NOBANIS – Invasive Alien Species Fact Sheet

Salvelinus fontinalis

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Species description

Scientific name: *Salvelinus fontinalis* (Mitchill, 1814), Salmonidae
Synonyms: *Salmo fontinalis* Mitchill, 1814; *Salmo canadensis* Griffith & Smith, 1834; *Salmo hudsonicus* Suckley, 1861; *Baione fontinalis* (Mitchill, 1814); *Salvelinus timagamiensis* Henn & Rinckenbach 1925
Common names: Brook trout, Brook charr (GB), siven americký (CZ), Bachsaibling, Amerikanischer Saibling (DE), kildeørred (DK), ameerika paalia (EE), Puronieriä (FI), Lindableikja (IS), Amerikine palija (LT), Avota palija, Amerikas palija (LV), Bekkerøue, Bekkeror, Bekkerøyr (NO), Pstrag zródlany (PL), Amerikanski goletz, Amerikanski forel (RU), Bäckrödning (SE).

Hybrids:
S. fontinalis x S. namaycush: Splake (GB), Splejk (SE)

S. fontinalis x S. alpinus: Sparctic charr, Sparctic trout (GB), Elsässer Saibling (DE), Brødding (DK), Bröding (SE)

S. fontinalis x Salmo trutta: Tiger trout, Tigerfish (GB) Tigerfisch (DE), Tigerfisk, tigerforell, tigeröring (SE)

Fig. 1. *Salvelinus fontinalis*, Brook Trout. Photo: Inge Lennmark. www.lennmark.se

In English, *Salvelinus fontinalis* is commonly referred to as the brook trout, even though it is more properly a brook charr (or char). However, here we use the more common, if somewhat misleading, name brook trout.

Species identification

Like other members of the salmon family, brook trout has a streamlined body with an adipose fin close to the tail. The back is dark green to brown, similar to the native brown trout (*Salmo trutta*), but with a distinctive marbled pattern of lighter colour, called vermiculations. The sides are lighter than the back, and have a sprinkling of pale (yellow) and red spots, the latter surrounded by blue "haloes". The pectoral (breast), pelvic (belly), and anal fins have white edges followed by a contrasting black stripe. The belly colour may vary, depending on the time of year and reproductive state, from creamy white to reddish in the males when spawning; the latter making it look somewhat like the native Arctic charr (*Salvelinus alpinus*) from the underside. The mouth is large. The tail fin is slightly concave, hence the North American name squaretail, and the scales are very small.

Colouring and appearance may vary with habitat and reproductive state: during spawning male trout develop a red colour along the belly, and the sides and fins become red. Sea-run fish are dark green above with silvery sides, white bellies and very pale pink spots (FishBase 2006, Page & Burr 1991).

The maximum recorded length and weight in its native range is 86 cm and 9.3 kg respectively (FishBase 2006, Page & Burr 1991), with an average length of 38–51 cm (Roberts 2000), but in European waters it is usually smaller. Reported lengths vary between sources; from 25–30 cm (Smedman & Svärdson 1966) to 30–40 cm, rarely exceeding 45 cm, and weights of 0.5–1 kg (Muus & Dahlström 1981). In many natural waters individuals are quite small, but in culture or artificially created fishery waters it can reach 2–3 kg (Smedman & Svärdson 1966). In its native area the maximum recorded age is seven years (FishBase 2006), but 24-year-old specimens have been reported from a stunted population in California, where the species is introduced (Reimers 1979). In Europe maximum recorded ages of 3–5 (Grande 1984, Muus & Dahlström 1981) or up to 6 years (Smedman & Svärdson 1966) is common.

Native range

The original area of distribution for brook trout is the eastern parts of North America: most of eastern Canada from Newfoundland to the western side of Hudson Bay; south in the Atlantic, Great Lakes, and Mississippi River basins to Minnesota and northern Georgia (the Appalachian mountains) (Page & Burr 1991). Today it is however widely distributed over most of Canada and the United States through introductions mainly for sports fisheries. It has also been introduced to more than 40 countries in temperate areas on all continents, including the southern hemisphere (Welcomme 1992).

