Invasion of the turtles?

Exotic turtles in the Netherlands: a risk assessment

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Commissioned by the Invasive Alien Species Team of the Food and Consumer Product Safety Authority

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Abstract

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We assessed the risk of exotic turtles becoming invasive in the Netherlands. Main components of this risk are the large scale of introduction of discarded pets to Dutch nature and the possible suitability of species to survive and reproduce successfully under present or future Dutch conditions which is enhanced by climate change. We establish a list of risk species, identify risk areas and discuss prevention, elimination and management measures. A number of recommendations is made.

Keywords: invasive species, alien species, exotic species, turtles, risk assessment

Cover: The Red-eared Slider, *Trachemys scripta elegans* in a pond in Oud Ade in 2006. © Renée de Kleijn.

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Summary

When species occur outside their native range they are called exotics. If they manage to become established in foreign territory and rapidly increase, they have become invasive there. At the moment, a number of exotic turtle species are present in Dutch nature. Especially the Red-eared slider *Trachemys scripta elegans* is regularly observed in many locations across the country. However, the Dutch turtle population consists almost exclusively of discarded pets and none of the species now present is as yet able to reproduce successfully. Presently they are therefore not invasive but climate change and the introduction of other, better suited turtle species could possibly change this.

Invasive species can cause major damage to native ecosystems and economy and could also present a risk to human health. The risks are determined by two general factors: 1) the likelihood they manage to become invasive which depends in turn on a combination of their ecological suitability for the environment at risk and the rate of introductions, and 2) the risk of impact once they get established. The one possible exception is the risk of introduction of dangerous alien diseases or parasites by exotic species. The big risk is that these could start rapidly spreading through native carries, once they are introduced by exotics. The damage in this case therefore does not depend on the invasion risk of the exotic carrier but merely on the rate of its introductions.

In this report we primarily investigate the 'invasion risk' and to a lesser extent the 'damage risks' associated with exotic turtle species. This study includes all turtle species worldwide except the Sea turtles, since there is presently no indication that any of these species has any chance to become invasive in Dutch ecosystems under present or future conditions.

Climate change can be expected to improve future conditions for turtles in the Netherlands considerably. We therefore first described the present and expected Dutch climate (up to 2050) and produced maps of other areas in the world with comparable climate characteristics. This enabled us to identify which species are native or invasive in these areas and therefore would possibly be able to survive and breed over here before 2050. In the assessment of risk species we also included the present occurrence in Dutch nature and pet trade or care centres, as a measure of introduction risk. Additionally, we screened literature to identify possible disease carriers. The resulting list is presented in Table 5 which is repeated below.

Table 5
Turtle invasion risk classification for the Dutch situation till 2050.

No risk	Possible risk	Risk	Substantial risk
Terrestrial tortoises*	*Chelodina longicollis*	*Chelydra serpentina*	*Trachemys scripta elegans*
All aquatic turtles not sufficiently matching criteria (see text)*	*Clemmys guttata*	*Apalone spinifera*	*Trachemys scripta scripta*
	Clemmys insculpta	*Graptemys geographica*	*Trachemys scripta troostii*
	Clemmys marmorata	*Pelodiscus sinesis*	*Graptemys pseudogeographica*
Probably becomes established but is then no longer exotic: *Emys orbicularis*	*Clemmys muhlenbergii*		*Chrysemys picta*
	Emydoidea blandingii		*Sternotherus odoratus*
	Pseudemys rubriventris		

The invasion risk for none of the species is assessed as higher than substantial, mainly because reproduction rate, as well as egg and juvenile survival of turtles in general, will likely still be low even under improved future Dutch conditions. There is very little specific information on the possible impacts of species available. We therefore assessed the possible impact of all species as being rather comparable. With the exception of the Snapping turtle *Chelydra serpentina* whose impact on humans could be large due to the biting risk, none of the impact risks were estimated to be more than considerable. The final risk classification was therefore for all species the same as the invasion risk in Table 5, except for the snapping turtle that was upgraded to 'substantial'. The complete risk classification results can be found in Table 6.

Since all the risk species are aquatic, the areas in the Netherlands that are most at risk for turtle invasions are water systems which have a high ecological status. Water bodies with endangered species (e.g., amphibians like the tree frog, crested newt, or common spade foot toad) are likely to be particularly vulnerable. Risk areas are also areas in which capture of turtles will likely be difficult. These are for instance 'De Biesbosch', 'De Oostvaardersplassen' and the 'Wieden-Weerribben'. All these areas however lie in parts of the Netherlands where the climatic conditions can be expected to become suitable at a relatively late date (see Figure 6). The areas likely to be first at risk are therefore the brook systems in Limburg and Brabant.

The best way to reduce the risk of exotic turtles becoming invasive in the Netherlands is by preventing they are discarded in large numbers, which is presently the main problem. This could possibly be achieved by a combination of trade regulation measures and publicity campaigns targeting both pet dealers and their customers. This should on the one hand prevent the selling in large quantities of the most risky species and on the other hand the discarding itself. The risk presented by the turtles already present in Dutch nature could possibly be reduced by having them gradually removed by professional musk-rat trappers and/or volunteer organizations. When established populations need to be eliminated or decimated, turtles can relatively easy be removed using non-destructive traps or seining.

Terminology and abbreviations

Turtle

The word turtle is widely used to describe all members of the order Testudines. However, it is also common to see certain members described as terrapins, tortoises or sea turtles as well. Precisely how these alternative names are used, if at all, depends on the type of English being used:

- British English normally describes these reptiles as turtles if they live in the sea; terrapins if they live in fresh or brackish water; or tortoises if they live on land. However, there are exceptions to this where American or Australian common names are in wide use, as with the Fly River turtle.
- American English tends to use the word turtle as a general term for all species. 'Tortoise' is used for most land-dwelling species, including the family Testudinidae and box tortoises. Oceanic species are usually referred to as sea turtles. The name 'terrapin' is typically reserved only for the brackish water diamondback terrapin, *Malaclemys terrapin*; the word terrapin being derived from the Algonquian word for this animal.
- Australian English uses turtle for both the marine and freshwater species, but tortoise for the terrestrial species.

In this report we will use 'turtle' for all aquatic and 'tortoise' for all terrestrial species. Exceptions are only made if the common name already deviates from this rule, as for instance in the diamond back terrapin *(Malaclemys terrapin)* (from: http://en.wikipedia.org/wiki/Turtle).

Temperature dependent Sex Determination (TSD)

In most turtle species, the gender of hatchlings is determined by the incubation temperature of the eggs. Two variations occur in turtles: **TSD 1a** where incubation below a pivotal temperature results in only males, incubation above it in only females and only incubation at a usually narrow range around it in both sexes (also indicated as Male - Female or **MF**). And **TSD II** where two pivotal temperatures around which both sexes are produced occur, with only females hatching below the lower and above the upper one and only males in between (**MFM**).

Genotypic Sex Determination (GSD)

The 'normal' sex determination type in which hatchling gender depends on chromosome configuration.

Successful reproduction

The term successful reproduction refers in this report to hatching of both males and females.

Established occurrence

A species is established somewhere when it has formed a sustainable population (i.e. including effective reproduction ability).

CDC	Centres for Disease Control and prevention, USA
CITES	Convention on International Trade in Endangered Species
DAISIE	Delivering Alien Invasive Species in Europe project funded by the sixth framework programme of the European Commission
EL&I	Dutch Ministry of Economic Affairs, Agriculture and Innovation

GISD	Global Invasive Species Database
ICWDM	Internet Centre for Wildlife Damage Management
ISSG	The Invasive Species Specialist Group (ISSG) is a global network of scientific and policy experts on invasive species, organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN)
IUCN	International Union for Conservation of Nature
LNV	The previous Dutch Ministry of Agriculture, Nature and Food Safety
NOBANIS	The North European and Baltic Network on Invasive Alien Species
RAVON	Reptielen, Amfibieën en Vissen Onderzoek Nederland: Reptile, Amphibian & Fish Conservation Netherlands
USGS	United States Geological Survey

1 Introduction and general approach

According to the definition used by the Dutch Ministry of Economic Affairs, Agriculture and Innovation (EL&I), an **exotic** species is:

*a non-native plant, animal or micro-organism that is not able to enter the Netherlands by its own efforts, but through human activity (transport, infrastructure) and has entered nature in the Netherlands, or threatens to do so in the near future. Species that enter the Netherlands by their own efforts, due to climate change for instance, fall outside this definition [..]. An exotic species can be said to be **invasive** if it establishes and develops at an explosive rate' (LNV, 2007, see also Figure 1).*

The occurrence of an exotic species is therefore not automatically an invasion, to become one the species at least has to increase rapidly in numbers. Such an increase is usually driven by reproduction but can in principle also be man-made if a continuous supply of individuals is being released into the environment. Once established however, invasive species are notorious for the huge damage they can cause to indigenous flora and fauna and the costs potentially involved in their management. Presently, there are no turtle species occurring naturally in the Netherlands, but a number of exotic species are observed in Dutch nature with some regularity. The website www.waarneming.nl shows observations for six North-American aquatic turtle (sub)species and one European one. All individuals of these species are however human introduced and do not yet successfully reproduce in the wild. The species from outside Europe that are presently found in Dutch nature mainly reflect which species are (were) popular as pets and are therefore unlikely to be the ones with the best suitability for Dutch conditions.
The few observed specimens of the European pond turtle *Emys orbicularis* are likely introduced by hobbyists or people who brought it home from a holiday. At present, this species is technically an exotic but is also protected under Annex IV of the EU Habitats directive. Due to Climate Change it is expected to extend its natural range to the Netherlands within the next decades and as such is then entitled to the same protection as 'native' Habitats Directive species (EC, 2007).

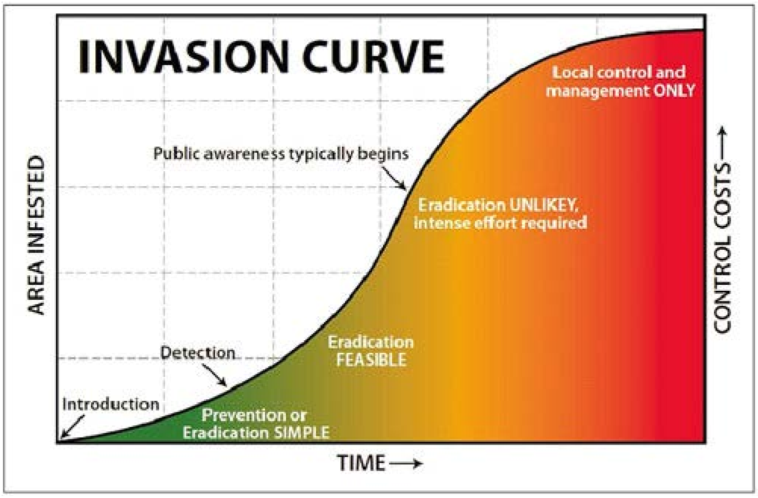

Figure 1
Schematic representation of the development of a biological invasion and the management costs associated.
From: Oregon State University website, http://blogs.oregonstate.edu/h2onc/category/landscapes/

Although no turtle species presently qualifies as an invasive, increasing but repeated observations over a number of successive years at the same locations show that specimen of at least four (sub)species can survive several years under Dutch conditions. But notwithstanding a number of observations of egg-laying, no reports of successful reproduction in the Netherlands are known. However, due to Climate Change, Dutch conditions for turtle survival and reproduction are expected to improve considerably. Additionally, other turtle species that are better adapted might become popular in the pet-trade, and can then also be expected to end up in considerable numbers in Dutch nature. Consequently, the risk of turtle species becoming invasive is potentially present for both the already 'resident' species as well as for species potentially fit for Dutch conditions. Of the latter group, the ones most suitable as pets probably present the highest risk.

Turtles in Dutch nature could potentially cause considerable harm, especially to populations of already endangered amphibian species. Additionally, exotic species can carry and/or introduce alien diseases. This infection risk could already pose a threat to the native fauna when very low numbers of turtles are present in Dutch nature. Other possible problems associated with invasive turtles are the risks of damage to infrastructure (i.e. digging through levees) and human health. The latter especially refers to the transfer of diseases that are dangerous for humans and to the damage that can be caused by a bite from larger and more aggressive specimen, *e.g*. the snapping turtle *(Chelydra serpentina)* or alligator snapping turtle *(Macrochelys temminckii)*.

Since the chance that turtles can become invasive in the Netherlands is clearly present but the possibly attached risks are largely unknown, the Invasive Alien Species Team of the Food and Consumer Product Safety Authority commissioned this risk assessment study.

The risk attached to exotic species has two components: firstly the risk of them becoming invasive, and secondly the risk presented by the damage they can do then. In this report we therefore primarily investigate the 'invasion risk' and to a lesser extent the 'damage risks' associated with exotic turtle species. This investigation includes all turtle species worldwide except the Sea turtles, since there is presently no indication that any of these species has any chance to become established in Dutch ecosystems under present or future conditions.

There are two different possible pathways for introduction of exotic species to the Netherlands: through introduction by humans (escaped/discarded pets or accidental or willing introduction) and through species extending their range to the Netherlands from populations in neighbouring countries. In both cases, their suitability for the present and expected Dutch conditions determines the probability of adult survival, reproduction success and successive population establishment. Since present conditions are generally too cold for turtle reproduction, the principle factor determining the boundary conditions for successful invasion is Climate Change. All species are assessed against this background. The risk of a turtle species becoming invasive increases: 1) if it is already present in or established at close distance to Dutch nature, 2) if it naturally occurs in or has successfully colonised areas with climatological conditions comparable to present or future Dutch ones, and 3) if it is available in the pet-trade or has 'pet potential'.

In addition, turtles can already present a significant risk to humans or native fauna species in small numbers when they are carriers of dangerous diseases or parasites.

This report will therefore:

- Describe the characteristics of the present and future Dutch climate (up to 2050) and produce maps of other areas in the world with comparable characteristics.
- Screen all turtle species for indigenous or invasive occurrence in these areas and identify 'risk species', which includes:
  - Their present occurrence in Dutch nature
  - Their known invasions in areas with similar climates to the present or future Dutch situation
  - Their occurrence in the pet trade (inventory of species offered by traders or present in care centres)

- Assess the 'risk species' on characteristics that make them possibly suitable for or might let them have a high possible impact on Dutch nature, and possible damage inflicted to infrastructure or humans.
- Describe the possible impacts of invasive turtles.
- Provide an overview of the most vulnerable areas in the Netherlands.
- Provide an overview of the options for prevention, elimination and management and make recommendations.

Reading guide

Chapter 2 first discusses the way in which ecology, climate change and introduction risk together determine whether a turtle species can become invasive in the Netherlands. Chapter 3 then discusses what is known about the types and extent of damage associated with exotic turtle introductions and invasions and the possible implications for the Netherlands. In Chapter 4 we develop criteria to determine the risk attached to turtle species and select risk species. This chapter end with an overview of these species categorized on invasion risk. In Chapter 5 we include the damage risks and present the final risk categorization. This chapter also includes descriptions of all the risk species. In Chapter 6 an overview of the possible Dutch risk areas is presented, in Chapter 7 the options for prevention, elimination and management are discussed and Chapter 8 finally contains the conclusions and recommendations.

2 What factors determine the risk of turtles becoming invasive in the Netherlands?

The risk of exotic species becoming invasive in a certain area is a combination of their suitability for the conditions in the area in question, the extent of their introduction to that area and their ability of rapid increase under the area's conditions (depending on factors like reproductive and dispersal capacity, growth rate, competition and predators, see e.g. Kolar and Lodge, 2001). In this chapter we discuss the general ecological characteristics of exotic turtles in relation to the risk that they can become invasive in the Netherlands before 2050. The role of the extent of introductions is discussed in relation to the selection of the actual risk species in Chapter 4.

For turtles to become invasive in the Netherlands, they first need to be able to survive under Dutch conditions. Subsequently they must either successfully breed or be constantly reinforced by a release of large numbers to Dutch nature. Since turtles are exothermal they are largely bound to climates warmer than the Dutch one. As our climate is changing, the question is not just which turtle species could become invasive given the present climatic conditions, but much more which species could possibly do so under the expected future ones. Possible future conditions for the Netherlands are described in Climate Change scenarios predicting conditions for the years 2050 and 2100 (KNMI 2009). Predictions for 2100 depend to a large extent on assumptions and extrapolations of mankind's current influence on climate change, consequently have a very large uncertainty and are therefore not very useful for risk assessment. We therefore only use the predictions for the year 2050 as our reference.

In this chapter we first describe the general climatic and habitat conditions required for turtles and the relationship with their general biology. Next we give an overview of the present Dutch climate and the expected changes until the year 2050. We then draw general conclusions on the likelihood of settlement of exotic turtle species under conditions from present up to 2050.

