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CONFERENCE MATERIALS

Freshwater Pearl Mussel in Finland—Current Status and Future Prospects[1]

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Abstract—Information on the present distribution and status of the threatened freshwater pearl mussel *Margaritifera margaritifera* populations in Finland was updated. The status of the populations was classified into seven categories which are *viable*, *maybe viable*, *non-viable/partly viable*, *dying-out*, *almost extinct, probably extinct,* and *extinct*. The main criteria for judging the viability class were the population size and proportion of juvenile mussels. According to calculated estimate 1.7% populations were *viable,* 8.5% *maybe viable*, 40.2% *non-viable/partly viable*, 14.5% *dying-out*, 30.8% *almost extinct*, and 4.3% *probably extinct*. The present number of rivers with *M. margaritifera* in Finland is 117.

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INTRODUCTION

Freshwater pearl mussel *Margaritifera margaritifera* L. is an endangered species, which is protected in Finland by the Nature Conservation Act since 1955. The species is also listed in Annex II of the European Union Habitats Directive as a species whose habitat must be protected for its survival. Despite the protection, the freshwater pearl mussel populations have been declining almost everywhere in its original distribution range. According to some estimates, the decline of known populations in central and southern Europe is as high as 95% (Bauer, 1988). In Finland, the decline of the populations was estimated to be ca. 70% since the situation at the beginning of the 20th century (Valovirta, 2006). The 1955 Act protected *M. margaritifera* in Finland from pearl fishing but not from destruction of its habitats. Since the era of pearl fishing, the reasons for the declining populations have included the clearing of rivers for timber floating, the construction of hydropower plants, eutrophication and pollution of the rivers, the building of forest roads, and other forestry operations such as drainage of forest and peat lands, which have led to the silting of rivers.

The overall state of *M. margaritifera* in Finland was evaluated for the first time in 2010 (Oulasvirta, 2010a). At that time there was altogether 91 confirmed rivers with *M. margaritifera* in Finland, out of which in 31 at least some level of recruitment took place. Since 2010, however, investigations have revealed new, previously unknown populations (Oulasvirta et al., 2015b; Taskinen et al., 2015b) (Park & Wildlife Finland, unpublished data). On the other hand, it is obvious that at the same time we are losing or have already lost some of the most threatened populations. In this paper, we have summarized these new data as well as the older records of the distribution and state of the freshwater pearl mussel populations in Finland. The basic information in this study is the data obtained from the field surveys conducted in 22 rivers in 2010–2013. Three of the rivers are located in Southern Finland and were investigated in connection with the field surveys conducted by Alleco Ltd (Oulasvirta, 2010b; Oulasvirta and Syväranta, 2012; Oulasvirta et al., 2012, 2013). 19 of the rivers, which are located in Northern Finland, were investigated in connection with the European Union Interreg North—project lead by Park & Wildlife Lapland (Oulasvirta et al., 2015d). These data were complemented with the available information from the published and unpublished studies by other researchers.

MATERIALS AND METHODS

Data for this study were collected from several sources. The present number of *M. margaritifera* rivers in Finland is based on the information obtained from several sourses (Valovirta and Huttunen, 1997; Oulasvirta, 2006). The status of the populations is mainly based on the data obtained from the field studies conducted between 2010–2013 on 22 rivers, out of which 19 are located in Northern Finland and three in Southern Finland (Fig. 1). In these rivers, the population status assessments were based on the population size, length distribution of the mussels and on the smallest individuals found. These were studied on

