6 are little marked. Finally the grounds of the stage 5 (E5-1, E5-2) are quite particularly marked in the semi-open zones. To the assessment, we highlight visible tracks in the crossed wet zones, without erosion nor destruction of the vegetation (slept herbs) (type 1), clearings with blueberries (*Vaccinium myrtillus*) impacted (destruction of plants on shelf spaces of some meters, type 2), sectors submitted to the erosion (type 3 and 4) in the clayey zones with stiff hillsides, where the approach of the control post by the runners was made in descent (change probably aggravated by heavy rainfall the day of the race, which succeeded a very rainy July).

In June, less than one year after the event, all the sectors showed strong recovery. With the exception of the areas classified 3 and 4 in October 2011, all came down to 0 or 1 (E1-2). In the wet areas (E2-2) after winter there is no more track of passage, and a healing of the progresses in the sectors of slopes is observed (E2-6, E2-3) (Figure 5b). The situation remains however unchanged in the semi-open zones (E5-1, E5-2).

The current situation, after 3 years, shows a healing, the tracks of the runners are not visible any more, except in some blueberries clearings (E5-2) for some meters approaching the control.

Remaining however is the question of the re-use of the site by orienteering runners (clubs, training courses) since the WOC 2011, which can make certain disturbances continue, but the density of elements on this karstic ground does not put concerns on an over attendance, if it is not, for the anecdote, the tacit sustainability of the locations of the controls regarding final of the middle distance of the WOC connected to a pilgrimage on the tracks of the champions by clubs in training course. Finally, on the occasion of these visits, numerous marks bound to the activities on this area were observed (in particular the standing about by the cattle) whose scale puts in perspective a little more those left by the followers.

**CONCLUSION**

This work made on the treatment of a big quantity of data and follow-up on the ground, even if it is only qualitative, goes to direction and gives precision about some studies carried out about the impact of the orienteering race on the environment. It would be useful however to reproduce it on other events, to strengthen the proposed model, and on other grounds, this study being representative only calcareous grounds of the Pre-Alps. But, put back in the whole experience feedback, it contributes to show the good environmental results, linked firstly to the actions and to the supervision of the practice, secondly to its intrinsic characteristics (Parker, 2010):

- The influx: the relation is inverse between the importance of the event (by the number of competitors) and their frequency (rare events of mass, with a few thousand participants, and numerous organizations of hundred runners);
- The space dispersal: the activity being based on the choice of routes, the borrowed progresses are many and different, where from a weak density in any spit (contrary to the ride, to the trail, to the mountain bike, to the sports in running waters) (Parker 2005d). The only compulsory passages are the controls, which are not the same for everybody and which are present only on the occasion of the event. The situation is different in the case of the Permanent Orienteering Routes where the sustainable positioning of the controls leads to the marking of the ground, unless using removable marker posts to modify regularly the routing offer, at least every 3 years
- The time dispersal: (i) on the scale of the event, the presence peak at the same time on the ground is of a one hour scale, with 40 to 55 % of the participants, which represents a lesser disturbance than for activities repeated every day (the fauna return); (ii) On the scale of the site, the activity is very episodic (by definition the interest is lesser when the ground is known) and the intervals between the events on the same site (minimum once a year, with more different controls), what allows the regeneration of the vegetation;
- The off-track activity: the least technical circuits are mainly on paths, paths which are besides favoured by the runners of the other courses (allow a fast run). However, the density of tracks or paths is often more important than the idea we usually have about a forest.

Orienteering is a sport which has accumulated good environmental references (experiences and scientific studies, good practice objectives, raising awareness and education), whose ecological impacts are small, under reserve, in the case of mass demonstration, to integrate well the main ecological stakes, which does not represent a threat as such, but which joins however in the whole of natural sports and of natural environment users and protected spaces.

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REFERENCES


**LIST OF FIGURES**

- Figure 1: races areas, mapped spaces and arenas (welcome, services, arrival and spectators) of the World championships and the 6 stages of the public races of the WOC 2011 in Savoie and sensitive areas identified on the grounds.
- Figure 2: protection of the Creusates peat bog during the WOC 2011 races.
Figure 3: quantifications of the spatial influence of an orienteering race on the mapped space: example of the stage 2 (long distance) of the WOC 2011 O’Festival: a) map, b) proportion of the participants crossing by control, c) areas used by the surface mapped by circuit and by runner (gross and accumulated).
- Figure 4: model of influence, in time and space, of an orienteering race (long and average distance) builds on the 6 stages of the WOC 2011 O’Festival: a) proportion of the runners present on the ground of the race from the 1st departure to the last arrival, b) proportion of the runners compared with the proportion of the used mapped surface, c) proportion of the route taken place on paths by category.
- Figure 5: follow-up of the evolution of the tracks left by the runners participating to the WOC 2011 public races: a) localization of the selected areas; b) examples of evolutions.
CAVALE
2 664 participants (75%)
on those controls