2.1 Climatic limitations for successful settlement

The approximate limits of the natural distribution of the order of Testudines in the world are shown in Figure 2.

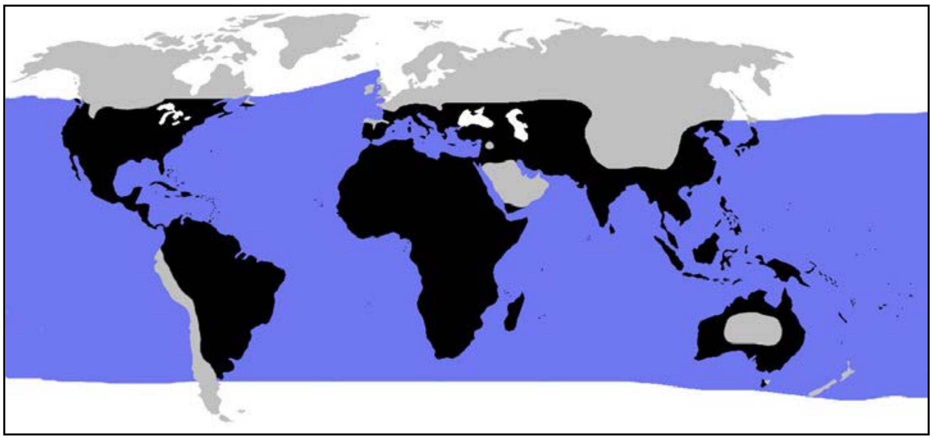

Figure 2

World distribution of turtles (Order Testudines), after data from Cogger and Zweifel (1998).
Black is land with turtles, blue sea with turtles. Grey is land without turtles, white is water without turtles (source: Wikipedia).

As the distribution of the European pond turtle *Emys orbicularis* (Figure 3) shows, this map is obviously not very accurate for Europe. Both Figures 2 and 3 however show clearly that the Netherlands are at best at the very edge of the Northern distribution limit of the Testudines, which more or less coincides with the 49th parallel.

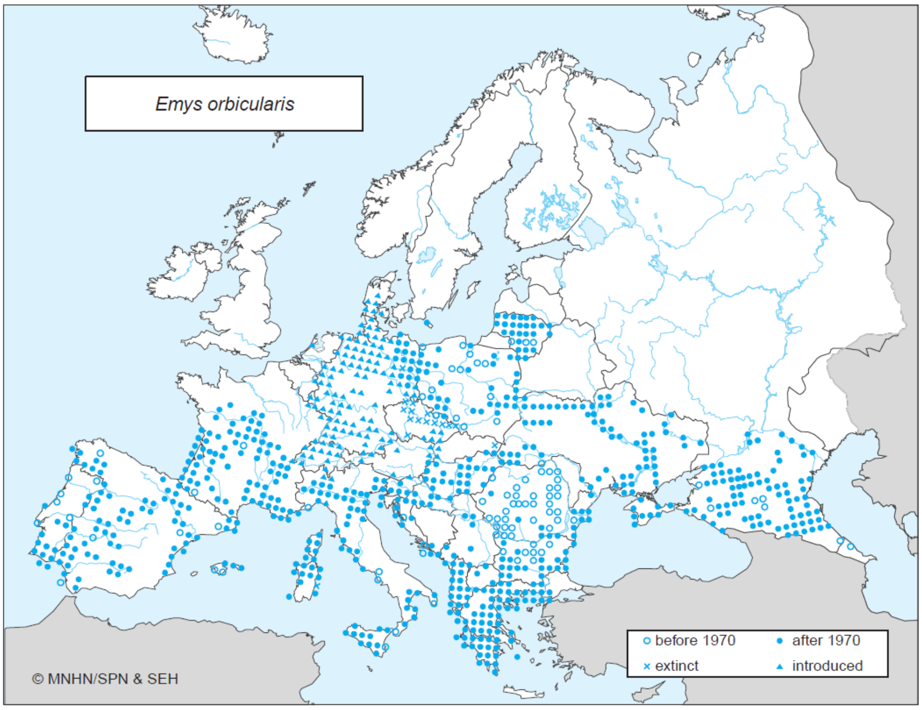

Figure 3

European distribution of Emys orbicularis, showing that the species naturally occurs as far north as Lithuania and is extending its range in North-West Europe. It is however still missing from most temperate coastal zones (source: Gasc et al., 1997).

At the moment, there are no turtle species naturally occurring in the Netherlands but as Figure 3 shows, the distribution of *Emys orbicularis* is moving towards it. This shift of *Emys* might already be due to climate change and indicates that conditions for some species now living at the very Northern or Southern limits of the turtle distribution zone might become suitable in the very near future (see also Figure 7).

Ernst and Lovich (2009) mention that the most probable factors determining distribution limits for North America's most northerly occurring species are the temperature limits for reproduction and juvenile survival. All turtles lay eggs in nests and successful development depends on the incubation temperature, i.e. the average temperature of the nesting site over the development period, being high enough. Most chelonian embryos develop successfully at incubation temperatures in the range of 24 to 32 °C, but in most species the sex ratio of hatchlings is temperature dependent (Temperature dependent Sex Determination, TSD).
Two variations are found in turtles, with the most common one, TSD 1A, typically producing only males at relatively cool incubation temperatures and only females at relatively warm temperatures. Only incubation temperatures around a pivotal temperature (typically around 29 °C) produce both sexes (Male - Female, MF).
A number of turtle species, however, has an FMF system called TSD II, in which both males and females are produced around two different pivotal temperatures. Below the first pivotal temperature range (usually around 20 - 21 °C) and above a second one (usually around 26 - 28 °C) only females are produced, and at temperatures in between the two only males (Wyneken et al., 2008). Examples of species with this second system are the common musk turtle *Sternotherus odoratus,* the snapping turtle *Chelydra serpentina* and possibly the painted turtle *Chrysemys picta*. In particular the last two have very large and far north reaching distribution zones, showing that they can successfully breed in relatively temperate climates.
A minority of all turtle species has genotypic sex determination (GSD), but as Table 6 shows this system relatively often occurs in species with distributions in relatively temperate zones. When disregarding *T. scripta* because it does not have a natural distribution in temperate zones, four out of the other fourteen species in the table have GSD, two have TSD II and one, *Chrysemys picta*, has an as yet unclear system with TSD II characteristics. Of the remaining seven, only three have a confirmed TSD 1A system. For another three species the system is not clear and for the last two no data was found. The fact that at least half of these species possess sex determination systems that allow the production of both sexes at relatively low temperatures is most likely not a coincidence.

Although it seems obvious that species with TSD II or GSD type sex determination have an advantage in temperate climates, this is not a foregone conclusion. As is shown for the European pond turtle *Emys orbicularis*, the 'normal' pivotal temperature of about 29 °C which was established at constant incubation conditions is not needed over the entire incubation period. The average may drop to at least around 26 °C under variable temperature conditions (Delmas et al., 2008), probably as long as a certain crucial part of the incubation period has a (much) higher average. This might explain the more northerly distribution of this species in the European continental climate zone. The Red Eared slider *Trachemys scripta elegans* on the other hand shows about the same pivotal temperature at constant incubation temperature, but does not successfully breed more northerly than the South of France yet (Cadi et al., 2004) which might indicate it needs a longer warm 'window'.

Temperate species typically lay their eggs in late spring and early summer, egg development occurs during summer, and hatching in early autumn (Wyneken et al., 2008). Soil temperature depends on ambient air temperature and solar radiation. It is generally slightly higher than mean air temperature. Nevertheless, mean air temperature is a very good indicator (Rödder, 2009). Therefore, apart from all other possible ecological limitations, the first question in determining the risk of a turtle species becoming invasive is if the temperatures the turtle needs for producing offspring of both sexes could be regularly reached in the Dutch summer period within the next 40 years. For successful establishment and even more so for a possible rapid increase in numbers, more than incidental success is needed. Therefore conditions need to be right in a sufficient number of places in at least the hotter than usual (but still relatively frequently occurring) years. Also, for real risks these temperature conditions need to be reached in the areas of the Netherlands with favourable turtle habitats.

2.1.1 Present Dutch average summer temperatures

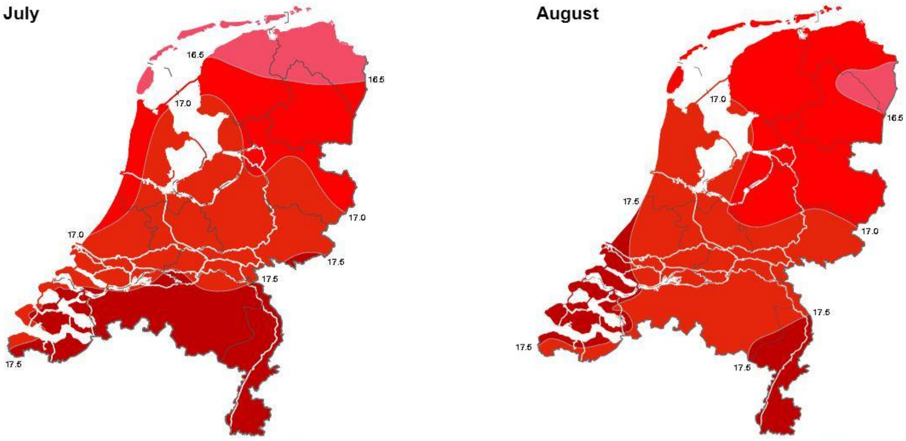

Figure 4
Average month temperature for July and August for the 1971 - 2000 period. Adapted from Sluijter and Nellestijn, 2002.

As Figure 4 shows, the normal average temperature for the summer months July and August over the 1971-2000 period in the Netherlands was approximately 17 °C. In the warm summers of 2003 and 2006 the average maximum temperature for the June - August period was 2 - 3 °C above the long term average, and as Figure 5 shows the maximal average month temperature that can then be reached is around 20 °C. Since average nesting site temperature also depends on (exposure to) solar radiation, slightly higher averages could be reached on sites with a favourable exposition and micro-climate. Even in the very warm summer of 2003 however, the periods with really hot and sunny weather did not last longer than a few weeks (Figure 5).

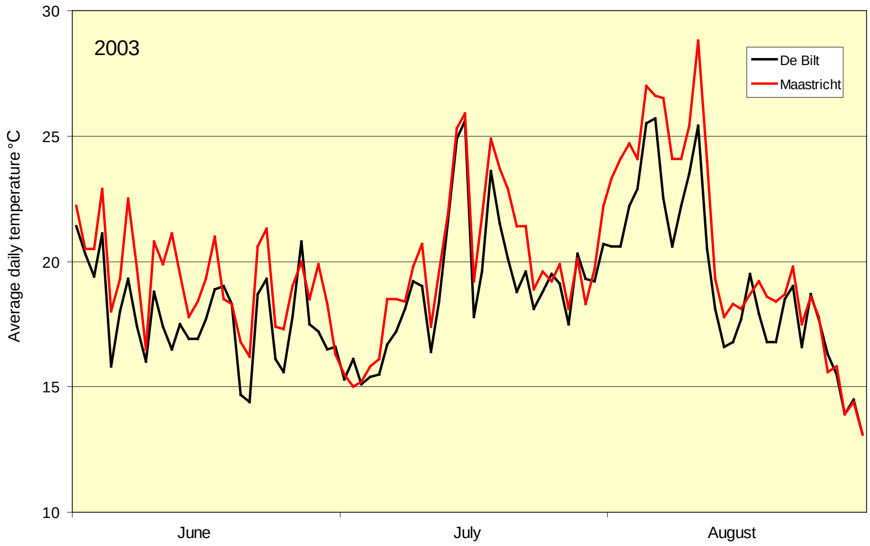

Figure 5
Average daily temperature in the months June to August 2003 for De Bilt (centre of the Netherlands) and Maastricht (most southern part of the Netherlands). From: data available on www.knmi.nl

2.1.2 Expected climate changes

The Royal Dutch Meteorological Institute (KNMI) developed four climate scenarios for the Netherlands. The characteristics of the two most extreme ones, W and W+, are shown in Table 1 below. The W and W+ scenarios are at least as likely to come true as the milder ones (KNMI, 2009).

Table 1
Characteristics of the W and W+ climate change scenarios. From: KNMI, 2009, translated.

W	Warm	2 °C global temperature rise in 2050 compared to 1990 no change in air circulation pattern in Western Europe
W+	Warm +	2 °C global temperature rise in 2050 compared to 1990 + winters warmer and wetter due to increasing Western winds + summers warmer en dryer due to increasing Eastern winds

For this risk analysis we use the most extreme W+ scenario as the primary reference because in this scenario the consequences for turtle invasion risk will be the largest.

The most important consequence of the W+ scenario for turtle settlement risk is the summers becoming warmer and dryer. This will increase the average temperature during the incubation period, lengthen the possible suitable reproduction period and increase the chance of higher soil temperatures due to less cloud cover and increased solar radiation. The scenario clearly shows an increase in the expected number of days with an average temperature over 25 °C (Figure 6).

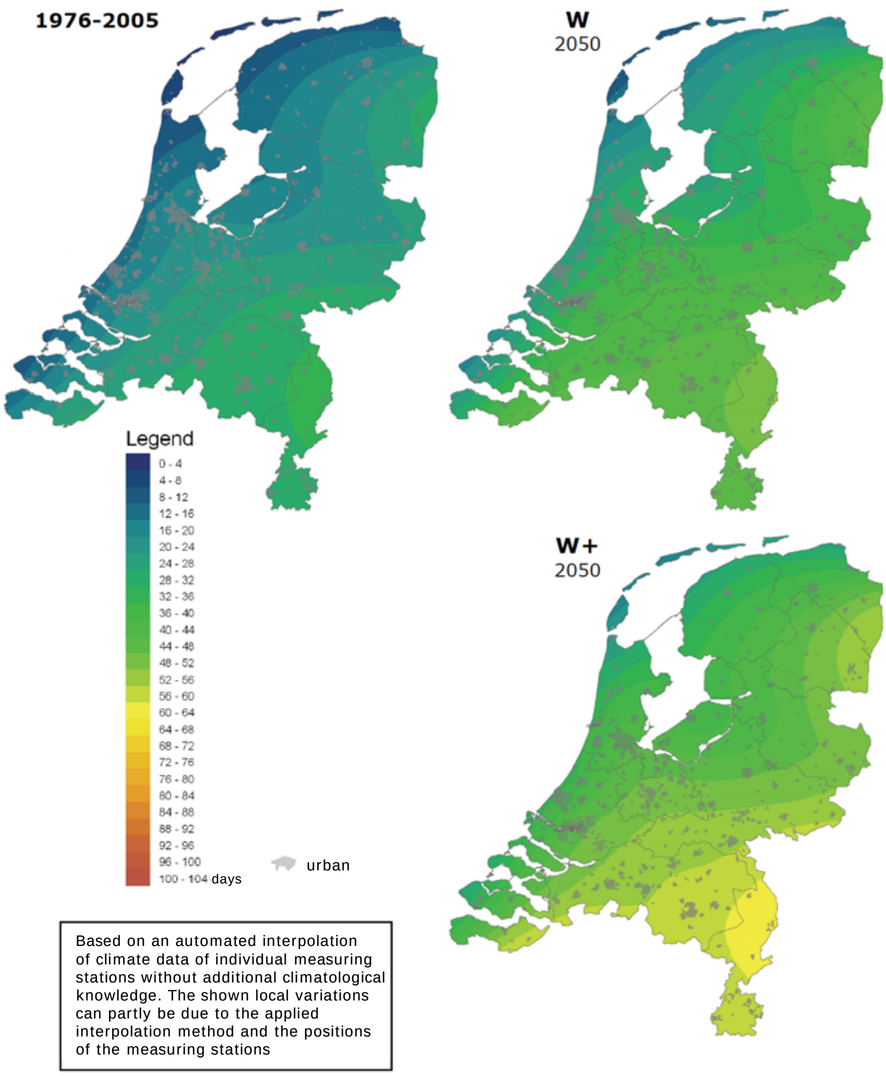

Figure 6
Expected increase in the average number of warm days (> 25 °C) by 2050 according to the W and W+ scenarios.
From: KNMI, 2009, translated.

Considering the already quite high average temperature during a few weeks in 2003 and the relatively low difference in average temperatures in that year between the South and the middle of the Netherlands (Figure 5), this could mean that by 2050 in (at least) the exceptionally hot and dry years average soil temperatures of over 25 °C could be reached for a longer period in a large part of the country.

As the prediction of the distribution changes for *Emys orbicularis* that were produced by the ALARM project shows, the Netherlands are expected to be well inside the envelope of suitable climate conditions for that species by 2050.