When a species is referred to as being *native* in this fact sheet, it refers to its being within its native range. Species such as brown trout (*Salmo trutta*) and Arctic charr (*Salvelinus alpinus*) have been extensively introduced for sports fisheries etc. within the NOBANIS area, and are not necessarily native to a particular location. (The native range of brown trout is Eurasia and North Africa (Page & Burr 1991), and Arctic charr is a circumpolar species which is native to some, but not all, countries in the NOBANIS area. It was introduced *i.a.* to Denmark and Latvia in the 1920s, but did not become established (NOBANIS 2006).

Alien distribution

History of introduction and geographical spread
Introductions of North American freshwater salmonids became common in the late 19th century, and their popularity for aquaculture and sports fisheries have led to some of them becoming almost cosmopolitan species, distributed in temperate areas all over the world (Welcomme 1992). Brook trout was first introduced to Europe, to the United Kingdom, in 1869 (Lehtonen 2002). In Austria it was introduced around the 1880s, and is now present in some twenty countries; from Spain in the south to Norway in the north (FishBase 2006, Welcomme 1988). Besides Europe the species has been introduced globally to other temperate areas, including the western parts of North America, temperate areas of South America, Asia, Africa and Oceania (FishBase 2006).

In many countries the first introductions were not considered "successful", *i.e.* they did not result in established populations. Continued stockings during the 19th and 20th century have however led to brook trout becoming established in most of the NOBANIS area.

It has been introduced to all Baltic Sea area and Nordic countries, except Iceland, Greenland, and the Faeroe Islands. It was imported to Estonia and Latvia at the turn of the last century, but did not become established.

Pathways of introduction
The first introductions of brook trout were carried out in the late 19th century, following the pattern of international movements of species for aquaculture described by Welcomme (1988), where the pre-1900 intentional introductions mainly involved freshwater salmonids introduced into temperate regions for aquaculture associated with the maintenance of sports fisheries, *i.e.* stockings in open waters, as well as for limited food production.

In Europe, brook trout was originally considered an attractive species, especially for sports fisheries, and it has been extensively stocked in natural waters. Escapees from hatcheries and aquaculture facilities have also been reported. Since brook trout is more tolerant of a lower pH than *i.e.* the native brown trout, it has been used as a replacement when populations of native salmonid species have dwindled or become locally extinct because of acidification.

Once the species has become established in the wild, natural dispersal has become possible, and further non-authorized introductions may also have taken place.

Alien status in region
Brook trout has been intentionally introduced to most parts of the NOBANIS area (Table 1). It was introduced to Denmark in the late 19th century for aquaculture/fish farms, from where it has escaped into streams (Rasmussen 2012, Muus & Dahlstrøm 1984). Today there are small self-reproducing stocks in the upper reaches of Villestrup Å and Lindenborg Å (Rasmussen 2012).

It was introduced to Estonia by way of Germany in 1896 (FAO DIAS 2006), and was maintained in one hatchery until the 1980s, but it has not become established in the wild and has died out (FishBase 2006).

The first introduction to Finland also came from Germany, for aquaculture purposes, in 1895 (Welcomme 1988), and brook trout was re-introduced in 1965 for aquaculture, fisheries and sports fisheries (FAO DIAS 2006). The species is established in the wild (Nummi 2000, and references therein).

Brook trout came to Germany from the United States in 1890 (Welcomme 1988). It is mainly produced for stocking in natural waters, occasionally including the hybrids tiger trout and sparctic charr. It is established in natural waters, where it regularly reproduces when the water is not to warm, but its distribution is mainly limited to acidic waters that are no longer suitable for the native brown trout (Geiter *et al.* 2002). It is considered as an invasive species (Aquatic-Aliens.de 2007). Imports from North America have continued into the 21st century, as eggs of the hybrid sparctic charr (*Salvelinus fontinalis* x *S. alpinus*) and of brook trout were imported from Canada in 2000 and 2003 respectively (ICES 2001, 2004a).