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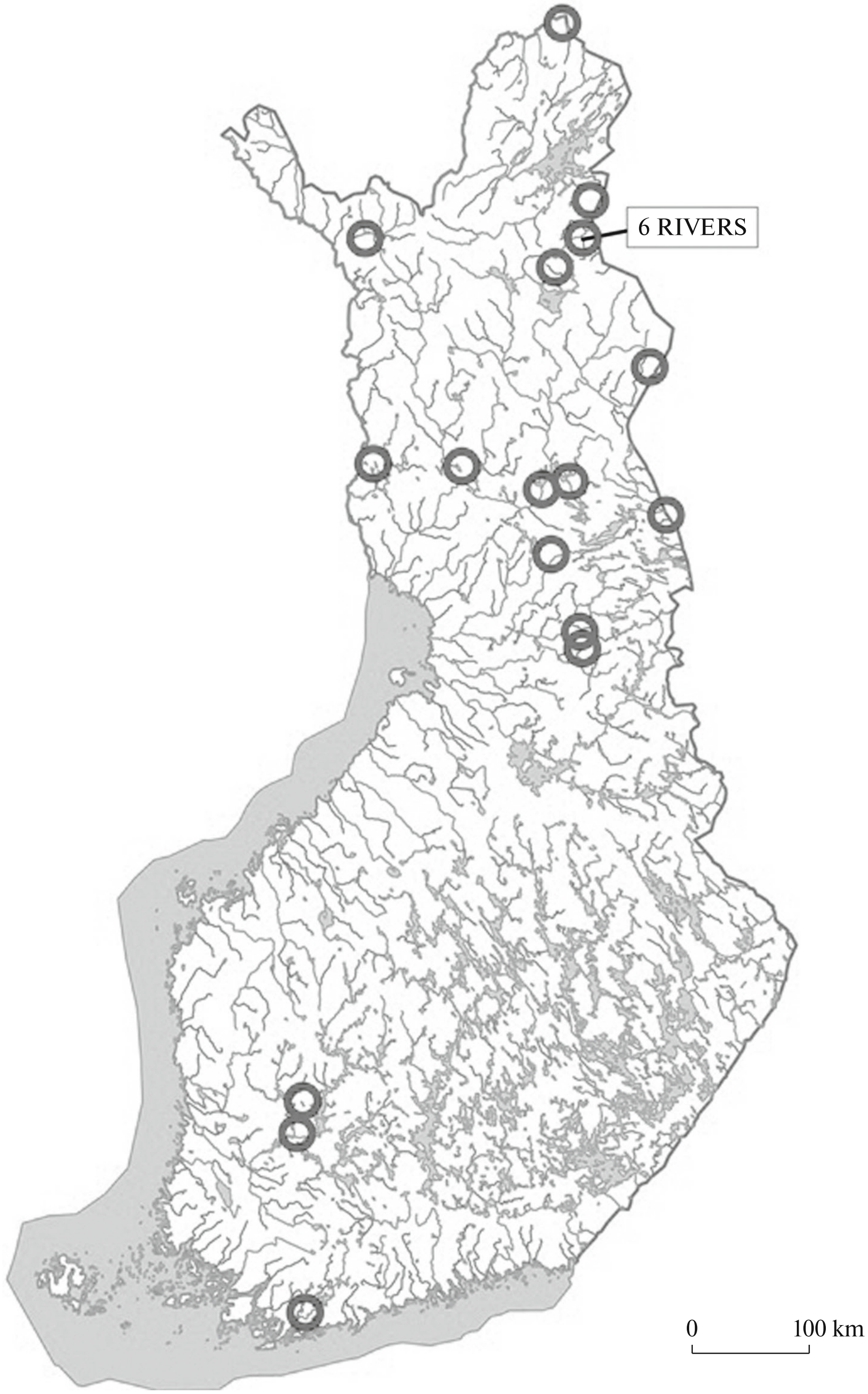

Fig. 1. The location of the *Margaritifera margaritifera* rivers, that were studied with random transects in 2010–2013.

transects, which were located randomly on the known distribution area of the mussels.

Usually a transect was a 20 m long stretch of river, which was investigated by snorkelling or Scuba diving. The upper and lower limits of the transect were marked with lead weighted rope across the channel, and their positions were recorded with GPS. In addition, bottom ropes across the river channel were laid at 5 m intervals between the start and end points. After that, a diver investigated the transect by swimming

Table 1. Criteria for determining the viability status of the freshwater pearl mussel populations*

Class	Status
Viable	>20%, <50 mm and >0%, <20 mm (>500 ind.)
Maybe viable	>20%, <50 mm or >10%, <50 mm and >0%, <20 mm (>500 ind.)
Non-viable/partly viable	<20%, <50 mm (>500 ind.) or >20%, <50 mm (<500 ind.)
Dying-out	All >50 mm, rich occurrence (>500 ind.)
Almost extinct	All >50 mm, sparse occurrence (<500 ind.)
Probably extinct	Documented occurrence, but probably recently extinct (after 1980s)
Extinct	Historical occurrence but vanished before 1980s

As *partly viable* were classified populations, in which recruitment took place in a certain optimal recruiting area, but where the population as a whole, according to the results obtained from random sites, was *non-viable.*
* Modified from Bergengren et al., 2010, Söderberg et al., 2009.

upstream and counting all mussels in 5 m sections. In big rivers, such as the Livojoki, Lutto, Suomujoki and Mustionjoki, the transects were established from shore to shore across the river channel and investigated by a diver from a 1–2 m wide area along the bottom rope.