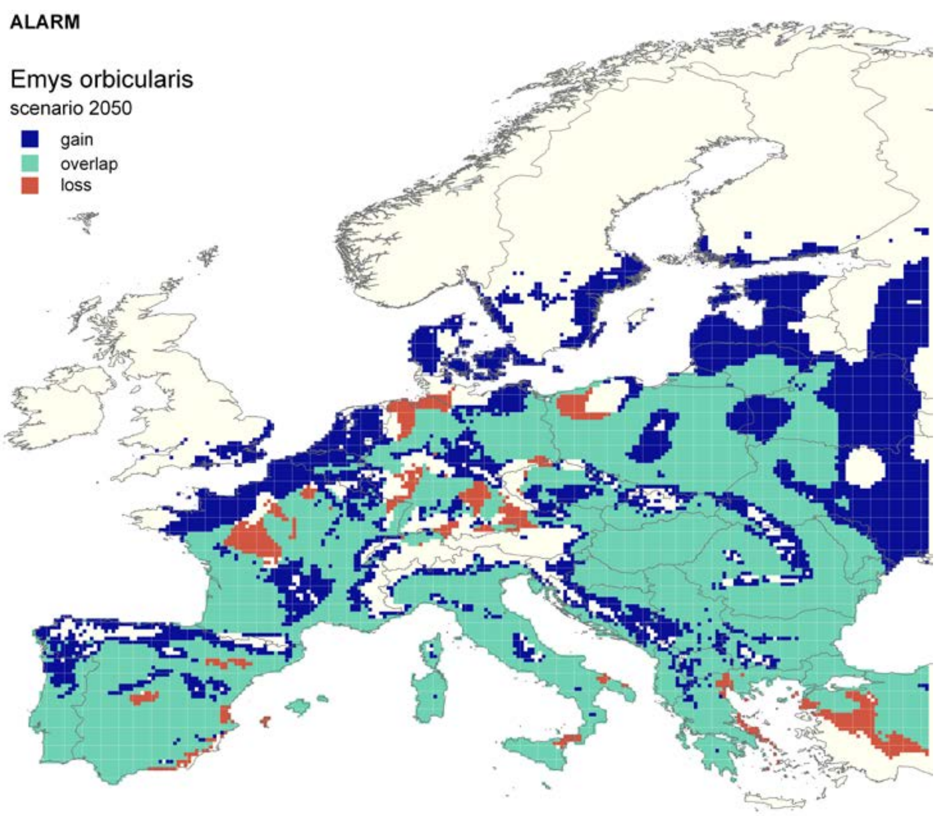

Figure 7
Changes in the zones with a favourable climate for Emys orbicularis from present to 2050.
Source: The ALARM project (www.alarmproject.net).

2.2 Ability for rapid increase

Terrestrial or fresh water turtles are not specifically known for their high reproduction or growth rates or for a large dispersal capacity (e.g. Wyneken et al., 2008). Moreover, these characteristics do not vary much across the group and are therefore not very relevant for discriminating between risk and non-risk species. They are however important for assessing the risk attached to turtles in general. In that respect we can conclude that the capacity of turtles to *develop at an explosive rate'* is generally speaking not expected to be very high, especially since species that possibly will reproduce here before 2050 will still be at the very edge of their climate envelope. There are however two factors that need to be discussed here since they can significantly influence increase rates. One of them is the help of humans and the other is a lack of competition and predators.

The role of humans
As the rapidly increasing distribution of turtles in the Netherlands (Figure 10) and for instance the figures on the spread of the Red-eared slider for Northern Europe (Bringsøe, 2006) show, the discarding of pets by humans is very likely a more important factor in facilitating rapid increase than reproduction or dispersal capacity. The effect of these introductions on the risk of species becoming established is separately discussed in Chapter 4, but for turtle species the large scale introduction by humans is also a factor that can have a significant effect on their increase once established. In fact, the risk of rapid future increase of *any* ecologically suitable species could be high, independent of the reproduction capacity of the species itself but depending on its popularity as a pet. The same is true for possible migrations of species like the European

pond turtle to our country. The speed with which such species will follow the shift of their climate zone is likely to be determined by introductions rather than by their own migration capabilities.

Lack of competition and predators

One of the factors facilitating establishment and/or a rapid spread of exotic species is the lack of competitors and/or natural enemies in their new habitat. Judging from the way in which introduced specimens seem to flourish, there is not much competition nor predation of adult turtles in the Netherlands. Since adult turtles are fairly well protected against predation by their shells and there are not many likely future predators for them in the Netherlands as well, this will probably not change very much. Larger mammals like otters and raccoons can be effective predators on adult turtles but they are not (yet) widely occurring in the Netherlands. Therefore their potential impact on turtle populations depends on their own successful increase. However, especially eggs and to a somewhat lesser extent juveniles are likely to be much more vulnerable to predation and the juveniles will most probably face a much fiercer food competition with native pond species as well. A whole range of predators for the egg and juvenile stages is mentioned for the species described later in this study. Recorded predators differ considerably between species but this is probably mainly caused by local context (presence of predators, predators being observed in the specific study or not, et cetera). However, these lists still provide an indication of which animals might be preying on turtles in the Netherlands. Translated to the Dutch situation, likely predators for turtle eggs are mice, rats, possibly the European Water Vole and all marten species. Martens and rats might also be able to eat juveniles, although contrary to eggs they might not easily recognize them as prey (yet). For this stage crows, herons, and large fish (e.g., pike) could also be predators.

2.3 Conclusion

At present, the Dutch summers are almost certainly not warm enough to allow the successful reproduction of any turtle species. This is also illustrated by Figure 8, which shows that areas with summer temperatures comparable to the present Dutch ones hardly exist anywhere else in the world. They certainly do not overlap with the general zone where turtles occur that is shown in Figure 1. When average summer temperatures (soil temperatures) however increase by 3 °C (predicted increase in annual average of 2 °C + 1° extra for the relatively warmer summers, W+ scenario), there is quite a large overlap between the zone with summer conditions comparable to our expected future climate (Figure 8) and the general turtle distribution zone (Figure 1). Moreover, the most Northern part of the distribution ranges of the North American species that extend farthest to the North (*e.g. Chelydra serpentina* and *Chrysemys picta*, distribution maps in Ernst and Lovich (2009)) closely matches the limits of these temperature zones, indicating that these can be interpreted as risk zones in the sense that species occurring in them have a high probability of being able to breed in the Netherlands before 2050. The conclusion is therefore that the expected Dutch climatic conditions for 2050 will most probably allow turtle species presently occurring in the temperature risk zones shown in Figure 8 to become invasive in the Netherlands, as far as summer temperatures are concerned. However, turtles do not possess traits like a high reproduction capacity etc. that largely determine the risk of a rapid increase although introductions by humans are a significant risk factor in this respect. Juveniles and especially eggs will probably face a significant predation risk.

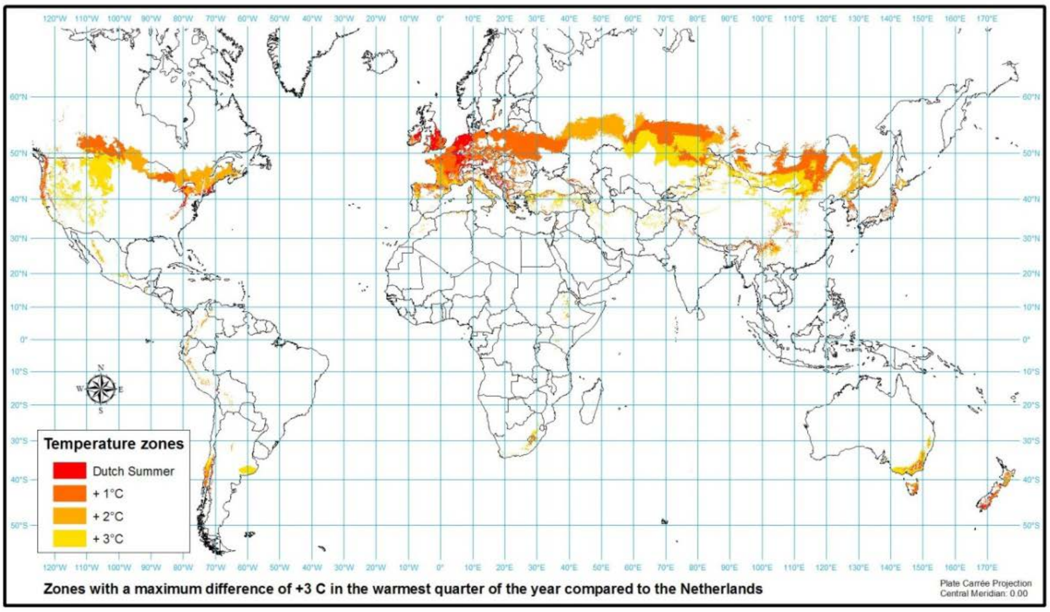

Figure 8

Zones with an average summer temperature comparable with Dutch conditions between present and 2050.
The map was produced using the Global Environmental Stratification (Metzger et al., 2011), a high resolution bioclimate map recently developed in the EU FP7 research project EBONE (www.ebone.wur.nl).

3 What are the impact risks of invasive turtles in the Netherlands?

In this chapter we will outline the possible impacts of turtles in the Netherlands. Our search for relevant information revealed that there is very little species specific information available. Anticipating the results of the risk species selection in Chapter 4 it is however clear that habits and habitats of the risk species are sufficiently alike to allow the expected effects to be described in a generalized form. What is known about the possible impacts of the specific risk species is reported in their species descriptions in Chapter 5.

3.1 Ecological impact risks

The most invasive turtle in the world is the red eared slider (*Trachemys scripta elegans*). Introductions due to releases and/or escapes from trade (for consumption or as pets) have been reported worldwide and earned the species ranking 93 on the list of the World's Worst Invasive Alien Species (ISSG, 2010; please note that only in the most Southern part of its European distribution it qualifies as an invasive according to the EL&I definition, in the other parts it is merely an exotic). Consequently, research on effects of invasive turtles focuses mainly on this species. Despite the fact that the red eared slider is such a notorious invader and is found at almost every continent save Antarctica (Salzberg, 2000; Rodder et al., 2009), the documentation of its impacts on local invaded ecosystems is still very limited. The same is true for turtles in general. What we found on relevant subjects is reported below.

3.1.1 Feeding and habits

Although some research was carried out on the possible impacts of invasive slider turtles in Europe, hard evidence of threats to the indigenous species *Emys orbicularis* (Linnaeus), *Mauremys leprosa* (Schweigger), and *Mauremys caspica* (Gmelin) in the wild, or to freshwater ecosystems is only limitedly available. In an experimental set-up in France, Cadi and Joli (2003) found sliders outcompeting *E. orbicularis* for basking sites and when housing both species in mixed groups a higher weight loss and mortality rate for the European pond turtle was found. (Cadi and Joli, 2004). Additionally, Servan and Arvy (1997) reported that *T. scripta elegans* was widely distributed and reproducing in three regions where the European pond turtle *E. orbicularis* occurred and Cadi et al. (2004) confirmed hatching of both sexes (a prerequisite for the formation of a viable population) from nests incubated in the wild. Further comparison of biological parameters with *E. orbicularis* showed that red-eared sliders were bigger, reproduced at an earlier age, had larger eggs, heavier young, and outnumbered the European pond turtle (Servan and Arvy, 1997). The earlier reproduction is caused by the fact that the minimum length of males of the red-eared slider at maturity is less than that of the *E. orbicularis* and thus males need only two to five years to reach maturity (Cagle, 1950) versus six to 16 years for *E. orbicularis* (Servan and Arvy, 1997). In 1997, the European Union banned the import of red-eared sliders on the grounds that they were having a negative effect on the indigenous European pond turtle (*E. orbicularis;* Ramsay et al., 2007).
More recent research of Polo-Cavia and co-workers (2008, 2009a, 2009b, 2010a and 2010b) confirms the competitive advantage of introduced red-eared sliders over European native turtles and in addition revealed the lack of anti-predator response of native amphibian tadpoles (Polo-Cavia et al., 2010a). They discovered that three of the four tadpole species tested reduced their swimming activity when cues from native turtles

were present in water, but not when the cues came from exotic turtles. This will favour the exotic predator in finding food and might clarify why alien predators sometimes prosper better in new habitats than locally adapted predators.
No further information of possible feeding impacts on for instance macrophytes, macrofauna, amphibians, etc. as well as on possible effects on water turbidity etc. was found.

Turtles in Dutch nature will mainly feed on macrofauna, eggs, tadpoles and juveniles of fish and amphibians and on unspecified plant material. Although the Red-eared Slider (*Trachemys scripta elegans*) is identified as one of the 100 worst invasive species in the world (ISSG, 2010), the factsheets of the invasives databases (DAISIE, 2011; ISSG, 2011; Somma et al., 2009b and 2009d; Bringsøe, 2006) do not offer much information on the specific impacts for this species. The precise ecological damage caused by turtles in Dutch nature can be assessed by extrapolating information from other (European) locations. However, information on its impacts is mainly limited to effects on native turtle species that are not present in the Dutch situation and amphibian larvae. There is no information on potential impact on aquatic vegetation and macro invertebrates.

Turtle impact in most of the waters they currently occur in in the Netherlands is expected to be rather low. The reason being that these are mainly urban water bodies with a rather low ecological status. In vulnerable habitats (e.g., ponds with rare species with a high ecological status), this could however be completely different. Therefore, for precautionary reasons the potential ecological impact of the invasive turtle species is regarded to be *considerable*.

3.1.1 Veterinary diseases and parasites

Although the list of parasites and veterinary diseases that can occur in and be transmitted by turtles is long (see for instance Exoticvetinfo, 2008), no indication was found that really dangerous (high impact) alien diseases or parasites were introduced anywhere through turtles. This does by no means indicate that no introductions happened or that there is no risk attached to them. The example of the spreading of the fungus causing Chytridiomycosis in amphibians (see e.g. Pasmans et al., 2010) shows that disease transport by any introduced species can basically have disastrous effects. It does however indicate that a possible role of turtles as an agent in spreading particularly devastating veterinary diseases or parasites is not noticed so far, where it likely would have been noticed in case of disastrous effects. The lack of any records therefore also indicates that the risk of disease or parasite introduction by exotic turtles is probably not larger than the general risk attached to any exotic species.

3.2 Human health risks

Disease transfer
Although turtles are mentioned as vectors for a number of human diseases (see e.g. Exoticvetinfo, 2008), the only reports in scientific literature on the risk of a disease transferred from turtles to humans concern Salmonellosis (Woodward et al,, 1997; Pasmans et al,, 2003; Nagano et al., 2006). Woodward and co-workers (1997) report that from 1993 to 1995, more than 20,000 laboratory-confirmed human cases of salmonellosis occurred in Canada. Although the major source of Salmonella infection was food, an estimated 3 to 5% of all cases of salmonellosis in humans were associated with exposure to exotic pets like turtles. In the United States, pet turtles were estimated to have caused 14% of reported human cases of salmonellosis, or 300,000 cases of salmonellosis annually, in the early 1970s (Lamm et al., 1972; Williams, 1999, in Bunnell, 2005). Reptiles, including turtles, transmit an estimated 74,000 cases of salmonellosis to people in the United States annually. The 'National centre for Infectious Disease' (CDC) in the USA warns on its website for the risk of *Salmonella* for humans who keep turtles as pets (CDC, 2010). *Salmonella* are naturally occurring

bacteria in turtles and those with *Salmonella* usually do not appear sick in any way. In addition, turtles do not shed *Salmonella* all of the time, so a negative test does not mean the turtle is clean. Infection of humans with *Salmonella* by turtles usually concern young children who tend to put small turtles in their mouth. Some cases may cause severe illness, hospitalization and even death in susceptible people such as children under 5, the elderly, and people who have lowered natural resistance to disease due to pregnancy, cancer, chemotherapy, organ transplants, diabetes, liver problems or other diseases. Therefore the CDC recommends to thoroughly wash your hands after handling a turtle and not to keep turtles as pets when members of the family are in the risk category (CDC, 2010). To prevent infections of children, the United States Food and Drug Administration banned the sale of sliders *(Trachemys scripta ssp.)* under four inches (10 cm) carapace length in the United States and Canada in 1975. Four inches is thought to be over the maximum size that a child can easily put into its mouth (Williams, 1999, in Somma and Fuller, 2009).

Biting risk and its possible social impact

There are two species of which the larger specimens can inflict serious damage to humans through bites. Those are the snapping turtle *(Chelydra serpentina)* and alligator snapping turtle *(Macrochelys temminckii)*. Because Dutch people are not accustomed to encounter turtles in the wild, the risk of especially curious children being bitten while handling a captured turtle is considerable. Bites with serious damage can possibly also lead to a media hype about the danger of getting attacked by 'dangerous' alien species. Although the actual public health risk might be rather small due to the low risk of encountering, a Snapper in the wild, such biting incidents could certainly result in a certain degree of social discomfort.