In Latvia, brook trout was first introduced in 1902. It was stocked in rivers, and further introductions were made until 1914, but there are no records of where these introductions took place (Nature of Latvia 2006). It has never been found in natural waters, but it is found in some aquaculture facilities (Birzaks pers.comm.).

The first record of brook trout from Lithuania is from 1885, when it was intentionally introduced for use in aquaculture. It is locally established in natural waters, and is considered invasive with impacts on native species through competition and genetic effects (NOBANIS 2006; main reference: Virbickas 2000).

In Norway, brook trout was first introduced in the 1870s. Since then it has been stocked in many parts of Norway, but there are only a few established populations, and these occur mainly in the upper parts of creeks and small rivers (Grande 1984). During the 1960s it was stocked in many lakes in Østlandet and Sørlandet, to compensate for the loss of native salmonids through acidification, and several of these stockings resulted in self-reproducing populations (Sivertsen 1994). It is considered potentially invasive (NOBANIS 2006, Langeland 1992). In a survey of fish status in Nordic lakes in 1996, brook trout was reported from 32 locations (Rask *et al*. 2000), though these are not necessarily all self-reproducing. It should also be noted that since lakes are not the preferred habitat of brook trout, this is likely to be an underestimate of the total number of populations. It is used in sports fisheries, and is considered useful for watercourses affected by acidification, where brook trout survives better than local species (Grande 1984, Welcomme 1988).

The first record of brook trout in Poland is from 1881, when it was intentionally introduced for fishing and angling. It is established locally, in a few water bodies with clean water, including oligotrophic lakes, but population numbers are difficult to estimate due to frequent introductions (Solarz 2006). Brook trout is considered invasive (NOBANIS 2006), with potential genetic impacts through hybridization with the native brown trout (*Salmo trutta*). Control through the use of selective piscicides may be considered if deemed necessary, *e.g*. in the Tatrzanski National Park (*ibid.*).

In the Russian Federation, brook trout was introduced for use in captive conditions, but it has since escaped and established locally in the wild (Bogutskaya & Naseka 2002).

In Sweden, brook trout has established self-reproducing populations in most parts of the country, mainly in cold, running and often slightly acidic waters. It has in some locations replaced the native brown trout (*Salmo trutta*) (Filipsson 1994, Spens, Alanärä & Eriksson 2007). From the areas to where it was intentionally introduced it has probably been able to spread to other water bodies, and there are more than 300 established populations in natural waters (Pakkasmaa & Petersson 2005). The first introductions were made in the 1890s, in the province of Jämtland (Filipsson 1994), but most of the deliberate releases were made in the 1950s and 60s (Pakkasmaa & Petersson 2005),

when rotenone treatment was introduced to create new fishery waters. Here it has, however, to a large extent been replaced by stockings of another introduced species, the North American rainbow trout (*Oncorhynchus mykiss*) (Filipsson 1994). In recent years, however, the number of permits for stocking granted by the county administrative boards has decreased, and in 2002 the number of permits was down to 30 in nine different counties (Pakkasmaa & Petersson 2005). As of January 1 2005, permission for stocking of brook trout may only be granted for water bodies where such permission has been granted previously, *i.e.* brook trout may not be introduced into new areas. Permission can only be granted on the condition that measures are taken to ascertain that the fish cannot disperse from the water body into which it is stocked.