The number of random transects established per river was 15–50 depending on the length of the mussel's distribution range and type of transect. After counting the mussels in the transect, the diver randomly collected the first 15 mussels for length measurements. This sample was taken in the vicinity of each random transect either upstream or downstream of it. The length measurements were used for determining the size distribution of the mussels. In addition, the smallest observed mussel was measured.

Apart from the mussel samples mentioned above, a random sample of the first 100 mussels was taken for length measurements from an "optimal" area, i.e., from the area with the highest proportion of juvenile mussels (if such an area could be detected). The aim of this sample was to ascertain whether the juvenile mussels occupy their own specific habitats in the river.

Besides the 22 rivers in which random sampling were conducted in 2010–2013, we collected all other available recent (after 1980–1990th) information on the state of *M. margaritifera* populations in Finland. These data were obtained from the published studies and written reports (Valovirta, 1987, 1990a, 1990b, 1993, 1996, 1997, 1998; Valovirta and Huttunen, 1997; Mela, 1998; Mäenpää and Pakkala, 2002; Valovirta et al., 2003; Oikarinen and Sihvonen, 2004; Oulasvirta, 2005, 2006, 2011; Geist et al., 2006; Oulasvirta et al., 2006, 2008, 2015a, 2015b, 2015c; Geist and Auerswald, 2007; Laaksonen et al., 2008; Pakkala, 2010, 2014; Porkka, 2011; Mäenpää, 2012; Laaksonen, 2013).

In addition to the written reports, we gathered all reliable unpublished data on *M. margaritifera* populations, that was available to us. These data include the unpublished data of Metsähallitus (Park & Wildlife Finland), Centre for Economic Development Transport and Environment of Lapland (here after ELY-Centre Lapland) and Alleco Ltd., as well as the personal information given by P.-L. Luhta, E. Moilanen and O. Isokääntä (Park & Wildlife Finland), M. Kangas (Ely-Centre Lapland), J. Pakkala (Ely-Centre Ostrabothnia) and I. Valovirta (WWF Finland).

Historical data of the *M. margaritifera* populations was obtained mainly from the written documents describing the pearl fishing era. Pearl fishing in Finland, and especially in the northern part of the country, has been documented for example by several authors (Fellmann, 1906, 1910; Itkonenm, 1948; Keltikangas, 1977; Montonen, 1985; Storå, 1989, 1995; Oulasvirta et al., 2006). Information on the old time pearl fishing was obtained also from the archives of the Finnish Museum of Hunting (Metsästysmuseo, 2007) and from Heikkinen (2002).

Terms and Definitions. In this paper the term population refers to the mussels that occupy the same river. Thus, the separate colonies of mussels in the same river are counted as a single population although there would be gaps between the colonies. On the other hand, mussels which exist in the main river and in the tributary of that river are considered to represent two different populations, although their occurrence would be continuous.

The state of the population was evaluated by applying certain criteria (Bergengren et al., 2010; Söderberg et al., 2009), where the population status is based on the population size and proportion of juvenile mussels in the population. The status of the populations was classified into seven categories which were *viable*, *maybe viable*, *non-viable/partly viable*, *dying-out*, *almost extinct*, *probably extinct* and *extinct* (Table 1). For estimating the population size the result of the mussel census from the random transects was extrapolated to cover the whole distribution range of the mussels in the river.

The viability of the population was basically determined according to the proportion of <20 and <50 mm mussels in samples. According to Dunca and Mutvei (2009), the mussels of 20 mm in length are in Swedish populations between 6–18 years and mussels of 50 mm

Table 2. The viability of the *Margaritifera margaritifera* in the Finland rivers in which data from population status was available

Class	Southern Finland		Northern Finland	
	n	*n*, %	*n*	*n*, %
Viable	–	–	1	2.0
Maybe viable	1	9.1	4	8.2
Non-viable (out of which *partly viable)*	2 (1)	18.2 (9.1)	21 (15)	42.8 (30.6)
Dying-out	2	18.2	7	14.3
Almost extinct	1	9.1	16	32.7
Probably extinct	5	45.5	–	–
Total	11	100	49	100

n—number of rivers; for Tables 2 and 3.

in length 16–27 years, depending on the growth rate of the mussels. These estimates were assumed to be valid in Finland also. The proportion of these size classes was calculated from samples taken from random transects. In those cases, where a specific recruitment area could be identified, this was cpecified when estimating the viability of the population (Table 1).

The criteria in Table 1 were applied to classify the state of the population in 60 rivers. These rivers included those 22 rivers that we investigated with random sampling and 38 other rivers for which reliable data on the state of populations was available from other sources. Typically these latter rivers are those, in which only adult mussels have been observed and thus they fall into viability classes 4–6.