3.3 Economic impacts

Although turtles are unwanted visitors of fish farms, real economic impacts of the presence of invasive turtles could not be found in literature. There is also no information on any effect of turtles on Dutch fish farms.
In contacts with members of Dutch water boards a concern was raised that hibernating turtles might tunnel into banks and watersides thus weakening them. Further interviews with local surveyors could not confirm this phenomenon and an internet survey did not yield any indication that damage caused by digging is even possible. Furthermore, a more general internet survey on damage in connection to turtles did not yield anything specific. Although the risk that unexpected effects might surface after when a species becomes sufficiently abundant can never be excluded, there is presently no indication for any real economic impact of invasive turtles.

4 Risk species

In this chapter we first establish selection criteria and then select risk species.

As discussed in the previous chapters, only species with the ability to become invasive are a possible risk. This chapter deals with their selection. The exception are possible disease carriers that will be selected separately. The damage risk attached to the selected species is dealt with in the next chapter.
Factors like the probability and extent of dumping (indicated by species already present in nature, in trade or care centre custody), the ability to survive in Dutch nature and the occurrence of species (naturally or introduced) under climatic conditions comparable to the Dutch ones between present and 2050, are obvious factors that need to be taken into account when assessing the risk of turtle species becoming invasive.

4.1 Selection criteria

Since turtles are not indigenous in Dutch ecosystems, every turtle that somehow manages to survive in the Dutch environment poses a risk. The risk attached to *introduced* specimens can roughly be split up in three categories:

1. The animals do not survive very long, but long enough to possibly transfer any disease carried by them to the native fauna.
2. The animals survive for a longer period and several introduced individuals of the same species become an established population. But although egg-laying and even single sex hatchings might occur, there is no successful reproduction. The population is kept stable or increases solely due to more releases. The introduced turtles become an additional component of the local ecosystem and impact on other native species (e.g., native turtles, fish, amphibians, macro-invertebrates) that are not (yet) adapted to the presence of turtles.
3. The established animals of the same species reproduce successfully. This enables the species to expand the 'colonized' area on its own accord and so to impact on a greater proportion of the ecosystem.

The actual risk for all three categories described above obviously depends on the extent of introductions to nature. A risk assessment therefore must include three components: 1) introduction risk, 2) establishment risk, and 3) disease introduction risk.

To characterize possible risk species we therefore used a three-way approach (Figure 9).

Firstly, the species currently present in the Netherlands were identified. These species are either already occurring in Dutch nature or are on sale as pets (or, as a consequence of this, in the custody of specialized care centres). Popularity in the pet-trade was included as an indicator because almost all turtles released to nature are discarded pets. Moreover, species popular in pet-trade are likely candidates for future release to the wild.

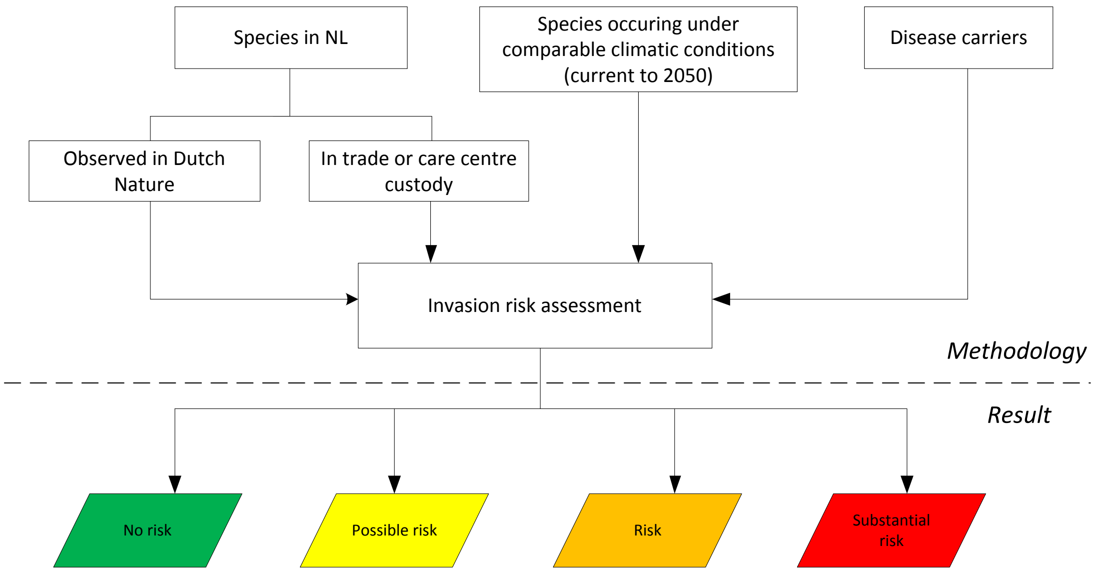

Figure 9
Schematic representation of the selection of potential risk species and invasion risk assessment.

Secondly, species occurring (as natives or invasives) in regions with comparable climatic conditions to the Dutch situation till 2050 were identified. These species are of interest since they are likely able to establish populations under either the current or expected Dutch climatic conditions. Species possessing a TSD II or GSD reproduction system (see Section 2.1) probably offer a higher risk.

Thirdly, we carried out a separate literature and internet survey for 'turtle' in connection with 'disease carrier'.

The results of these three different steps are reported in the next sections.

4.2 Applying the criteria

4.2.1 Species occurring in the Netherlands

Species observed in Dutch nature
Seven turtle species have been observed in Dutch nature since 2000. Interestingly, all these species are aquatic turtles. An overview of the species observed is presented in Table 2.

Table 2

*Occurrence of turtles in Dutch nature from 2000 to 2010. Source: www.waarneming.nl and RAVON database (indicated with *).*

Species	Common name	# obs.	Years	First obs.
Chelydra serpentina	Snapping turtle	7	2005;2008;2009	2005
Emys orbicularis	European pond turtle	12 *[1]	2005;2009;2010	1969
Trachemys scripta scripta	Yellow bellied slider	72	2006;2007 - 2010	1999
Trachemys scripta troostii	Cumberland slider	106	2004;2006 - 2008;2010	2004
Pseudemys rubriventris[2]	Red bellied slider	5	2008 - 2010	2008
Trachemys scripta elegans	Red-eared slider	1262*[3]	2000 - 2010	1975
Graptemys pseudogeographica	False map turtle	35	2004 - 2010	2004

[1] There are also five observation for the 1969 - 2000 period registered in the RAVON database: one for 1969, two for 1975 and two for 1980.

[2] Two of the observations of (probably the same individual of) *P. rubriventris* on www.waarneming.nl were accompanied by photographs. These pictures (see Figure 13) almost certainly show a specimen of a male Western painted turtle *(Chrysemys picta bellii)*. Since this species is generally called 'Roodbuikschildpad' (Red Bellied turtle) in the Dutch pet trade, this also puts question marks against the other *P. rubriventris* observations.

[3] There are also 225 observations for the 1975 -1999 period registered in the RAVON database.

A lot of observations on www.waarneming.nl and in the RAVON database are just replications for known locations. For a better impression of the increase in distribution range for the four species that are observed in relatively large numbers, an overview of the number of 5x5 km squares in which the species occur is presented in Annex 3.

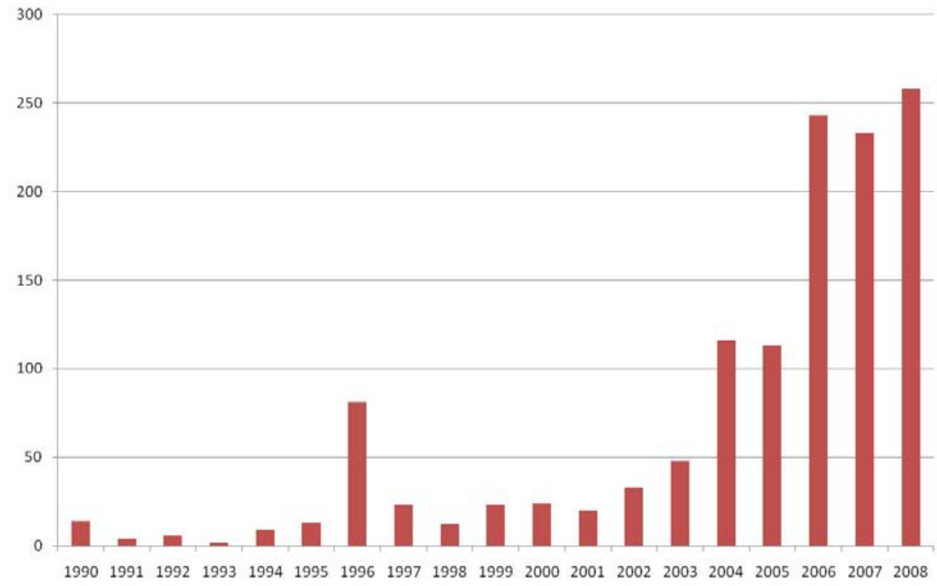

Figure 10

Overview of the increase in the number of 5x5 km squares (uurhokken) with turtle observations in the Netherlands from 1990 to 2008, the last year for which data is complete. Based on observations registered in the RAVON database.

Species in trade or in custody of care centres

It proved to be rather difficult to get clear answers from organizations involved in the trade or semi-professional care of turtles. Although the information acquired was sometimes limited or only adequately provided by one of the parties contacted, it presents the best overview of the actual situation that is possible at the moment.

The pet trade is represented by five contacted whole-sellers and twenty specialized shops. Regular pet-shops (retailers) were not contacted since they are supplied by the whole-sellers and are therefore covered. The whole-sellers reported to mainly trade in (reported in order of decreasing numbers) Cumberland sliders *(Trachemys scripta troostii),* Yellow-bellied sliders *(Trachemys scripta scripta*), False map turtles *(Graptemys pseudogeographica)*, Musk turtles *(Sternotherus odoratus)*, and River cooters *(Pseudemys concinna)*.
The amounts of animals sold varied between whole-sellers. Three sold between 1,000 and 3,000 animals per year, while two had annual sales of 10,000 to 15,000 animals. The smaller traders got their animals mainly from the two larger ones who in turn acted as importers and obtained their animals from specialized US farms. The total number of turtles yearly sold through whole-sellers in the Netherlands therefore most probably lies between 25,000 and 30,000 specimen. Animals were sold for approximately € 4 to € 7 resulting in retail prices of approximately € 5 to € 14.
Since reptiles, amphibians and insects have become rather popular pets over the last decades, several specialized stores now focus on these groups exclusively. These stores are independently organized and often act as importers themselves. They obtain their animals from several small exporters and/or breeders. These specialized shops offer a wider variety in more exclusive species for sale, undoubtedly to avoid competition with the species provided by the whole-sellers. It is therefore from this type of shops that most of the more exclusive but also more aggressive species originate.

Table 3
Species offered by a random selection of 20 specialized shops.
Additional prize information from whole-sellers or www.huisdierprijzen.nl is incorporated.

Species - Scientific name	Common name	# shops where available	Prize indication of shop in €	Prize indication web/whole-seller in €
Testudo horsfieldii	Russian tortoise	10	Not available	Juvenile 150.00 (Sub)adult 195.00
Sternotherus odoratus	Musk turtle	1	Not available	34.50
Geochelone elegans	Indian star tortoise	1	Not available	495.00
Trachemys scripta troostii	Cumberland slider	13	Not available	14.00
Chinemys reevesii	Reeve's turtle	1	Not available	
Pseudemys rubriventris	American red-bellied turtle	1	Not available	18.00
Testudo hermanni boettgeri	Herman's tortoise	5	Not available	125.00 175.00
Chelus fimbriatus	Mata mata turtle	2	Juvenile 120,- (Sub)adult 225,-	 (Sub)adult 345.00
Emydura subglosa	Red-bellied short-necked turtle	1	82,50	80.00
Geochelone carbonaria	Red footed tortoise	4	Juvenile 125.00 (Sub)adult 325.00	Juvenile 145.00 (Sub)adult 425.00
Geochelone denticulata	Yellow footed tortoise	1	Juvenile 129.95 (Sub)adult 325.00	Not available
Geochelone pardalis	Leopard tortoise	2	155.00	Juvenile 125.00 (Sub)adult 425.00
Geochelone sulcata	African spurred tortoise	10	275.00	165.00
Graptemys pseudogeographica	False map turtle	3	49.95	30.00
Kinosternon scorpioides	Scorpion mud turtle	1	17.50	35.00
Malaclemys terrapin terrapin	Diamondback terrapin	1	99.50	Not available
Pseudemys peninsularis.	Florida-slider	2	19.95	18.00
Trachemys scripta elegans	Red eared slider	1	Not available	Not available

Besides whole-sellers and specialized shops, 30 care centres were contacted. These centres range from (semi)-professional centres to private initiatives. Only five centres provided information, indicating that they receive 80 to 200 turtles per year of which only a few individuals are terrestrial turtles. Only one of the care centres provided detailed information on the animals received. This information is also annually reported to the responsible authorities. This was also the only care centre where received animals stay permanently, other centres reported to relocate animals to for instance large parks with enclosed areas (locations not specified) or, due to space limitations, to release animals back into the wild (to unspecified locations).
The detailed information of the one professional care centre shows that the centre received a total of 982 individuals of 59 species over the last 30 years. In the period 2007 till 2009, they received 510 individuals of 18 species, of which the Red eared slider (*Trachemys scripta elegans*) and the Yellow bellied slider (*Trachemys scripta scripta*) were the most abundant with 184 and 164 specimen, respectively. Despite the low response, we assume the list is fairly representative for species in care centre custody since 59 species presents about a quarter of the total number of all existing terrestrial and fresh water turtle species. A full list of the specimen received by the centre is presented in Annex 2.

The likelihood of an introduction to Dutch nature in sufficient numbers mainly depends on the availability / volume of trade of species as pets, which is directly linked with purchase price. The number of individuals of a species imported by whole-sellers, the numbers in care centre custody as well as a low whole-sellers price (< € 15) are therefore good risk indicators.

Figure 11
Turtles in a large basin at one of the care centres, Schildpaddencentrum Nederland in Alphen aan de Rijn. © Fabrice Ottburg.

4.2.2 Species occurring in areas with comparable climatic conditions

An overview of climatic risk zones for the whole world is presented in Figure 8 and a more detailed one for Europe in Figure 12. On every continent (excluding Antarctica) there are areas with climatic conditions matching the Dutch summer conditions expected till 2050. Turtles occur in all these areas, save most of inland Asia and the South American area of Chile. All these species are potential risk species because they might be able to successfully survive and reproduce in the Netherlands (Ernst et al., 2006).

The species natively or invasively occurring in the risk zones shown in Figure 8 are listed in Table 4. Note that both aquatic and terrestrial turtles occur in this table, that data on distributions outside the natural ranges is far from complete and that it does not differentiate between exotics and real invasives. Detailed data on invasive and exotic occurrences for the USA is available from the United States Geological Survey website (USGS, 2011). For Europe, the database developed by the DAISIE 6th framework project (DAISIE, 2011) is the best source encountered, but contains information that is at least for the Netherlands partly incomplete and incorrect (e.g. data for *Graptemys pseudogeographica* is missing while *Mauremys leprosa* is incorrectly listed as occurring in the Netherlands). The data is also seemingly biased towards countries for which data was available. For the other continents no data at all was easily available.

Table 4
Freshwater turtle and tortoise species occurring outside their natural range in areas with climatic conditions comparable to Dutch conditions until 2050. Note that the information is biased and incomplete because detailed data is readily available for the USA, incomplete and inconsistent for Europe and missing for other continents. Moreover, none of the available sources differentiates between exotic and really invasive occurrences.