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Austria					X		
Belarus							
Belgium							X
Czech republic					X		
Denmark			X				
Estonia		X					
European part of Russia							
Finland			X				
Faroe Islands	X						
Germany					X		
Greenland	X						
Iceland	X						
Ireland							
Latvia		X					
Lithuania				X			
Netherlands							
Norway				X			
Poland				X			
Slovakia							X
Sweden					X		

Table 1. The frequency and establishment of *Salvelinus fontinalis*, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** – The species is not found in the country; **Not established** – The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** – Few sites where it is found in the country; **Local** – Locally abundant, many individuals in some areas of the country; **Common** – Many sites in the country; **Very common** – Many sites and many individuals; **Not known** – No information was available.

Ecology

Habitat description

The native habitats of brook trout are small streams, creeks, rivers and lakes, and it prefers cool, clear, well-oxygenated waters (FishBase 2006, Page & Burr 1991). Some populations of brook trout are anadromous, *i.e.* they spend part of their life cycle in marine or brackish waters, but return to

freshwater to reproduce. According to FishBase (2006), the temperature range is 0–25° C, and Elliott (1994) gives the range for growth as 7–20° C.

Brook trout is more tolerant of slightly acidic waters than many species native to the NOBANIS area, and stocking experiments have shown that it may survive and thrive in waters with a pH down to about 4.5 (Grande 1984). It may also grow faster and obtain a better condition and quality than the native brown trout (*Salmo trutta*) in acid lakes, a trait that has made it attractive for stocking in waters where native species do not thrive or have disappeared (*ibid.*).

Reproduction and lifecycle

Like many salmonids, brook trout exhibits a fair amount of variability in life history traits such as size, age at maturity, and fecundity. Some of this variation, such as time for spawning, may be dependent on latitude and temperature (Roberts 2000 and references therein), but there can also be substantial variation between populations on a small geographical scale, including differences in age at maturity, and reproductive effort (Öhlund 2002 and references therein), something that should be taken into account for the figures given below.

Brook trout reach sexual maturity after two to four years. For European waters, Muus & Dahlström (1981) give the range as 2–3 years for males, and 3–4 years for females. Grande (1984) gives the figures of one to three years (one for fast growing males, on average two to three years for most males, and three years for females) for a Norwegian population. Spawning takes place in running water in late summer or autumn, depending on latitude and temperature, and the eggs hatch in the spring, after about 100 days. The eggs are deposited in a redd or nest, a small pit constructed by the female on a gravelly substrate (Muus & Dahlström 1981). The fry remain hidden in the gravel, feeding on the yolk sac, until water temperature begins to rise in early spring, when they emerge to search for insects to feed from (Mayhew 1987). Even though brook trout is more tolerant of acidic waters than *e.g.* brown trout, reproduction will usually not take place in waters with a pH below approximately 5 (Grande 1984).

The food habits of brook trout vary with age and life history stage. As fry (the first stage after the larval stage), brook trout feed primarily on insect larvae, but as adults they have a wide dietary range, and are able to feed on a diverse range of organisms including worms, leeches, crustaceans, insects, molluscs, fish, amphibians, and even small mammals such as voles (FishBase 2006). The growth rate is high compared to other salmonids, but since the lifespan is rather short, approximately 5 years, they rarely reach a large size (Smedman & Svärdson 1966).

Dispersal and spread

In its native range, general upstream movements have been observed in early spring, summer and late fall, and downstream movements in late spring and fall. Anadromous populations run to the sea in the spring as stream temperatures rise, but do not venture more than a few kilometres from river mouths, and they may remain there for up to three months (FishBase 2006 and references therein).

In Sweden brook trout have been shown to be able to disperse upstream from the point of introduction. Björkelid (2004) has shown that brook trout can disperse against the flow and across barriers such as waterfalls, and colonize the narrow headwaters of a watercourse. It can even move trough mires at high water flow, thus potentially gaining access to the headwaters of adjacent drainage areas.