The result obtained from the above 60 rivers was used to make a calculated estimate of the overall status of the *M. margaritifera* populations in Finland. Since all of the rivers lacking the data of the population status were located in the northern part of the country, only the data from the northern Finland rivers were used for extrapolation.

In addition to the criteria presented in Table 1, populations were classified according to the overall occurrence of mussels under 50 and 20 mm in length. This was done because in many of the rivers single observations of young mussels had been done, but the data were insufficient for determining the proportion of juvenile mussels. As long as no accurate information is available, these populations fall into viability classes 1–3.

RESULTS

At present, there are altogether 117 known freshwater pearl mussel rivers in Finland. This figure includes only confirmed records of mussels from the last 40 years, i.e., more or less the time period in which scientific surveys have been done. Most of the nowadays *M. margaritifera* rivers are located in northern Finland. In southern Finland, there are only 11 rivers with *M. margaritifera* left, and even from those it is highly probable that five of them had become extinct after the 1980s (viability class 6, Table 2). The most important area for *M. margaritifera* in southern Finland is the River Kokemäenjoki drainage area, where three *M. margaritifera* rivers still exist (Fig. 2). One of them was discovered as late as 2014, which proves that even in Southern Finland there are still new *M. margaritifera* populations to be found.

In the northern part of the country, *M. margaritifera* is known from 106 rivers. The most important catchment areas in terms of the number of *M. margaritifera* rivers are River Iijoki catchment (29 *M. margaritifera* rivers), River Kemijoki catchment (28 rivers) and River Lutto catchment (25 rivers) (Fig. 2). The Lutto and its tributaries is the upper part of the Tuloma River basin, which has it outlet in the Barents Sea, Russia.

The results of the viability estimates show that the status of *M. margaritifera* in Finland is critical. This concerns especially the populations in southern Finland. It is highly probable that *M. margaritifera* has become extinct quite recently, i.e., during the last few decades, in the rivers Kiskonjoki, Pohjajoki, Karvianjoki, Isojoki, and Pyhtäänjoki. These were classified to represent the category 6 populations, *probably extinct* (see more in the Conclusions section).

The only recruiting *M. margaritifera* populations in southern Finland are found in the River Kokemäenjoki catchment area, where 3 *M. margaritifera* rivers exist close to each other in the same sub-catchment. The population in one of the streams, the 2014 discovered River Turkimusoja, was classified as *maybe viable*, although the analyses of the surveys conducted in 2015 in the river are still in process (I. Valovirta, personal information). The other two *M. margaritifera* rivers in the area are the Ruonanjoki and the Pinsiö-Matalusjoki, which were classified as *partly viable* and *non-viable,* respectively. In fact, the Pinsiö-Matalusjoki could as well be classified as a *dying-out* population, since the young mussels there are only single rare findings.

Out of the 49 northern Finland rivers, from which data on population status were available, only one population (2%) could be classified as *viable*. This populations are found from a small brook in the Lutto drainage area. Four populations (8.2%) were classified as *maybeviable,* 21 populations (42.8%) as *non-viable* (out of which 15 *partly viable*), seven populations (14.3%) as *dying-out* and 16 populations (32.7%) as *almost extinct* (Table 3).

When these figures are extrapolated to the uninvestigated *M. margaritifera* rivers in Northern Finland and the data from Southern Finland rivers are combined, the proportion of *M. margaritifera* populations in different viability classes in the whole of Finland is