Continent	Species	Habitat type	Invasive / occurring as exotic in
Africa	*Geochelone pardalis*	Terrestrial	-
	Pelomedusa subrufa	Aquatic	Spain
	Pelosius subniger	Aquatic	United States
	Trionyx triunguis	Aquatic	Israel
Asia	*Chinemys reevsii*	Semi-aquatic	United States, Germany
	Cuora flavomarginata	Semi-aquatic	United States
	Mauremys japonica	Aquatic	-
	Mauremys mutica	Aquatic	-
	Pelodiscus sinensis	Aquatic	United States
	Testudo horsfieldii	Terrestrial	Germany, Czech republic
Australia	*Chelonida expansa*	Aquatic	-
	Chelonida longicollis	Aquatic	-
	Emydura macquarii	Aquatic	-
Europe	*Emys orbicularis*	Aquatic	UK, NL, DE, CH, AUT, CZ*
	Mauremys caspica	Aquatic	United States, Germany, Italy
	Mauremys leprosa	Aquatic	The Netherlands**, Italy
	Testudo graeca	Terrestrial	-
	Testudo hermanni	Terrestrial	-
	Testudo kleinmanni	Terrestrial	-
	Testudo marginata	Terrestrial	-
North America	*Apalone spinifera*	Aquatic	United States
	Apalone mutica	Aquatic	-
	Chelydra serpentina	Aquatic	United States, the Netherlands, Germany
	Chrysemys picta subspec.	Aquatic	United States, Spain, Germany, Austria
	Chrysemys picta bellii	Aquatic	United States
	Chrysemys picta dorsalis	Aquatic	United States
	Chrysemys picta picta	Aquatic	United States
	Clemmys guttata	Aquatic	-
	Glyptemys insculpta	Semi-aquatic	United States
	Actinemys marmorata	Aquatic	-
	Glyptemys muhlenbergii	Aquatic	United States
	Emydoidea blandingii	Semi-aquatic	United States
	Graptemys geographica	Aquatic	United States, Spain
	Graptemys pseudogeographica	Aquatic	United States
	Graptemys pseudogeographica kohnii	Aquatic	United States
	Kinosternon subrubrum	Aquatic	United States
	Macroclemys temminckii	Aquatic	Germany
	Malaclemys terrapin	Aquatic	United States
	Pseudemys rubriventris	Aquatic	-
	Pseudemys coccina	Aquatic	Spain, Germany
	Sternotherus odoratus	Aquatic	United States
	Terrapene carolina carolina	Terrestrial	-
	Terrapene carolina major	Terrestrial	-
	Terrapene carolina triunguis	Terrestrial	-
	Terrapene ornata ornata	Terrestrial	-
	Trachemys scripta elegans	Aquatic	Worldwide
	Trachemys scripta ornata	Aquatic	-
	Trachemys scripta scripta	Aquatic	United States
	Trachemys scripta troostii	Aquatic	United States
South America	*Chelus fimbriatus*	Aquatic	Germany*
	Trachemys scripta callirostris	Aquatic	United States

List according to data from USGS and DAISIE websites
- no record found of the species as invasive / exotic
* natural range extension, does therefore not qualify as exotic or invasive according to the Dutch definition
** incorrect according to the available Dutch data

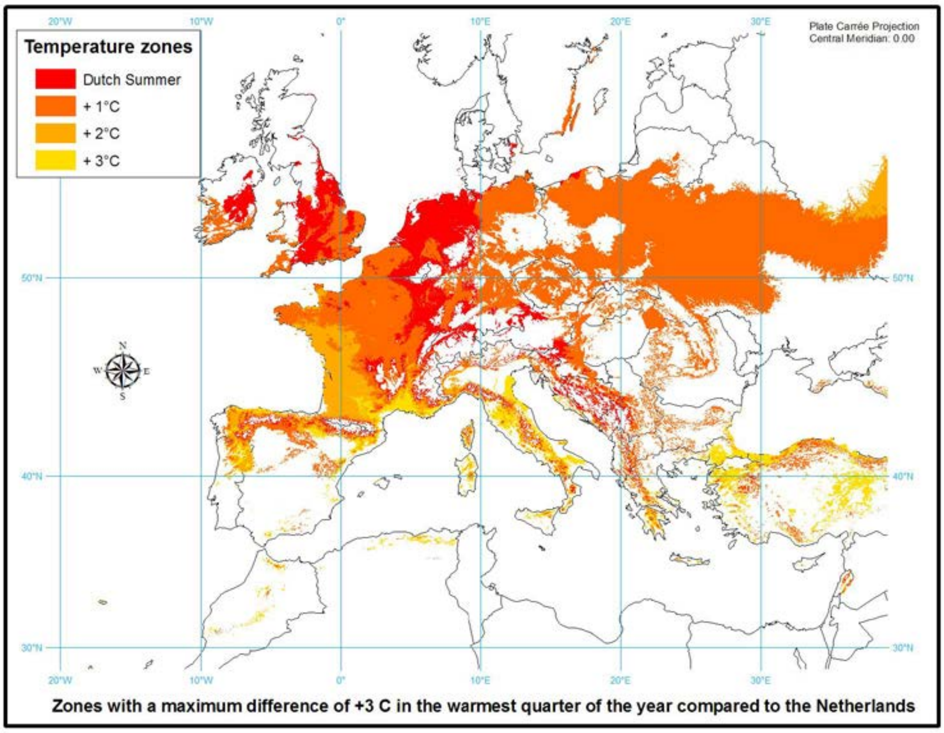

Figure 12
Turtle species established in the indicated 'risk zones' could possibly become invasive in the Netherlands before 2050.
The temperature zones are based on the Global Environmental Stratification (Metzger et al., 2011).

4.2.3 Carriers of dangerous parasites or diseases

An independent reason to include species in the risk list is when they are known or suspected carriers of a disease or parasites that can cause serious illness in humans or are serious threats to native flora or fauna. In that case only a few individuals or even just a single one can cause severe harm.

In 1975, the United States Food and Drug Administration banned the sale of sliders (*Trachemys scripta* ssp.) under four inches (10 cm) carapace length in the United States and Canada due to the risk of transmitting the disease salmonellosis (Ernst et al. 1994, in Bunnell, 2005). Four inches is thought to be over the size that a child can easily put into its mouth (Williams, 1999, in Somma and Fuller, 2009). The importation of red-eared terrapins into New Zealand was also banned by the Department of Agriculture due health concerns (Robb, 1980, in Ramsay et al. 2007). From: ISSG, 2010.

These are however the only cases of health care measures taken in relation to a specific disease carrier that were found during the literature and internet survey. This is however no disease introduction but purely a transmission risk while its agent, *T. scripta,* will already be evaluated due to the occurrence of several subspecies in Dutch nature. This survey therefore did not yield any species that should be added to the list of risk species for being a carrier of a dangerous disease. This does however not mean that there is no risk of disease or parasite introduction by turtles at all. This risk certainly exists, but will be treated as a general risk attached to the entire species group in Chapter 5.

4.3 Final list

In the previous sections, we identified quite a number of species that may present a risk of becoming invasive or harmful for various reasons. But not all of these species will also present an actual risk, now or in the near future. In this section, we report the results of an integrated assessment carried out for the potential risk group, combining all separate risk factors and resulting in a list of species characterized according to their estimated risk as *'no risk', 'possible risk', 'risk',* or *'substantial risk'* species (according to the scheme in Figure 9). As no species were identified as being a possible vector for dangerous disease or parasite introduction, this list purely reflects the estimated risk of the species themselves becoming invasive. Damage risks will be included in the next chapter.

Although some terrestrial species present in the trade originate from regions with climatic conditions comparable to the climatic conditions of the Netherlands till 2050, they are not reported in Dutch nature nor as far as could be established in any other European country. Moreover, native European terrestrial species are in decline in their natural Southern-European ranges mainly due to habitat destruction and road kills, and are therefore not likely to expand their range. Another factor is that purchase prizes for terrestrial species are comparatively high. This suggests that the people purchasing such animals are less likely to do so on impulse and are therefore also less likely to get rid of them. Although a fair number of them are turned in at care centres, these animals are more likely to be re-sold rather than to be discarded. In addition, terrestrial species are very easy to catch (unlike the aquatic species) and discarded individuals will therefore very likely be removed from nature very soon after their release. As a consequence, terrestrial tortoises are not considered to be 'risk species' and are not discussed any further.

Figure 13

This 'Red bellied turtle' was observed twice in 2008 at Den Helder - De Schoten and registered as Pseudemys rubriventris at: waarneming.nl. It quite likely is a male Western Painted Turtle (Chrysemys picta bellii). © Henk van Boeijen.

The three subspecies of the Common Slider, *Trachemys scripta*, are already present in Dutch nature in quantity and therefore have already met introduction and adult survival criteria. Although invasive / exotic populations of the Red-eared slider *T. s. elegans* overlap with the 'risk zones' indicated in Figures 8 and 12, this is mainly due to the extent of trade in this species in the past. That role (at least in Europe) is now taken over by the other two subspecies but subspecies are able to cross-breed. Risks for them are therefore linked and all three together as well as individually are categorized as a *substantial risk*.

In addition, the False Map Turtle *Graptemys pseudogeographica* also falls in the *substantial risk* category due to its current presence in Dutch nature and overlap of natural distribution range with risk zones.

From the turtles occurring in or close to regions with comparable climatic conditions to The Netherlands till 2050 (Table 4), several are available in the pet trade (Table 3), and/or already in custody of care centres (Annex 2), or basically suitable to become popular pets. Species already traded in or in care centre custody here, with large natural distributions with major overlap with the risk zones indicated in Figure 8 and with a TSD II or GSD system that enables them to reproduce successfully at relatively low temperatures generally classify as *risk* species. The two exceptions are the Painted Turtle *(Chrysemys picta)* and the Common Musk Turtle *(Stenotherus odoratus)*. Both have very well fitting ecological characteristics and are suitable pets, C. picta is possibly already observed in Dutch nature (Figure 13) and is relatively often turned in at care centres (Annex 1), while S. odoratus is reported as presently popular in trade (Section 4.2.1). They are therefore classified as *substantial risk* species. For details see the species descriptions in the next sections.

For at least three of the species observed in Dutch nature the European pond Turtle (*Emys orbicularis*), the Snapping Turtle (*Chelydra serpentina*) and the Red-bellied Turtle (*Pseudemys rubriventris*)) the number of observations is very low and consequently adult survival in the Netherlands is difficult to establish. As a precaution it is assumed that adults of these species indeed can survive. All three species therefore already met one of the most important criteria for becoming invasive. However, the European Pond Turtle *Emys orbicularis* is a native European species. It is protected under the EU habitats directive and extending its range towards the Netherlands due to natural causes (Climate Change). According to the European Commission: *When a species or habitat spreads on its own to a new area, this territory has to be considered part of the natural range* (EC, 2007). Technically, it is therefore impossible for this species to become invasive because as soon as it is able to colonize Dutch habitats it is no longer exotic (see also LNV, 2007 and Trouwborst and Bastmeijer, 2010). It therefore falls in the *no risk* category. For the Red-bellied Turtle *Pseudemys rubriventris*, all observations are rather uncertain (see Figure 13) and although the species is available as pet and basically suitable to be traded in quantity, it has a relatively small natural range that does not overlap anywhere with the risk zones indicated in Figure 8. This species is therefore only categorized as a *possible risk*. Although at the moment relatively high priced, the Snapping Turtle (*Chelydra serpentina*) could in principle be available in large quantities and at low prices when in sufficient demand, but due to the biting risk it is unlikely that it ever will become very popular. At the same time it is very northerly native occurrence indicates it could probably already become invasive under the present Dutch climatic conditions. It is therefore assessed as a *risk* species.

Species not yet traded in or in care centre custody but being basically ecologically suitable as well as suitable as pets are classified as *possible risk* species. All other species are classified as *no risk*. Table 5 presents the results of the risk classification in a concise form. A comprehensive cross table overview of risk species and risk factors is given in Table 6.

Table 5
Turtle invasion risk classification for the Dutch situation till 2050

No risk	Possible risk	Risk	Substantial risk
Terrestrial tortoises*	*Chelodina longicollis*	*Chelydra serpentina*	*Trachemys scripta elegans*
All aquatic turtles not sufficiently matching criteria (see text)*	*Clemmys guttata*	*Apalone spinifera*	*Trachemys scripta scripta*
	Clemmys insculpta	*Graptemys geographica*	*Trachemys scripta troostii*
	Clemmys marmorata	*Pelodiscus sinesis*	*Graptemys pseudogeographica*
Probably becomes established but is then no longer exotic: *Emys orbicularis*	*Clemmys muhlenbergii*		*Chrysemys picta*
	Emydoidea blandingii		*Sternotherus odoratus*
	Pseudemys rubriventris		

* As far as can be assessed using the presently available knowledge and data.

Please note: although the most risky species have been identified, this study is still based on presently available knowledge and for a large part based on species natural distributions. These are mostly determined by climatic restrictions but distribution patterns of habitat, inter-specific competition and geographic factors like the presence of barriers (e.g. mountain ranges or coasts) sometimes also play a decisive role. This means that an unknown amount of uncertainty remains considering the ecological (un)suitability of the species in the 'no risk' group. This point is perfectly illustrated by the Red-eared slider. Without the present knowledge of its survival capability in temperate climates this species would never have been assessed as a likely problem. In reality, any species that is introduced to nature in large quantities and unexpectedly turns out to possess an ability for adults survival in colder climatic conditions can establish a large presence. When such a species also turns out to have the unexpected ability to successfully reproduce in a colder climate it can really become a serious problem. Large scale introduction of *any* species can therefore always presents a serious risk!

5 Final risk assessment

In this chapter the invasion risks of the species selected in the previous chapter are complemented by an assessment of their damage risks. An overview of the results is presented in Table 6 on the next page.
The structure of the table is explained in Section 5.1. A number of impact risks have been incorporated as general risks for the species for which specific information was missing. These general risks are discussed in Section 5.2. Individual ecological descriptions of the risk species are provided in Section 5.3.

5.1 Explanation of the risk assessment overview table (Table 6)

The risk assessments shown in the table consist of two main components: 1) the risk of species becoming invasive, and 2) an assessment of the impact risks once a species has become invasive.

The factors determining the **risk of becoming invasive** were already discussed in Chapter 4 and are summarized here: all species already surviving in Dutch nature in considerable numbers with a considerable chance to be able to reproduce successfully before 2050, plus all species that are likely to be able to survive as adults and highly likely to be able to reproduce before 2050 (which means they can probably already do so under present conditions) form the *substantial risk* category. Species present in trade or care centres and likely to be able to breed over here before 2050 form the *risk* category. The *possible risk* category is made up of the species likely to be able to breed in the Netherlands before 2050 but not observed in trade, care centres or nature yet. The Red bellied turtle *Pseudemys rubriventris* is added to this category because it could already be present in Dutch nature.
All other species fall in the *no risk* category.

The general nature of possible **impact risks once a species is invasive** is discussed in Chapter 3. Although little specific information is available, the impact invasive turtles can have on native habitats and species through competition, predation, introduction of alien parasites and diseases etc. is certainly not negligible. However, very large impacts are also unlikely because these would not have gone unnoticed. Because of the general lack of quantitative or species specific information this risk is assessed as *considerable* and the same for all species. It is discussed in more detail in Section 5.2.1.
There is also little species specific information on the possible impact on humans but large impacts are again unlikely to have gone unnoticed. There certainly is a considerable biting risk attached to the Snapping turtle and the impacts of serious biting incidents could be *large* in the Netherlands. The risk of Salmonella transfer is specifically described for the sliders species and could possibly be a *considerable risk*. For the general risk for human health attached to the other species however, there is no indication of a possible problem. Moreover, discarded pets are the most likely origin of any future invasion and there is a considerably higher amount of interaction of humans with them before they are introduced to nature. As long as there are no clear problems with disease transmission in the pet trade, they are therefore unlikely to pop up in free nature. The general risk of invasive turtles for human health is therefore assessed as just *present*.

In the **assessment of total risk** the invasion and impact risks are combined. Although there is some differentiation between the species in the risks to human health, this does not lead to a much more differentiated risk assessment than the one based solely on invasion risk. The only difference is that the final classification for the snapping turtle is upgraded to *substantial* due to the biting risk. For none of the species the sum of the possible ecological and health impacts is assessed to be large enough to justify an upgrade of the final risk classification to large.

Table 6

Overview of the results of the risk assessment. The risk of breeding in Dutch conditions is mainly assessed using the temperature zones map (Figure 8). The sex determination system is probably an important factor in the ability to reproduce successfully at relatively low temperatures and is therefore indicated. TSD = Temperature dependant Sex Determination. Turtles have two variations: TSD 1a where incubation below a pivotal temperature results in only males, incubation above it in only females and only incubation at a usually narrow range around it in both sexes (also indicated as Male - Female or MF). And TSD II where two pivotal temperatures around which both sexes are produced occur, with only females hatching below the lower and above the upper one and only males in between (MFM). GSD = Genotypic Sex Determination. For further explanation of the table see text.