Impact

Affected habitats and indigenous organisms
Introduction and stocking are activities strongly affecting the distribution and structure of fish communities in lakes. In a study of lakes in Fennoscandia, Rask *et al.* (2000) found that one third of the lakes had at least one introduced species. The greatest number of introductions concern native species that are translocated within their range, but non-native species, especially from North America, are also used to a large extent. Some of these, such as rainbow trout (*Oncorhynchus mykiss*) are rarely able to establish self-reproducing populations, and are dependent upon continuous stocking for their presence in the area (*ibid.*), whereas others, such as brook trout, have established hundreds of self-reproducing populations in lakes and watercourses (Pakkasmaa & Petersson 2005).

Studies from North America on the effects of introductions of brook trout into waters where it is not native have shown impacts such as decline of native salmonid species. Species that have been replaced or negatively impacted include strains of cutthroat trout (*Oncorhynchus clarki*), golden trout (*O. aguabonita*), and bull trout (*Salvelinus confluentus*). It has also been hypothesized that brook trout may have been responsible for the lack of success in establishing populations of Arctic grayling (*Thymallus arcticus*) through stocking (Fuller 2006a and references therein). Brook trout has also been identified as one of the factors contributing to the continued decline of threatened populations of chinook salmon (*Oncorhynchus tshawytscha*) (Levin *et al*. 2002). In addition to out-competing the salmon, they may be important predators of salmon eggs and juveniles (*ibid.*).

Conversely, brown trout, a species not native to North America, has replaced brook trout in some of its native waters (Fausch & White 1981 in Fuller 2006b).

While many investigations focus on interactions with other species of fish, in particular salmonids, there are studies that explore other potential endpoints, from the level of individual species to ecosystem processes that may be impacted by introductions of brook trout. These include effects through predation on various species of amphibians (frogs, toads and salamanders), zooplankton (*e.g.* daphnids and copepods) and other invertebrates (*e.g.* various life stages of mayflies, caddis flies, and diving beetles) up to increases in primary productivity through predation on grazing invertebrates (Dunham *et al.* 2004 and references therein). Schindler *et al.* (2001) found that trout introduced to previously fishless oligotrophic mountain lakes fundamentally altered nutrient cycles, and stimulated primary production by accessing benthic sources of phosphorous that would normally not be available to pelagic communities in such waters. At the landscape scale, introduced trout, including brook trout, have been suspected of having contributed to the decline of mountain garter snake (*Thamnophis elegans elegans*) populations in the Sierra Nevada (US), through predation on amphibians, a common prey for trout and snakes (Matthews *et al.* 2002).

It is often traits that promote a strong competitive ability, such as broad feeding range, fast growth rate, lack of predators or parasites, and wide tolerance to abiotic conditions that make non-native species of fish popular for introductions (Welcomme 1992). This certainly applies to brook trout, which has a fast growth rate, wide dietary range, and is more tolerant to a low pH in the water than *i.e.* the native brown trout.

The biology and ecology of brook trout is rather close to that of native salmonids such as brown trout (*Salmo trutta*), salmon (*Salmo salar*), Arctic charr (*Salvelinus alpinus*) and grayling (*Thymallus thymallus*) (AquAliens 2002). For brown trout similarities include habitat and temperature requirements, feeding habits, and life history characteristics such as spawning time

(Öhlund 2002 and references therein). Since the two species have not evolved together, there has been no selection towards their developing differences in resource use, and it is likely that there will be competition for a limited resource if the two species are brought together (Fausch 1988 in Öhlund 2002.).

Competition for space (such as position in a stream, which is critical for access to food and cover) is one area where interactions can be expected. The pattern of distribution when brook trout co-occurs with brown trout, in Sweden as well as in North America, seems to be that brook trout mainly occupies small streams or the upper headwater reaches of river systems, and that these are the localities where brook trout is likely to be competitively dominant (Öhlund 2002 and references therein). Abiotic features of these habitats include lower water temperature and a high proportion of upwelling groundwater, making them less influenced by ambient air temperature. Other features of habitats where brook trout is found include low productivity and lower structural heterogeneity (*ibid*.).