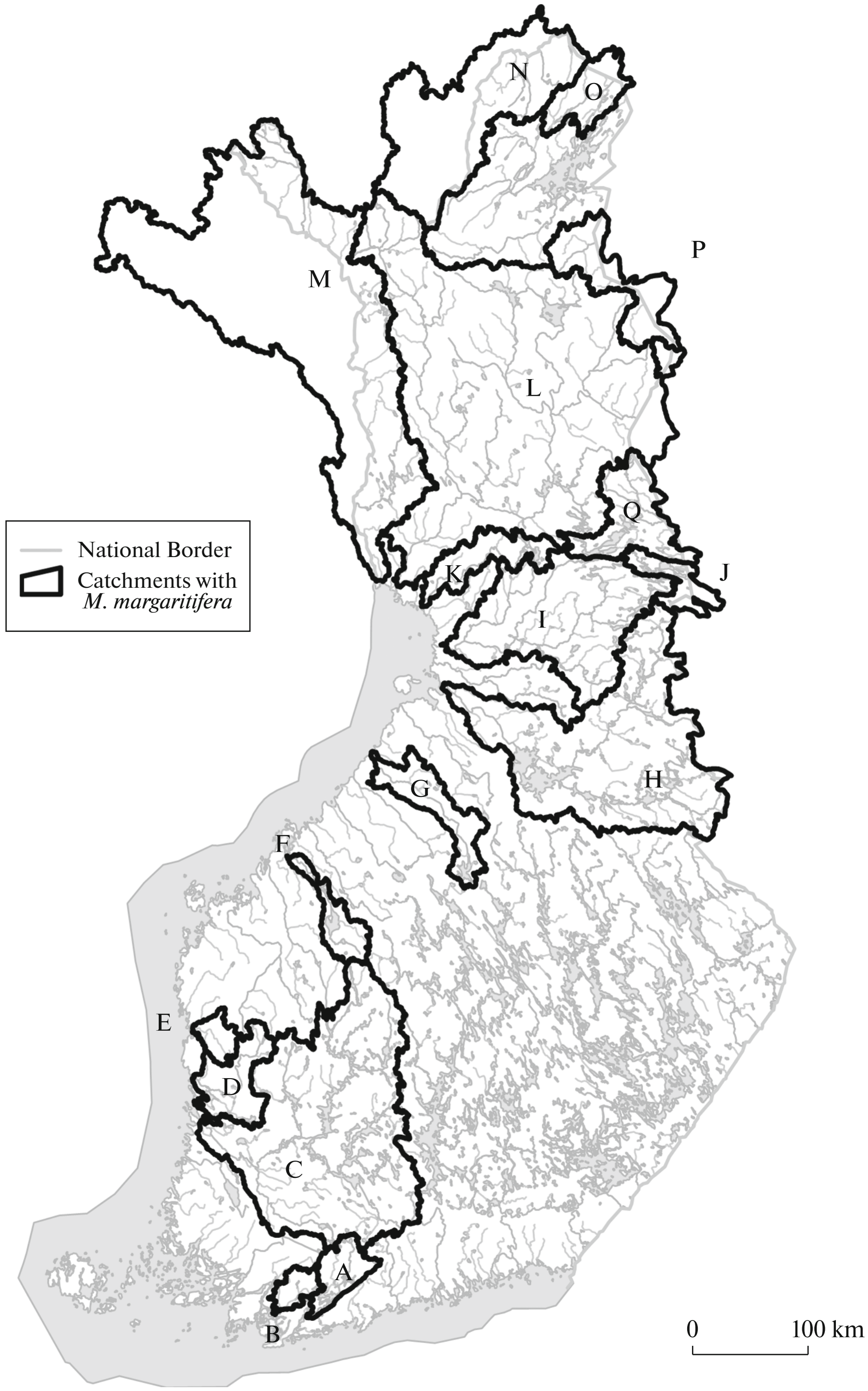

Fig. 2. The main catchment areas with *Margaritifera margaritifera* in Finland. Codes of the areas (A–Q) refer to Tables 4 and 5. The information of the number of *M. margaritifera* rivers and population viability status in different catchment areas is given on those tables.

as follows: *viable* 1.7%, *maybe viable* 8.5%, *non-viable/partly viable* 40.2%, *dying-out* 14.5%, *almost extinct* 30.8% and *probably extinct* 4.3% (Table 4). It should be noted that this is a calculated estimate based on the proportions found in the investigated populations. Biggest gaps in the knowledge, which make the estimate uncertain, are in the Lutto and Kemijoki catchment areas, in which more than half of the populations are uninvestigated in terms of the population status (Table 5).

Table 3. The calculated estimate of *Margaritifera margaritifera* populations in different viability classesin the whole of Finland

Class	*n*	*n*, %
Viable	2	1.7
Maybe viable	10	8.5
Non-viable	47	40.2
(out of which *partly viable)*	(33)	(28.2)
Dying-out	17	14.5
Almost extinct	36	30.8
Probably extinct	5	4.3
Total	117	100

When only the overall existence of juvenile mussels is taken into account, regardless of their proportion in the population, the result is that confirmed observations of mussels <50 mm in length (indicating recent recruitment) have been done in 53 rivers and mussels <20 mm in length (indicating very recent recruitment) have been detected from 23 rivers (Table 6).