Name	Type	Risk factors for becoming invasive				Risk of becoming invasive	Effect risk when established		Assessment of total risk
		Numbers observed in Dutch Nature	Survival in Dutch nature	Trade and care centre volume	Breeding in Dutch conditions before 2050		On habitats and other species	On humans	
Chelydra serpentina	Aquatic				TSD II				
Trachemys scripta elegans	Aquatic				TSD 1a				
Trachemys scripta scripta	Aquatic				TSD 1a				
Trachemys scripta troostii	Aquatic				TSD 1a				
Graptemys pseudogeographica	Aquatic				TSD 1a				
Chrysemys picta	Aquatic	?			TSD II?				
Sternotherus odoratus	Aquatic				TSD II				
Apalone spinifera	Aquatic				GSD				
Graptemys geographica	Aquatic				TSD 1a				
Pelodiscus sinesis	Aquatic				GSD				
Chelodina longicollis	Aquatic				GSD				
Clemmys guttata	Aquatic				TSD 1a?				
Glyptemys insculpta	Semi-aquatic				GSD				
Actinemys marmorata	Aquatic				TSD 1a?				
Glyptemys muhlenbergii	Aquatic				?				
Emydoidea blandingii	Semi-aquatic				TSD 1a				
Pseudemys rubriventris	Aquatic	?			?				
All other (semi) aquatic turtles	(semi) aquatic				Predominantly TSD1a				
All terrestrial turtles	Terrestrial				Not assessed				
Sea turtles	Marine	Not assessed							A priori assessed as non-existent
Emys orbicularis	Aquatic		?		TSD 1a	Native as soon as established			Native as soon as established
Column legends		Never observed	Highly unlikely	None	Highly unlikely	Not applicable	None	None	Not applicable
		Low	Unlikely	Low	Unlikely	No risk*	Small	Small	No risk*
		Considerable	Probable	Considerable	Probable	Possible risk	Considerable	Considerable	Possible risk
		High	Likely	High	Likely	Risk	Large	Large	Risk
		Massive	Proven	Massive	Highly likely	Substantial risk	Very large	Very large	Substantial risk

* As far as can be assessed using the presently available knowledge and data.

5.2 Species descriptions including specific risk assessments

In this section detailed descriptions of the 'substantial risk' and more general ones for the 'risk' and 'possible risk' species are provided. Although technically not a risk species (see Section 4.3) a description of the European pond Turtle *Emys orbicularis* is also included because it is the only turtle species expected to become part of Dutch nature due to natural range extension. Unless specific references are cited, the general information in these descriptions is drawn from Ernst et al. (2006) and Ernst and Lovich (2009). Species specific information on type of reproductive system (genotypical or type of temperature dependent system) is derived from Ewert and Nelson (1991) and Valenzuela (2004).

5.2.1 Substantial risk species

Chelydra serpentina, the snapping turtle

Figure 14
The Snapping turtle. © Edgar van der Grift.

Additional sources used for general information
USGS fact sheet (Fuller et al., 2009)

Occurrence in the Netherlands
Three reports from 2005 (two dead, one caught), two from 2008 (one dead, one caught) and one uncertain observation from 2009 are registered on www.waarneming.nl. Three (probably) other ones are mentioned in the 'bijtschildpad' lemma of the Dutch Wikipedia. All of these animals were (re)captured and removed from nature. No observations are registered in the RAVON foundation database. However, as a Youtube-movie (www.youtube.com/watch?v=HTgTgVUU4n0) of a snapping turtle caught by two fishing boys in Breda in 2008 shows, not all observations end up in 'official' archives and not all caught snappers are removed from nature. Although it is likely that adult snappers can survive Dutch winters, this was not yet actually observed.

Description
Dutch name: Bijtschildpad

Family: Chelydridae

Native distribution: Mainly North America, US east of Rocky Mountains and Canada up to about 52 °N.

Distribution outside native range: The species has been introduced to California, Taiwan and China where it is being bred on turtle farms.

Conservation status: Not threatened

Habits: Highly aquatic. Rarely basks and rarely moves over land as part of their normal daily behaviour. Snapping turtles may however travel extensively overland to reach new habitat, to mate or to lay eggs. Pollution, habitat destruction, food scarcity, overcrowding and other factors will drive Snapping turtles to move overland; in their native range it is quite common to find them travelling far from the nearest water source.

Habitat: Freshwater. Sometimes also enters brackish waters, such as estuaries. Uses a variety of aquatic habitats, such as ponds, shallow lakes and slow-moving streams. Also along the banks of deep waters. Avoids fast-moving streams. Prefers water bodies with soft mud or sandy bottoms, abundant vegetation and a variety of submerged objects, e.g. branches and tree stumps, to hide underneath. The banks of the water bodies should not be too steep.

Hatching success:

Laying season:	April-November
Peak laying season:	June
Incubation time:	9-18 weeks
Optimal incubation temperature:	26.5 °C

In temperate localities, the hatchlings overwinter in their nest.

Sex determination is temperature dependant, the Snapper has a TSD II system:
- <20 °C: only females
- 21-22 °C: both females and males
- 23-24 °C: only males
- 25-28 °C: both females and males
- ≥29 °C: only females

Due to the low first pivotal temperature successful hatching under present and future Dutch conditions is likely to be possible.

Food:
Snapping turtles are omnivorous. They forage in the water. Their food consists of:
- Invertebrates, e.g. crayfish, shrimps, crabs, snails, worms, water mites, clams, leeches, freshwater sponges, insects
- Fish (adults, eggs)
- Amphibians, e.g. frogs and toads (adults, tadpoles, and eggs), salamanders
- Reptiles, e.g. small snakes, small turtles
- Birds, e.g. young water birds
- Small mammals
- Aquatic plants
- Carrion

Natural enemies:
Eggs: mink, otter, skunk, fox, raccoon, rat
Juveniles: crocodiles, alligators, fish, water birds, e.g. herons, birds of prey, otter
Adults: -
Snapping turtles do not guard their nests and do not lay their eggs near crocodile nests to prevent predation. About 90% of all nests do not survive the first 24 hours. Predation significantly decreases if carapace length >7.5 cm.

Lifespan: At least 40 years, and up to 70+ years.

Adult survival probability in the Netherlands: The species can survive well in small streams, ditches, ponds and lakes. It naturally occurs in areas with climatic conditions that make it probable it can survive under present Dutch conditions.

Ecological impacts: Unknown.

Dangers for humans: Aggressive when lifted from water or teased. Can inflict a serious bite or even, in case of full grown turtles, amputate fingers and toes. Their ability to protrude their neck and snapping beak relatively far often surpasses expectations. It is rumoured that people who swim in turtle waters can be bitten as the animals confuse them with food. Turtles with a carapace >20 cm are already a danger to children. Full grown snapping turtles have a carapace of up to 50 cm in length and a body length of up to 1 meter. Snapping turtles have sharp claws that may also inflict injury to humans.

Risk assessment: The natural distribution zone of all sub-species of the snapping turtle together is large, generally reaches 50 °N and in some areas 52 °N. This shows that the species is both a generalist and can reproduce in a relatively temperate climate, which is in line with its possession of a TSD II system with a lowest pivotal temperature of 21-22 °C. Hence it would probably already be able to successfully reproduce under present Dutch conditions. There is therefore a high risk of the species becoming invasive should it ever become popular in pet trade and be introduced to Dutch nature in numbers. Combined with the fact that it can become quite large and can inflict serious damage through biting, this is without doubt a species with ***substantial risk*** for the Netherlands.

Trachemys scripta elegans, the Red-eared Slider

Figure 15.
The Red-eared Slider. © Renée de Kleijn en George Pieterse.

Additional sources used for general information
NOBANIS fact sheet (Bringsøe, 2006), USGS fact sheets (Somma et al., 2009b and 2009d), GISD fact sheet (ISSG, 2010), DAISIE fact sheet (DAISIE, 2011).

Occurrence in the Netherlands

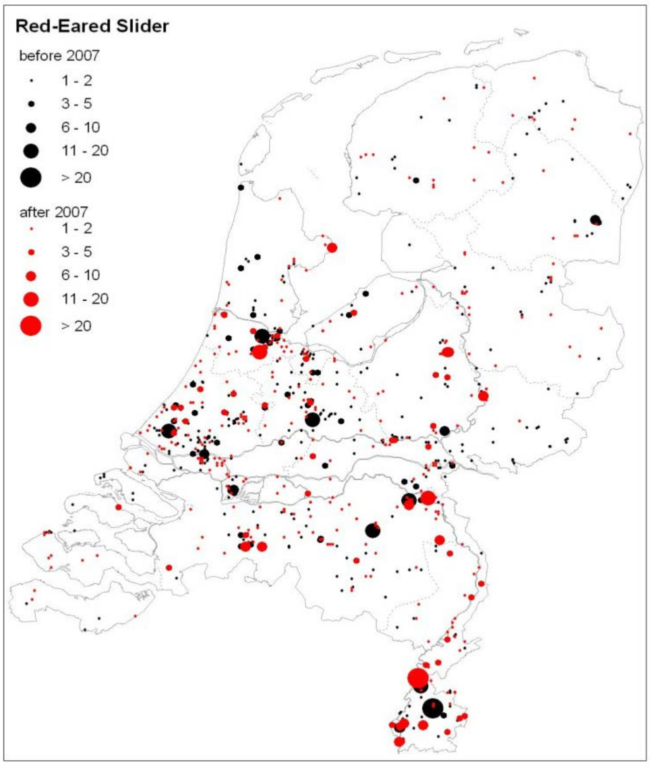

Figure 16
Observations of the Red Bellied slider in the Netherlands, before and after 2007.

The first registered observation of a Red-bellied slider in Dutch nature dates from 1975. Since then, the number of observations has gradually increased, see Table 2 and Annex 3.

Description
Dutch name: Roodwangschildpad

Family: Emydidae

Native distribution: Mainly North America

Invasive distributions: Considered to be among the 100 worst existing invasives (ISSG, 2010). Established invasive populations in most (sub) tropical parts of the world and exotic (non-reproducing, due to pet-dumping) populations in many temperate countries, including most of the North-European ones (a.o. Rödder, 2009).

Conservation status: Not threatened

Habits: The Red-eared slider is a semi-aquatic turtle. Mating takes place in the water, but some suitable terrestrial area is required for egg-laying by nesting females. Mating starts in spring when the water temperature reaches about 8 to 10 °C. Nests are preferably made close to the water edge. Some females, however, move as far as two km from the water to find suitable nest sites. The slider is a diurnal turtle. It basks frequently, often in groups or even piles. Red-eared sliders become less active in fall, when temperatures fall below 10 °C, and are inactive in winter. They winter underwater at the bottom of ponds or shallow lakes. Occasionally, when temperatures increase, they rise to the surface for food, water and basking. When the temperature begins to drop again, however, they will quickly return to their inactive state. Red-eared sliders occasionally winter on land, underneath logs or in the soil. Sliders will generally come up for food in early March-April.

Habitat: Freshwater, but can tolerate anything from brackish waters to manmade canals and city park ponds. The Red-eared slider is found in a wide variety of habitats, including slow-moving rivers, ditches, swamps, lakes and ponds. The species prefers large quiet water bodies with soft bottoms, an abundance of aquatic plants and suitable basking sites. Small turtles usually limit their activity to areas of heavy floating vegetation. For hibernation in winter, clean waters with sufficient amounts of oxygen are needed.

Hatching success:

Laying season:	June
Incubation time:	8-16 weeks

Hatching times are weather dependent: temperatures between 22 °C to 30 °C for 55 to 80 days are preferred. Hatching of eggs requires 50 to 60 days at 26 °C.
Incubation temperature determines the sex of the hatchlings:

26-28 °C:	only males
30-32 °C:	only females

Late season hatchlings may spend the winter in the nest and emerge when the weather warms in the spring.

Successful hatching (even single sex) in the Netherlands is still impossible due to low summer temperatures. Since 2000, egg-laying females have been observed occasionally but none of the eggs hatched. Between 1996 and 2008 at least seven observations of eggs were registered but only one observation of a sub adult (which in all probability must have been a released pet!) is known. In Europe successful reproduction (hatching of both males and females) in the wild was registered in Spain, Italy and the South of France (Cadi et al., 2004, see Rödder et al., 2009 for an overview). Bringsøe (2006) concludes from reports on hatchings in the South of Germany that reproduction there is possible during very favourable summers. Rödder (2009) uses observations of 'reproduction' from the middle of France, Germany and the UK for modelling. Most of these observations were however anecdotic or obtained from gray literature (e.g. a report of 'hatchings' from the Bonn area, Rödder personal communication) and it is within the present context not verifiable what these 'reproductions' exactly entail. Cadi et al. (2004) refer to a report of fertilized eggs from near Paris, but without evidence of successful reproduction. Quite probably all these observations only concern egg-laying or at best single sex hatchings.

Food: Red-eared sliders are omnivores and eat a variety of animals and plants including fish, crayfish, carrion, macrophytes, tadpoles, snails, crickets, wax worms, aquatic insects, small vertebrates, and numerous aquatic plant species. Younger turtles tend to be more carnivorous than adults do. As they grow larger and older, they become increasingly herbivorous, although adult turtles will still opportunistically eat aquatic invertebrates (especially insects and molluscs), fish, frog eggs, tadpoles and aquatic snakes.

Natural enemies:

Eggs:	rodents
Juveniles:	fish, crocodiles, alligators, birds of prey
Adults:	fish, crocodiles, alligators, birds of prey

Lifespan: At least 20 years. and up to 40 years.

Adult survival probability in the Netherlands:
- The species can survive well in ponds and lakes, and discarded adults are presently doing very well under Dutch conditions.

Ecological impacts:
- Competition with e.g. European pond turtle (*Emys orbicularis*) for food, basking sites and nesting sites (Polo-Cavia et al., 2008, 2009a, 2009b, 2010a, 2010b). In one study, *E. orbicularis* were shown to shift their basking activity toward places considered to be of lower quality, while the dominant Red-eared slider occupied the better basking sites. The competitive advantages of the slider may include lower age at maturity, higher fecundity, and larger adult body size.
- The Red-eared slider has been considered occasionally aggressive towards individuals of other turtle species.
- Contribute to the spread of diseases and parasites that could affect native turtles and other aquatic wildlife.
- May harm vulnerable populations of e.g. rare amphibians or molluscs through predation.
- Red-eared sliders seem to be adaptable to many climates. This combined with their omnivorous diet and ability to adapt to various habitats, gives them great potential for impacting indigenous habitats should reproducing populations become established.
- Continuous releasing of exotic pet turtles in natural ecosystems increases the risk of parasite transmission to native species; the Red-eared slider is known to carry nematodes.

Dangers for humans:
- Sliders may carry diseases harmful to humans, in particular Salmonellosis caused by *Salmonella* bacteria.
- Large adults can inflict painful bites.

Risk assessment: According to the Global Invasive Species Database (GISD, www.issg.org), *The red-eared slider (Trachemys scripta elegans) has been the most popular turtle in the pet trade with more than 52 million individuals exported from the United States to foreign markets between 1989 and 1997. Despite the vast worldwide occurrence of the sliders little is known of their impact on indigenous ecosystems, clearly research and education on the dangers of releasing pet turtles into the wild are needed. Their omnivorous diet and ability to adapt to various habitats, gives them great potential for impacting indigenous habitats.* However, the species is not expected to be able to reproduce successfully in the Netherlands in the next couple of decades and the European Union has already banned the import of the species in 1996 (EC, 1997). Although breeding and trading the species within the EU is still legal, it is no longer popular (see Table 3). The large numbers that where released to nature in the past years (judging by their size mainly animals that were dumped after spending a number of years as pets) can therefore be expected to drop within the next ten years, and the number of animals in nature will follow suit due to natural causes. However, due to their longevity, excellent survival capacity and their ability to interbreed with the other slider subspecies, the chance that they will be able to reproduce successfully before their natural disappearance is still considerable. Should they become established they could prevent or slow down the immigration of the European pond turtle *Emys orbicularis*. Although there is somewhat more information on their ecological impact available than for most other turtle species, there is no reason to expect a heavier impact (of comparable numbers) on native flora and fauna. But due to the above described risks and their being a Salmonella carrier, it is undoubtedly still is a ***substantial risk*** species for the Netherlands.

Trachemys scripta scripta, the Yellow-bellied Slider

Figure 17
The Yellow-bellied Slider. © Fabrice Ottburg.