In a comparison of sympatric and allopatric populations of brook and brown trout in Sweden, based on electro fishing and national electro fishing data, Öhlund (2002) found it likely that brook trout had a negative impact on brown trout in terms of lower growth rate, delayed maturation and higher apparent mortality in sympatric populations. Since female brook trout have potentially higher growth rates than brown trout, and can mature at smaller size, the reproductive potential of brook trout may substantially exceed that of brown trout in habitats with low productivity. A combination of abiotic factors and behavioural differences "might gradually decrease the ability of brown trout to withstand competition from brook trout as stream size and or productivity declines" (Öhlund 2002).

Indirect effects on other species, including endangered species, may occur through the replacement of native species such as brown trout with brook trout. Brown trout and salmon (*Salmo salar*) are the only hosts for the parasitical larval stage (the glochidia) of the freshwater pearl mussel (*Margaritifera margaritifera*), a species listed as vulnerable on the IUCN Red List of Threatened Species. Brook trout can not serve as a host to the glochidiae; even strains of brown trout that are not native to the water body may be inefficient as hosts to the larvae, and if no hosts are present the reproduction of the mussel will fail. According to the Swedish Action Plan for the conservation of the freshwater pearl mussel, introduced species are one of the factors that may have a negative impact on this species, and introductions of ***e.g.*** brook trout should not be permitted in waters where *Margaritifera margaritifera* is still present (Naturvårdsverket 2005).

Genetic effects

Genetic effects may occur through ***i.e.*** hybridization, which can lead to a loss of local adaptations and failure to reproduce by native species. Brook trout can form viable hybrids with native as well as other introduced salmonid species. Some of these hybrids are fertile and can maintain self-reproducing populations.

Splake is a cross between a male brook trout and a female lake trout (*Salvelinus namaycush*), another North American species. Splake is genetically stable and capable of reproducing. It possesses characteristics of both parent species, but exhibits a higher growth rate and lives longer than either. In appearance it is closer to lake trout, though more speckled on the back (Smedman & Svärdson 1966). **Sparctic charr** is a cross between brook trout and Arctic charr (*Salvelinus alpinus*). Sparctics grow faster than either parent species, are more robust, and thus popular for sports fisheries. Some of these hybrids are fertile (Muus & Dahlström 1981). **Tiger trout** is a cross between a female brook trout and a male brown trout (*Salmo trutta*). Hybrid mortality is high, and

survivors are sterile, but it is considered a good game fish. Tiger trout is mainly the result of an artificial cross (*i.e.* they are produced in hatcheries), but hybridization can occur in nature (Fuller 2004).

Sparctic charr and splake have been found locally in Sweden, *e.g.* in the Piteälven (Tjeggelvas) and Skellefteälven (Ikesjaure) Rivers in the northern part of Sweden, but are believed to be relatively uncommon (Josefsson 1999 and references therein). In a nationwide survey to assess the distribution of fish species in Swedish lakes performed in 1996, splake was again reported from two localities (Appelberg *et al.* 2004). Sparctics have also been observed in Germany (Geiter *et al.* 2002), and a study of brook trout hatchery stocks in Germany (Bavaria) found that of the two stocks studied, the frequency of hybrids was 3 to 100 % (Gross *et al.* 2004).

Splake (SPeckled LAKE trout)	*Salvelinus namaycush* x *S. fontinalis*
Sparctic charr (SPeckled ARCTIC charr)	*Salvelinus fontinalis* x *S. alpinus*
Tiger trout	*Salvelinus fontinalis* x *Salmo trutta*

Human health effects
No available information.

Economic and societal effects (positive/negative)
Brook trout is mainly used for sports fisheries. In addition to its value for individual fishermen, recreational fishing and tourism may create a demand not only for food, accommodation and transportation, but also for related recreational activities such as camping, boating, canoeing, etc; all of which may provide economic opportunities locally. In areas where native species of salmonids have disappeared because of acidification, brook trout is likely to be seen as a positive replacement.