DISCUSSION

The results of this study show that only around 10% of the *M. margaritifera* populations in Finland would be in a good or relatively good state (viability classes 1–2). Most of the populations, ca. 40%, would fall into category 3 *non-viable/partly viable*. Around 15% of the populations will be dying quite rapidly (viability class 4) and ca. 35% are almost extinct or perhaps are already extinct (viability classes 5–6). Although it is widely known that *M. margaritifera* is a critically endangered species, the result in sparsely populated Finland is unexpected. For example, in the neighboring countries of Sweden and Norway the state of *M. margaritifera* is not as bad. According to the latest statistics the number of *M. margaritifera* rivers in Sweden was 629 in 2014. Around half of the populations had mussels <50 mm in length indicating at least some level of recruitment (P. Olofsson, personal information). In Norway, the number of *M. margaritifera* rivers was ca. 360 in 2010 and approximately two third of the populations had some level of recruitment (Larsen, 2010).

Mostly the reasons for the bad shape of the *M. margaritifera* populations in Finland are still obvious. Since the era of pearl fishing, the reasons for the declining populations have included the clearing and straightening of rivers for timber floating, the construction of hydropower plants, eutrophication, the building of forest roads, and other forestry operations such as ploughing and drainage of forest and peat lands, which have led to the silting of rivers. Especially the drainage operations have been extensive; almost

Table 4. The viability of the *Margaritifera margaritifera* populations in the main catchment areas

Code*	Catchment area	Number of rivers	*Viable*	*Maybe viable*	*Non-viable/ partly viable*	*Dying-out*	*Almost extinct*	*Probably extinct*	No data
A	Karjaanjoki	1	–	–	–	1	–	–	
B	Kiskonjoki	1	–	–	–	–	–	1	
C	Kokemäenjoki	3	–	1	2	–	–	–	
D	Karvianjoki	3	–	–	–	–	1	2	
E	Lapväärtinjoki	1	–	–	–	–	–	1	
F	Ähtävänjoki	1	–	–	–	1	–	–	
G	Pyhäjoki	1	–	–	–	–	–	1	
H	Oulujoki	9	–	1	3	1	4	–	
I	Iijoki	29	–	1	2	4	11	–	11
J	Kem (Karelia)	1	–	–	–	–	–	–	1
K	Simojoki	2	–	–	–	–	–	–	2
L	Kemijoki	28	–	2	5	2	–	–	19
M	Tornionjoki	2	–	–	1	–	–	–	1
N	Teno	3	–	–	1	–	–	–	2
O	Näätämö	1	–	–	–	–	1	–	
P	Lutto	25	1	–	7	–	–	–	17
Q	Koutajoki	6	–	–	2	–	–	–	4
	Total	117	1	5	23	9	17	5	57

"–"—no rivers having this class. Codes of the catchment areas refer to Fig. 2. Areas A–G (grey background) are located in Southern Finland and H–Q in Northern Finland.

Table 5. Number of *Margaritifera margaritifera* rivers in different main drainage areas

Code	Catchment area	*M. margaritifera* rivers	Mussels <50 mm	<20 mm
A	Karjaanjoki	1	0	0
B	Kiskonjoki	1	0	0
C	Kokemäenjoki	3	3	2
D	Karvianjoki	3	0	0
E	Lapväärtinjoki	1	0	0
F	Ähtävänjoki	1	0	0
G	Pyhäjoki	1	0	0
H	Oulujoki	9	4	1
I	Iijoki	29	10	3
J	Kem (Carelia)	1	?	?
K	Simojoki	2	1	?
L	Kemijoki	28	14	8
M	Tornionjoki	2	2	2
N	Teno	3	1	?
O	Näätämö	1	0	0
P	Lutto	25	13	7
Q	Koutajoki	6	5	?
	Total	117	53	23

Mussels <50 and <20 mm mean confirmed observations of mussels under 50 and 20 mm in length (0 = only adult mussels found, ? = no data). Codes of the catchment areas refer to Fig. 2. Areas A–G are located in southern Finland and H–Q in northern Finland.

Table 6. River basins, in which the searching for new freshwater pearl mussel populations should especially be targeted in Finland

Catchment	Target areas/rivers
Kemijoki	River Ounasjoki sub-basin with the tributaries River Luiro sub-basin with the tributaries River Tenniö sub-basin with the tributaries River Kitinen sub-basin with the tributaries River Värriöjoki sub-basin with the tributaries
Koutajoki	Upper parts
Teno	River Utsjoki with the tributaries River Inarijoki with the tributaries
Tornionjoki	Main channel of River Tornionjoki
Simojoki	Upper parts of the main channel and the tributaries

40% of the world's forest and peat land ditches are in Finland (Joosten and Clarke, 2002). The consequence of this is seen in the poor water quality in many rivers. The siltation and sedimentation result in clogging of the river bed, which causes oxygen depletion in the interstitial water and makes the habitat unsuitable for juvenile mussels buried into the river bottom. The low oxygen levels in the interstitial water is one of the main factors explaining the decline of *M. margaritifera* in Europe (Geist and Auerswald, 2007). Oxygen levels in the interstitial water can be verified with redox potential (E_h) measurements in the river bed. Low redox values (<300 mV) and a big difference (>20%) between the value in the interstitial water and the free flowing water correlate with the low recruitment rate of *M. margaritifera* (Geist and Auerswald, 2007). This has been noted also in the Finnish rivers, where redox measurements have been made (Oulasvirta and Syväranta, 2012; Oulasvirta et al., 2012, 2013, 2015c).