Additional sources used for general information
USGS fact sheets (Somma et al; 2009a and 2009d)

Occurrence in the Netherlands

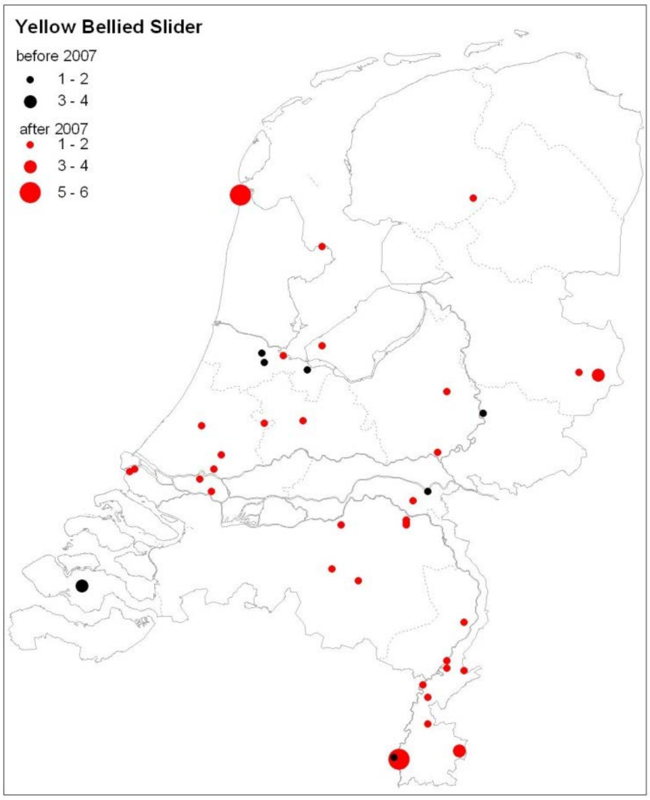

Figure 18
Observations of the Yellow Bellied slider in the Netherlands, before and after 2007.

The Yellow bellied slider was first observed in Dutch nature in 2005 and numbers as well as distribution are rapidly increasing (Figure 18, Table 2 and Annex 34).

Description
Dutch name: Geelbuikschildpad

Family: Emydidae

Native distribution: South-Eastern USA

Distribution outside native range: Reports of observations of a few individuals from several Southern USA States

Conservation status: Not threatened

Habits: The Yellow-bellied slider is a semi-aquatic turtle. Mating takes place in the water, but some suitable terrestrial area is required for egg-laying by nesting females. Mating starts in spring when the water temperature reaches about 8 to 10 °C. Nests are preferably made close to the water edge. Some females, however, move as far as 1.6 km from the water to find suitable nest sites. The slider is considered a diurnal turtle; it feeds mainly in the morning and frequently basks on shore, on logs, or while floating, during the rest of the day. At night, it sleeps lying on the bottom or resting on the surface near brush piles, but in all cases it prefers to stay in the water.

Habitat: Freshwater. The Yellow-bellied slider is found in a wide variety of habitats, including slow-moving rivers, lakes, floodplain swamps, marshes, shallow streams, seasonal wetlands and permanent ponds. Highest densities of sliders occur in waters with soft bottoms and where algae blooms and aquatic macrophytes are abundant. Dense surface vegetation provides cover from predators and supports high densities of aquatic invertebrates and small vertebrates, which offers better foraging than open water. Hatchlings live mostly in shallow waters with sufficient plant cover to avoid predators. For hibernation in winter, clean waters with sufficient amounts of oxygen are needed.

Hatching success:
Laying season: April-July
Peak laying season: May-June
Incubation time: 8-12 weeks
Incubation temperature determines the sex of the hatchlings:
26-28 °C: only males
30-32 °C: only females
The hatchlings usually stay with the nest through winter.

The likeliness of successful hatching in the Netherlands is probably comparable to that of the Red-eared slider, i.e. could be possible towards 2050.

Food: Yellow-bellied sliders are omnivorous. They forage in the water. Hatchlings are almost entirely carnivorous, feeding on insects, spiders, crustaceans, molluscs, tadpoles, small fish, and carrion. As they age, adults eat less and less meat such that up to 95% of their nutritional intake comes from plants.

Natural enemies:

Eggs: rodents, lizards
Juveniles: rodents, fish, crocodiles, alligators, snakes, birds of prey
Adults: crocodiles, alligators, birds of prey

Lifespan: At least 30 years.

Adult survival probability in the Netherlands:
Adult Yellow-bellied sliders are surviving well under Dutch conditions.

Ecological impacts:
- Competition with e.g. European pond turtle (*Emys orbicularis*) for food, basking sites and nesting sites.
- Contribute to the spread of diseases and parasites that could affect native turtles and other aquatic wildlife.
- May harm vulnerable populations of e.g. rare amphibians through predation.

Dangers for humans:
- Sliders may carry diseases harmful to humans, such as bacteria of the genera *Salmonella* and *Arizona*.
- Large adults can inflict painful bites.

Risk assessment: The Yellow bellied Slider is one of the species that has taken over the role of the Red-eared Slider in pet trade since the import of that species in the EU was banned, but is unlikely to be traded in the large numbers that were common for that last species. The number of specimen in nature can however be expected to increase considerably over the next years, and since the species will probably continue to be popular in trade discarded numbers will continue to be high over the next decades unless preventive measures are taken. Like the other *Trachemys scripta* subspecies, *T. s. scripta* can only be expected to be able to reproduce close to the end of our 2050 time horizon, but due to the expected considerable presence in nature by that time and the possibility of interbreeding with the other *T. scripta* subspecies, it is a ***substantial risk*** species for the Netherlands.

Trachemys scripta troostii, the Cumberland Slider

Additional sources used for general information
USGS fact sheets (Somma et al., 2009c and 2009d)

Occurrence in the Netherlands

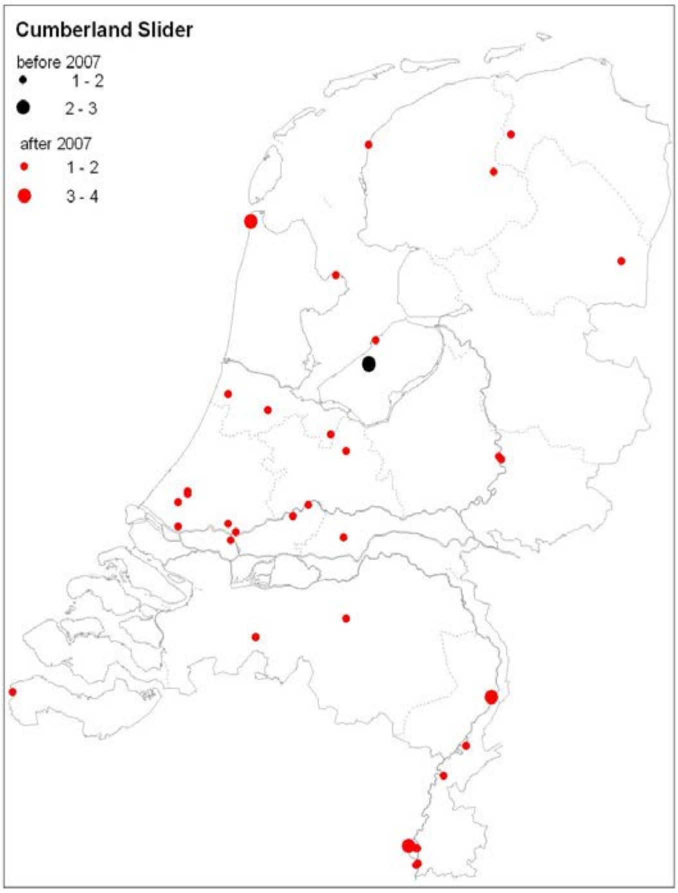

Figure 19
Observations of the Cumberland slider in the Netherlands, before and after 2007.

The Cumberland Slider was first observed in Dutch nature in 2004 and the speed of increase in the number of observations and in distribution is about the same as for the Yellow bellied Slider (Figure 19, Table 2 and Annex 34).

Description
Dutch name: Geelwangschildpad

Family: Emydidae

Native distribution: Eastern-northeastern Tennessee and the extreme southwestern corner of Virginia

Distribution outside native range: Maryland, USA

Conservation status: Not threatened

Habits: The Cumberland slider is a semi-aquatic turtle. Mating takes place in the water, but some suitable terrestrial area is required for egg-laying by nesting females. Mating takes place from March to early June and in warmer climates again from September to November. The nests may be constructed large distances from the water. Cumberland sliders are less active in winter. This turtle is a communal basker. It basks on protrusions out of the water and may bask in stacks or with other species. In colder weather, this turtle goes underwater and hibernates in the mud. It may also use muskrat holes and hollow stumps to hibernate. The slider is a diurnal turtle. At night, it sleeps lying on the bottom or resting on the surface near brush piles, but in all cases it prefers to stay in the water.

Habitat: Freshwater. The Cumberland slider is found in a wide variety of habitats, including slow-moving streams, lakes, wetlands and ponds. This species prefers quiet waters with muddy bottoms. Areas with a profusion of aquatic vegetation, organic substrate, and overhanging basking spots are especially favoured. Hatchlings live mostly in shallow waters with sufficient plant cover to avoid predators. For hibernation in winter, clean waters with sufficient amounts of oxygen are needed.

Hatching success:

Laying season:	April-July
Peak laying season:	May-June
Incubation time:	8-12 weeks

Incubation temperature determines the sex of the hatchlings:

26-28 °C:	only males
30-32 °C:	only females

The hatchlings usually stay with the nest through winter.

The likeliness of successful hatching in the Netherlands is probably comparable to that of the Red-eared slider, i.e. may be possible towards 2050.

Food: Cumberland sliders are omnivorous. They forage in the water. Hatchlings are almost entirely carnivorous, feeding on insects, spiders, crustaceans, molluscs, tadpoles, small fish, and carrion. The adult eats algae, seeds, aquatic vegetation, tadpoles, small fish, insects, crayfish, worms, and molluscs.

Natural enemies:

Eggs:	rodents, lizards
Juveniles:	rodents, fish, crocodiles, alligators, snakes, birds of prey
Adults:	crocodiles, alligators, birds of prey

Lifespan: At least 30 years.

Adult survival probability in the Netherlands:
Adult Cumberland sliders are already doing well in Dutch nature.

Ecological impacts:
- Compete with e.g. European pond turtle (*Emys orbicularis*) for food, basking sites and nesting sites.
- Contribute to the spread of diseases and parasites that could affect native turtles and other aquatic wildlife.
- May harm vulnerable populations of e.g. rare amphibians.

Dangers for humans:

- Sliders may carry diseases harmful to humans, such as bacteria of the genera *Salmonella* and *Arizona*.
- Large adults can inflict painful bites.

Risk assessment: Together with the Yellow Bellied Slider, the Cumberland slider has taken over the position in pet trade formerly taken up by the Red-Eared Slider. Like the Yellow Bellied Slider, the species can probably not be expected to be traded in the quantities previously normal for the Red-Ear, but its distribution can be expected to increase to a stable level much higher than the present one. Like the Yellow bellied Slider, the Cumberland Slider can be expected to be able to reproduce successfully around 2050 and, also due to the possibility of interbreeding with the other *T. scripta* subspecies, the risk of it becoming an invasive in the long term is considerable. Since it basically carries the same ecological and human health risks as the other Trachemys scripts subspecies, it also falls in the same category of ***substantial risk***.

Graptemys pseudogeographica, the False Map Turtle

Additional sources used for general information
USGS fact sheets (McKercher, 2009a and 2009b)

Occurrence in the Netherlands

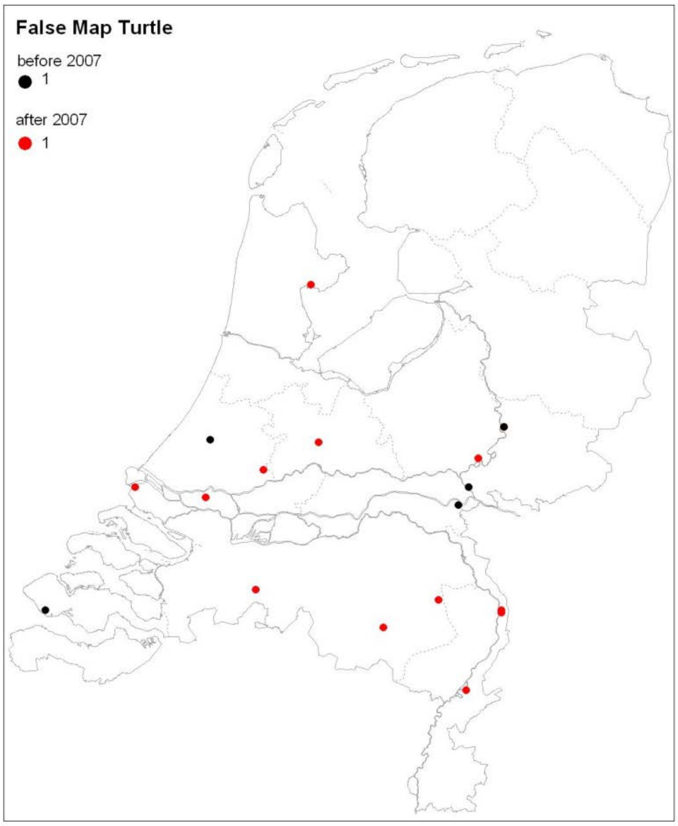

Figure 20
Observations of the False map turtle in the Netherlands, before and after 2007.

Description
Dutch name: Zaagrugschildpad

Family: Emydidae

Native distribution: Texas, Louisiana, Mississippi and Arkansas and north along the Missouri, Mississippi, and Ohio river drainages

Distribution outside native range: a few local occurrences in Virginia and Florida. Not registered as invasive in databases (ISSG, 2010; DAISIE, 2011), but is found in Dutch nature since 2004.

Conservation status: not threatened but all *Graptemys* subspecies are recently put on CITES Appendix 3 by the USA.

Habits: False map turtles are active from April to September. They become active after hibernation if the water temperature is 4-7 °C. They are diurnal and spend a considerable amount of time basking. They forage for short periods during the day. They are very aquatic and do not roam far from water. They bask on anything above the water as long as it is away from shore in deep water. Snags and fallen trees with many limbs provide ideal basking areas. Often they bask in large groups. False map turtles breed in spring. They usually do not migrate long distances to lay eggs. The nest is dug during the day from 5 to 150 m from water in open sandy areas, e.g. sand bars, or areas with low shrubs.

Habitat: Freshwater. False map turtles are found mainly in large rivers and backwaters, also found in lakes, sloughs, ponds, marshes, and drowned forests in reservoirs. They prefer slow moving water with places to bask, and plenty aquatic vegetation. Fast-moving and deep waters are avoided. They require muddy bottoms to hibernate and in which prey species can be found.

Hatching success:
Laying season: May-July
Peak laying season: June-July
Incubation time: 8-11 weeks
Incubation temperature determines the sex of the hatchlings:
25 °C: only males
35 °C: only females
The body temperatures of nesting females range from 24.6°C to 28.2 °C at air temperatures ranging from 21.1 °C to 32.0 °C.
The young emerge in August or September or they may overwinter in the nest.

Food: False map turtles are omnivorous. They feed on aquatic insects, molluscs, and aquatic plants. They also consume fish (especially fish carrion), crayfish, snails, and amphibian larvae.

Natural enemies:
Eggs: foxes, raccoons, otters
Juveniles: crows, grackles, black birds, herons, gulls, rats, large fish
Adults: -

Lifespan: At least 15 - 20 yrs.

Adult survival probability in the Netherlands:
Adult false map turtles have survived in Dutch ponds, marshes, and rivers.

Ecological impacts:
False map turtles act as both predator and prey. Their prey includes molluscs, crayfish, snails, fish, and tadpoles.

Dangers for humans:
There are no known adverse effects of False map turtles on humans.

Risk assessment: The native distribution range of the False Map Turtle has a fair amount of overlap with the risk zones indicated in Figure 21 especially in the most Northern parts. It does not (yet) have a large presence in Dutch nature and care centres. The recent inclusion in Appendix III of CITES of all *Graptemys* subspecies will probably prevent a future popularity in trade, but due to its potential it is still assessed as a ***substantial risk*** species

Chrysemys picta ssp., the Painted Turtle

Additional sources used for general information
USGS fact sheet (Gregoire, 2009a)

Description
Dutch name: Amerikaanse sierschildpad

Family: Emydidae

Native distribution: Species with a natural range running from coast to coast (in Southern Canada) on the American continent. Largest part of its range lies in Southern Canada and North-Eastern part of the US. Parts of its Northern distribution limit reach about 52 °N.

Distribution outside native range: In USA observed in Florida, in Europe registered for Spain, Germany and Austria (DAISIE, 2011). Possibly also observed in the Netherlands (Figure 13).

Conservation status: Not listed on IUCN red list very common in natural range and may even be caught for consumption in many US states.

Habits: In the colder parts of its range the species is active from about March till October. Basks on any structure extending from the water. Commonly share basking sites, basking period usually lasts about two hours. Can stay submerged for several weeks while hibernating. They can move over considerable distances, sometimes overland from one water body to the next.

Habitat: Usually the most abundant turtle in suitable shallow water bodies. Prefers slow-moving shallow water habitats with soft bottoms, and abundant basking sites. Hatchlings and smaller juveniles inhabit shallow water habitats but move to deeper waters when they become older. Is fairly tolerant of polluted waters.