In addition to the ecological risks involved in introductions of alien species, economic gains must however also be weighed against the short- and long-term costs associated with a fishery based on stockings of an introduced species (*cf.* Dunham *et al.* 2004).

Management approaches

Prevention methods
Brook trout was originally intentionally introduced. Established populations may be difficult – and costly – to control or contain, but further introductions, if any, should in principle be possible to control, and, as with all intentional introductions, the precautionary principle adhered to. To prevent unauthorized introductions, information about risks and relevant rules should be made available.

To minimize the risk of unwanted side-effects from introductions and transfers of aquatic species, such as the spread of diseases and pathogens, the European Community has recommended its members to adhere to the *ICES Code of Practice on the Introductions and Transfers of Marine Organisms* (ICES 2004b), and the corresponding European Inland Fisheries Advisory Commission (EIFAC) *Code of Practice and Manual of Procedures for consideration of introductions and transfers of marine and freshwater organisms*. The new (2007) EC *Council Regulation concerning*

use of alien and locally absent species in aquaculture (European Commission 2007), is a part of the Community's strategy for the sustainable development of European aquaculture (European Commission 2002). The proposed Regulation introduces an obligatory permit system for all movements to aquaculture facilities in the Community, and requires that all movements that are considered "non-routine" be preceded by an environmental risk assessment. It further requires that a register of introductions and translocations be kept by a designated national authority. The brook trout however, is one of the 10 species that is exempted from these regulations.

National legislation concerning intentional introductions of alien species has become more stringent; from in many cases no limitations at all to an increasing number of restrictions and outright bans on introductions. Most countries in the NOBANIS area require as a minimum a permit from a national authority for the release of alien species of fish into natural waters, sometimes including a general prohibition on the importation and/or release of alien species. Some have "white lists" of alien species for which permission may be granted (*e.g*. Sweden, including brook trout and splake), others have "black lists" of species that may not be introduced (*e.g.* Estonia). Some countries have even developed legislation and national strategies specifically dealing with alien species and populations. For further information about national legislation in the NOBANIS area, see www.nobanis.org/Regulations.asp.

Eradication, control and monitoring efforts
Experiences from the United States shows that attempts to eradicate trout have varying degrees of success. The use of piscicides such as rotenone can pose serious risks to other species, and methods not involving chemicals that have been successful include systematic electro fishing in streams (Dunham *et al.* 2004 and references therein), and gill netting in small lakes (Hoffman & Larson 1999a, Parker *et al.* 2001).

There are examples of how removal of brook trout has led to the reestablishment (through recovery or recolonization) of various species including salamanders (Hoffman & Larson 1999b), frogs (Vredenburg 2004), and zooplankton (Parker *et al.* 2001), but also where species have failed to reappear after brook trout removal (Parker *et al.* 2001).

Information and awareness
Raising awareness about the risks associated with introductions of alien species and the rules that apply can be an efficient means to prevent illegal introductions that are undertaken due to a lack of knowledge about the risks and rules involved. Such information could be disseminated *e.g.* through sports fishery organizations and tourist information boards.

Knowledge and research
Research on brook trout is undertaken *e.g.* within the Swedish *AquAliens* research programme, which is aimed at increasing knowledge about how to assess the risks posed by introduced aquatic species and their impact on ecosystems and economy. More information can be found at www.aqualiens.tmbl.gu.se/english.html, where the research programme can be downloaded (see Work Package 6, Aquaculture).

Recommendations or comments from experts and local communities
No available information.

References and other resources

Contact persons

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Links

Alien species in Swedish waters. *Salvelinus namaycush*

Animal Diversity Web: *Salvelinus fontinalis*

FishBase: *Salvelinus fontinalis*, Brook trout

Personal comments

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