In addition to ditching and forestry operations, another major single factor impacting the mussel populations has been the harnessing of rivers for hydropower production. The hydropower dams have prevented Atlantic salmon (*Salmo salar*) from ascending to its historical spawning grounds in large areas and lead to the lack of suitable host fish for *M. margaritifera*. For example, according to the experimental data in the main channel of the River Lutto and the River Livojoki, a tributary of the River Iijoki, the primary or even only suitable host for *M. margaritifera* in those rivers was the Atlantic salmon before brown trout *S. trutta* (Taskinen et al., 2015a). Closing of these rivers with hydropower dams in the 1960th terminated salmon migrations to the river systems and ceased recruitment of the mussels in the main channels, in which they are salmon dependent. The same process has probably taken place in many other former salmon rivers in the past. Indeed, at present none of the *M. margaritifera* populations in Finland's existing or historical salmon rivers is known to be functional. From a conservation point of view this is the main concern, since it has been shown that the salmon river mussel populations are genetically morevariable and are hence important for conserving the genetic diversity of *M. margaritifera* (Välilä et al., 2015). Presumably the *M. margaritifera* populations living in the large salmon rivers are also the indigenous populations from which the species has spread into headwaters, where it has adapted to use the brown trout as a host.

The results of our study show that without extensive conservation efforts the distribution of *M. margaritifera* in Finland will be fragmented into a few isolated headwaters populations, in which the threat for the extinction is high even without human impact. The situation is especially critical in Southern Finland, where the species will become extinct quite soon in most of the rivers unless urgent restoration measures are taken. Even in the sparsely populated Northern Finland the distribution of the species can be expected to decrease remarkably. Up north, *M. margaritifera* is most vulnerable in the present and historical salmon rivers Livo, Simo, Lutto, Suomu and Näätämö. In the River Utsjoki, which is the fifth salmon river with *M. margaritifera* in Finland, the state of the mussel population is unknown.

The future prospects and required conservation measures vary from river to river depending on the threats and state of the population. All the functional populations (viability classes 1–2) live in tiny headwaters brooks. Within these populations, the primary conservation measure is to protect the rivers against harmful human activities. In practice, this would mean the protection of the river as a nature reserve or as a Natura 2000 area. At the moment, only 33 of the rivers with *M. margaritifera* in Finland belongs to the Natura 2000 network and only 13 rivers are included into national parks or other nature reserves.

The future development in class 3, *non-viable/partly viable,* populations is more difficult to predict. Most obviously these populations will gradually regress, if the rate of recruitment is not on a sustainable level. However, two thirds of the populations in this category were classified as *partly viable,* i.e., populations in which the recruitment rate was higher on certain sections of the river. Usually such an optimal area was found from the upper part of the mussel's distribution range, where the anthropogenic impact was lower. In the *partly viable* populations, it is possible that remnants of the original population would remain in these restricted sites. It is uncertain, however, how the isolated sub-populations would survive in a long run.

What makes the drawing of conclusion uncertain with the *non-viable/partly viable* classified populations is the fact, that especially in this category it is questionable whether the applied criteria for defining the viability of the populations are justified. Determining the state of the population according to the proportion of juvenile mussels is valid, if both the mortality and recruitment rate of the mussels are assumed to be constant. However, if the rate of recruitment and mortality vary spatially within the river or temporally between years, the same criteria no longer apply. Many of the populations in Finland, and especially the very northern ones are certainly frontier populations living probably at the extreme climatic limits of the species. Taskinen et al. (2014), for example, showed that the development time for the glochidia in the host fish gills was ca. 11 months in one of the Northern Finland population. This result, and our own observations of the size cohorts of mussels within a river indicate, that the recruitment of freshwater pearl mussel in cold environment might even naturally take place quite seldom, maybe only in the most favourable (mild) years, and even then only in certain stretches of the river, where the circumstances are optimal. This could explain the absence or small number of the juvenile mussels in the random sampling in a given time, and still the population could be functional.

Since the problems usually derive from the surrounding drainage area, the primary conservation measure in the populations within the *non-viable/partly viable* populations should be the restoration of the catchment area. Restoration measures in the river bed are also required, if the habitat is destroyed by siltation or clearing and straightening of the river.

The conclusions and future perspectives in viability class 4–6 populations are more predictable. The *dying-out* populations will be disappearing in near future, unless urgent restoration measures are started. The primary conservation measure with them should be the captive breeding of juvenile mussels. The methods of mussel rearing with variations are widely used in many of the Central European countries (Thielen et al., 2015; Thomas et al., 2010). At present, there is no captive breeding station for mussels in Finland. Establishing such and initiating the mussel rearing as soon as possible would be important, because the collapse of the mussel population may happen quickly after it has begun. There are already examples of that kind of process in Finland. In the River Ruonanjoki and the River Pinsiö-Matalusjoki for instance, the mussel populations decreased by over 50% between 1999 and 2013 (Oulasvirta et al., 2013). Another example is from the River Ähtävänjoki, which in the 1980s with its ca. 50000 specimens was the biggest *M. margaritifera* population in southern Finland (Valovirta, 1987). In 2012–2013 surveys, the size of the population was no more than 5000 mussels (Pakkala, 2014), and in 2015 the number of the mussels was estimated to be no more than couple of hundreds instead of thousands (J. Pakkala, personal information).

Among the populations belonging to class 5, *almost extinct*, the restoration efforts may already be too late. If the number of the mussels has already collapsed and the density of mussels is very sparse, it is possible that they are not able to produce glochidia anymore. In that case, even the artificial propagation of juvenile mussels may be impossible or it may require special actions like transferring adult mussels into the breeding station.

Rivers Kiskonjoki, Karvianjoki, Pohjajoki, Isojoki and Pyhäjoki were classified as *probably extinct* (class 6). It is obvious that *M. margaritifera* has become extinct in these rivers recently, i.e. after the 1980–1990s. In the River Kiskonjoki, a colony of ca. 1000 mussels was still found in the 1990s (Valovirta, 1998). In the field surveys conducted in 2013, no mussels were detected anymore (Laaksonen, 2013). In the River Karvianjoki *M. margaritifera* was still found in the 1980s (I. Valovirta, personal information), but in the 2005 surveys the same sites were empty (Oulasvirta, 2005). In the River Isojoki, only a few dozen mussels were found in 2001 (Mäenpää and Pakkala, 2002). Even though these would still be alive, the population is practically extinct. The situation with rivers Pyhäjoki and Pohjajoki is similar or even worse, only individual mussels were detected during the last surveys in the 1980s (I. Valovirta, personal information).

The knowledge of the *M. margaritifera* populations that had vanished before the 1980s (viability class 7 *extinct*) is based mostly on the historical documents of pearl fishing. In the beginning of the 20th century there were still more than 200 known *M. margaritifera* rivers in Finland (Valovirta, 2006). The real number of rivers was probably much higher, because particularly the populations in remote wilderness areas were unknown. According to the written documents (Brander, 1955a, 1955b, 1956; Keltikangas, 1977; Storå, 1989; Heikkinen, 2002; Metsästysmuseo, 2007) pearl fishing has been conducted at least in the following river basins, from which the species has disappeared: Kymijoki, Porvoonjoki, Eurajoki, Perhonjoki, Kalajoki, Siikajoki and Uutuanjoki. In eastern Finland, *M. margaritifera* has probably become extinct in many rivers in Kainuu area, which also was renowned for its pearl rivers (Heikkinen, 2002). In addition to the rivers where pearl fishing was practised, the species has most likely disappeared from many other rivers. For example, an empty shell of freshwater pearl mussel was found from the River Gumbölenjoki in 2008 indicating that freshwater pearl mussel has existed not so a long ago less than 20 km from the City of Helsinki (Laaksonen et al., 2008).

In the previous survey in 2009, 91 rivers with *M. margaritifera* were known in Finland (Oulasvirta, 2010a). 31 of the rivers contained mussels smaller than 50 mm in length. In this study the same figures were 117 and 53 rivers respectively. Thus, at the same time when *M. margaritifera* populations are lost, new populations are found when further investigations are carried out. The first prerequisite for saving the populations is to know where they are. Therefore searching for new population should be the target also in the future work. Especially in northern Finland, there are vast areas, which are still totally unmapped for freshwater pearl mussel. Such are found for example from the Kemijoki, Tenojoki and Simojoki river basins. From the unharnessed salmon rivers,uninvestigated are still the River Tornionjoki, the River Utsjoki and the upper parts of the River Simojoki. The target areas where the basic mapping project should especially be focused in northern Finland are shown in Table 6.

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