Hatching success: Nesting in June and July in colder parts of the range. Nests usually dug in sandy or loamy soils in open areas, with often a Southern exposure. Nesting usually is within 200m of the water, but may be as far as 600m. One to five clutches (two on average) are produced per season, average number of eggs per clutch around 10. Hatching in the North around mid-August, incubation period 70 - 80 days. Sex determination is temperature dependant, with a TSD 1a system according to most literature but a single paper reporting TSD II behaviour:

21-22 °C: both females and males (reported in a single paper)
23-28 °C: only males
28-29 °C: both females and males
≥29 °C: only females

In colder areas, hatchlings overwinter in the nest. Hatchlings have natural freeze tolerance.

There is a risk that successful hatching is already possible under present Dutch conditions.

Food: Omnivorous generalist in the broadest sense. Known prey are aquatic greens and algae and any small animals of the water such as insects, crustaceans, and fish.

Natural enemies: In the natural range, nest predation is sometimes extremely high, mostly by raccoons. But egg and hatchling predators are also red ants, fly larvae, garter snakes, crows, foxes, rodents, skunks and badgers. Water predators vary from large water bugs to bullfrogs and the snapping turtle. Adults may be taken by e.g. birds of prey, alligators or otters. The main predator of all life stages is the raccoon.

Lifespan: 30 - 40 years, possibly up to 61.

Adult survival probability in the Netherlands: Good. The species is widespread in the US with a distribution zone reaching far north, showing that they can both survive and reproduce in colder conditions.

Ecological impacts: Unknown.

Dangers for humans: Unknown

Risk assessment: The species is commercially harvested in its natural range, probably for trade. It is not eaten much because it is too small (Ernst and Lovich, 2009) and therefore probably also not bred for consumption. Due to its natural occurrence at very Northerly latitudes (large overlap of natural range with Figure 21 risk zones) and its suitability for the pet trade it is a potential high risk species for the Netherlands. It is banned from import to the EU since 2006, but can still be bred and sold inside the EU. The species therefore still presents a ***substantial risk*** for the Netherlands.

Sternotherus odoratus, the Common Musk Turtle or Stinkpot

Additional sources used for general information
USGS fact sheet (Somma and Fuller, 2009)

Description
Dutch name: Muskusschildpad

Family: Kinosternidae

Native distribution: It has a rather large native range reaching from the far South-Eastern part of Canada through the Eastern United States from southern Maine in the north, south through to Florida, and west to central Texas, with a disjunctive population located in central Wisconsin.

Distribution outside native range: Single observation in California.

Conservation status: Generally not threatened, but is listed as threatened in Iowa and as a species at risk in Canada.

Habits: Musk turtles are almost entirely aquatic. They typically only venture onto land when the females lay their eggs, or in some cases, to bask under lighting. They are chiefly crepuscular. The basking habit is poorly developed. They hibernate underwater buried in the mud bottom. Home ranges are small and probably confined to one water body. Individuals usually do not go very far but can sometimes move overland for distances up to a recorded distance of 700m.

Habitat: Mainly shallow, heavily vegetated waters of slow moving creeks, or ponds.

Hatching success: Nesting in the north takes place from May through August. Nesting takes place on the open ground, under stumps and fallen logs and in the walls of muskrat houses in shallow nests as well as well-formed ones as deep as 10cm. Females are noted for sharing nesting sites.
Usually two to five eggs constitute a clutch, and four clutches may be laid each year. Hatchlings emerge in September and October in the north after an incubation period of about 75 or 80 days. *Sternotherus odoratus* has a TSD II system with pivotal temperatures (sex ratio about 1) of probably around 24 and 26 °C. Sex-ratios in the north tend to be male biased. Successful hatching under present Dutch conditions is probably still unlikely, but only a small increase in summer temperatures is required for it. Successful hatching under (near) future Dutch conditions is therefore likely.

Food: Musk turtles are omnivorous bottom feeders**.** Under 5 cm they feed predominantly on small aquatic insects, algae, and carrion, whereas those over 5 cm feed on any kind of food. Known prey are earthworms, leeches, clams, snails, crabs, crayfish, aquatic insects, fish eggs, minnows, tadpoles, algae, and parts of higher plants.

Natural enemies: Musk turtles are predated on by for instance snapping turtles, rodents, snakes, foxes, skunks, birds of prey and several fish species all eat eggs, hatchlings and adults. They can defend themselves by releasing a foul-smelling liquid from their musk-glands.

Lifespan: probably 20 - 30 **year**s, with over 54 years recorded in captivity.

Adult survival probability in the Netherlands: Adults are probably able to survive under present Dutch conditions

Ecological impacts: Unknown

Dangers for humans: Unknown

Risk assessment: The risk of the species being able to become invasive in the Netherlands in the long term is considerable since it is a generalist with reproduction adapted to the 23 - 27°C range, which will be easily reached in hot summers within a couple of decades. Since the species apparently is becoming popular in pet trade (see Section 4.2.1), it is assessed as a ***substantial risk*** species for the Netherlands.

5.2.2 Risk and possible risk species

All risk and possible risk species have natural distributions with large overlap with the risk zones indicated in Figure 8. The difference between the two groups is that the species in the risk group are already found in pet trade or in care centre custody in the Netherlands, while the possible risk species are not. There is one exception, the Red-bellied Turtle *Pseudemys rubriventris*, which is traded in the Netherlands and possibly observed in Dutch nature, but has a natural range without any overlap with the risk zones and is therefore only classified as a risk species. To facilitate a better comparison of the natural ranges with risk areas, the descriptions are ordered per continent.

North-American species

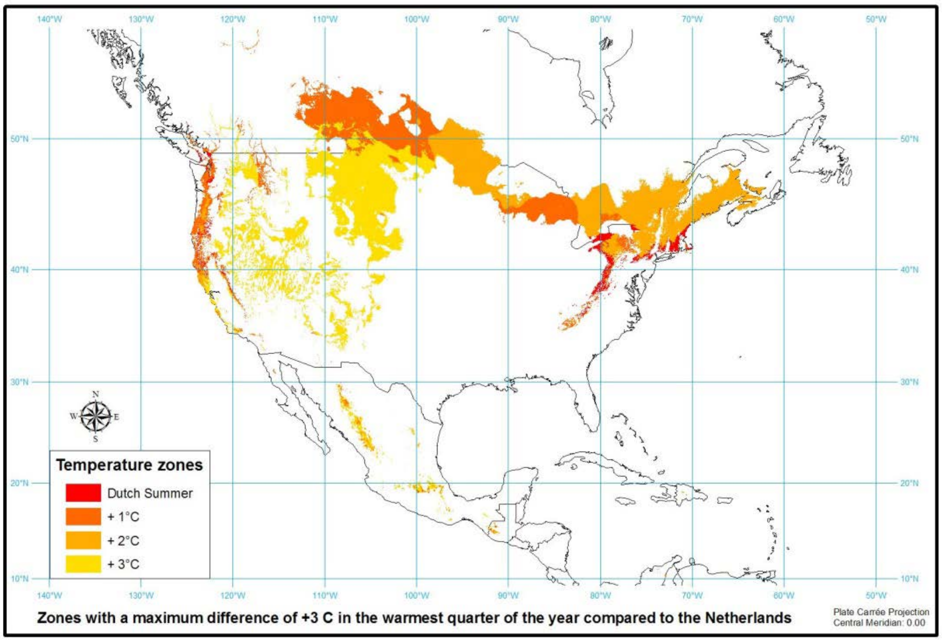

Figure 21
North-American risk zones. The temperature zones are based on the Global Environmental Stratification (Metzger et al., 2011).

<u>Possibly already introduced to Dutch nature</u>

Pseudemys rubriventris
Additional general information: USGS fact sheet (Gregoire, 2009b)

The Red-bellied turtle, also called the Northern Red-bellied Cooter (roodbuikschildpad) belongs to the Emydidae family. It has a life span of at least 40 and up to 55 years. Its natural range lies within the temperate climate zone and stretches in the Atlantic coastal plain from central New Jersey south to northeastern North Carolina and westward up the Potomac River to eastern West Virginia. There are also some relict populations in southeastern Massachusetts (Fritz and Havas, 2007). The species is not threatened.

The Red-bellied turtle is a semi-aquatic turtle which is found in relatively large deep bodies of water (depth 2 to 3.50 m): creeks, rivers, marshes, ponds, lakes. Sometimes in brackish water at the mouths of rivers. Soft bottom and abundant aquatic vegetation are preferred. Rocks and logs should be present for basking in

the sun. Wanders on land, fall and spring. Their terrestrial biomes are mainly savannah or grassland. Mean preferred body temperature is 27-28 °C. Preferred water temperature: 20-28 °C.
Mating takes place in shallow waters in spring or fall. They become terrestrial for short periods of time while laying eggs. Females try to return to the same nesting sites every year. They show little evidence of migration and often occupy the same habitat year-round. Eggs are laid in nests dug in soft soil in open areas usually close to the water. Often nests are in tilled or disturbed soil. The laying season is May-July, with the peak in June-July. The incubation time is between 10-15 weeks. TSD system and optimum incubation temperature are unknown. The hatchlings may overwinter in the nest and emerge in spring.

Red-bellied turtles are diurnal reptiles, spending most of their days basking on logs and swimming. They are most active from April to October. During winter, when water is covered with ice, they hibernate in the mud at the bottom of rivers. Red-bellied turtles are not territorial. They are shy and wary of humans and predators and swim rapidly and bury themselves in the mud when scared. Numerous individuals frequently inhabit the same rocks or logs while sunbathing. The Red-bellied turtle is omnivorous. They eat primarily aquatic vegetation and algae. Secondary food sources include crayfish, snails, worms, fish, amphibians, insects, and tadpoles. Juveniles are herbivorous and adults are omnivorous. Natural enemies are crows, rats, mice, shrews (eggs) herons, rats, mice, opossums, turtles, large fish (juveniles) raccoons, skunks, foxes, crows, herons, and bullfrogs (adults).

Red-bellied turtles have probably been found in Dutch urban ponds and rivers. So far there is no proof that the animals reproduce or survive severe winters in the Netherlands. Only five rather questionable observations are registered at www.waarneming.nl, the first ones from 2008 and the last one from 2010. Two of the 2008 observations almost certainly concern a male Western Painted Turtle (*Chrysemys picta bellii*, see Figure 13). Since this last species is commonly called 'Red bellied turtle' in Dutch trade, the accuracy of the determination in the other three cases is also questionable. As the species has a very limited natural distribution area with no overlap with the risk areas depicted in Figure 21 and there is probably no risk of large scale introduction to Dutch nature, there is only a very low risk of it becoming invasive. Since there are no other specific risks identified for this species it only carries a ***possible risk*** for the Netherlands.

In trade or care centre custody

Apalone spinifera

Additional general information: USGS fact sheet (Somma, 2009)
The spiny softshell turtle (drieklauw weekschildpad) has a round, leathery carapace, gets up to about 50cm in length and has a maximum life span of up to 25 years. It has a wide distribution range across the South Eastern USA stretching in one location just over 48,°N and partly overlapping the zone with summer temperature characteristics comparable to the Dutch future ones (Figure 21). It is a primarily carnivorous and primarily riverine species that spends quite a lot of time basking. It mainly is a ***risk*** species for the Netherlands because it has GSD (genetical sex determination) and can therefore become invasive at relatively low temperatures.

Graptemys geographica

Adults of the Northern map turtle (Landkaartschildpad) grow up to 27 (females) or 16 (males) cm in length and reach a maximum age of around 20 years. Their main range is in the mid-eastern USA area below the Great Lakes, up to about 48 °N and partly overlaps with the zone with summer temperature characteristics comparable to the Dutch future ones (Figure 21). It usually does not do well in captivity. It is a carnivore that primarily feeds on snails and clams and is most often found in large water bodies with a rocky or gravel bottoms. It has TSD 1a, under experimental conditions mostly males are produced at 25 and mostly females at 30 °C. Due to its difficult husbandry it has low attractiveness to the pet-trade but is still encountered in relative high numbers in Dutch care centres. Since it is probably able to reproduce successfully around 2050, it is considered to be a ***risk*** species for the Netherlands.

Not yet encountered in the Netherlands

Actinemys marmorata (Clemmys marmorata)

The Western or Pacific pond turtle (Marmerschildpad) is a small to medium sized semi-aquatic turtle growing up to approximately 20 cm carapace length. It can probably reach an age of up to 40 or 50 years. Their distribution range is entirely along the North American West coast, reaching from northern Baja California, Mexico, north to the Puget Sound region of Washington. The Northern part of the range consists of a number of isolated populations and as of 2007, they have become rare or absent in the Puget Sound area. In the Northern part of their range they overlap with the risk temperature area of Figure 21. The Western Pond Turtle occurs in both permanent and intermittent waters, including marshes, streams, rivers, ponds and lakes. They favour habitats with large amounts of emergent logs or boulders, where they aggregate to bask. Terrestrial habitat may be as important as aquatic for this turtle as it spends sometimes months on land. Western Pond Turtles are omnivorous and most of their animal diet includes insects, crayfish and other aquatic invertebrates. Fishes, tadpoles, and frogs are eaten occasionally, and carrion is eaten when available. The species has TSD 1a with a pivotal temperature around 30 °C. It is on the IUCN red list as vulnerable. The species only seems marginally suited for Dutch conditions and is therefore a ***possible risk*** species.

Clemmys guttata

The spotted turtle (druppelschildpad) is a small (up to 14 cm) semi-aquatic turtle that can reach at least 30 years of age. Their range stretches roughly from almost North to South along the Eastern coast of the USA, with a number of isolated populations more inland and at least one in Canada. The Northern part of the range largely overlaps with the risk temperature zone indicated in Figure 21. Spotted turtles prefer unpolluted, slow-moving, shallow waters with a soft bottom substrate and some submerged and emergent vegetation. They are usually found in shallow bodies of water including bogs, marshes, swamps, sedge-meadows, woodland streams and brooks, permanent and seasonal pools and ponds. The Spotted turtle is omnivorous but juveniles are mostly carnivorous eating insects, such as crickets, worms, snails, slugs, spiders and fish. As spotted turtles age, they may consume vegetative matter, such as the stems of aquatic grasses and filamentous green algae, but adults' diets will primarily consists of protein-rich foods: insects, fish, snails and crustaceans. They have also been recorded to feed on carrion, including fish and duck. They have a TSD system that is clearly different from both II and 1a (Ewert and Nelson, 1991), with eggs incubated between 22.5 and 27 °C producing predominantly males and temperatures over 30 °C producing only females. The spotted turtle is a ***possible risk*** species for the Netherlands because of this TSD system that already produces both sexes at relatively low temperatures.

Emydoidea blandingii

Blanding's turtle (Amerikaanse moerasschildpad) is medium sized turtle with a maximum shell length of approximately 25 cm with a lifespan of over 40 years (estimated maximum of over 77). The species' range centres on the Great Lakes, and extends from central Nebraska and Minnesota eastward through southern Ontario and the south shore of Lake Erie as far east as northern New York, with a few isolated populations in southeastern New York (Dutchess County), New England and Nova Scotia. The largest part of the range overlaps with the risk temperature area indicated in Figure 21. Emydoidea lives in productive, eutrophic habitats, with clean shallow water, a soft but firm, organic bottom, and abundant aquatic vegetation. It is found in lakes, ponds, ephemeral pools, marshes, creeks, wet prairies, and sloughs. Food includes crustaceans, fish, frogs, tadpoles, snails, leeches, insects, and some aquatic plants. They often feed at night during warm weather.

The sex determination system is TSD1a, with a pivotal temperature somewhere between 25 and 30 °C. The species is listed as endangered throughout most of its range. Its IUCN red list status is near threatened. For the Netherlands it is a ***possible risk*** species because of its Northern distribution and the large overlap between its range and the risk area indicted in Figure 21.

Glyptemys insculpta (Clemmys insculpta)
The wood turtle (bosbeekschildpad) is a semi-aquatic turtle reaching a carapace length of 14 to 20 cm and an age of around 20 years in the wild (up to 50 in captivity). Their distribution range in the North-Eastern USA and South-Eastern Canada extends from Nova Scotia in the north (and east) to Minnesota in the west and Virginia in the south. Most of their range overlaps with the risk temperature area of Figure 21. It is the most terrestrial of the American turtles and can also be found in forests and grasslands, but will rarely be seen more than several hundred meters from flowing water. It prefers shallow, clear streams with compacted and sandy bottoms. The wood turtle is omnivorous and is capable of eating on land or in water. Prey includes beetles, millipedes, and slugs. Also, wood turtles consume specific fungi, mosses, grasses, various insects, and also carrion. The species does not show evidence of TSD but appears to have GSD. The wood turtle is a pretty turtle and popular in the (illegal) pet trade. It is declining due to collection and its IUCN red list status is vulnerable. It is protected in most of the states in its native range and is a CITES Appendix 2 species. The Wood turtle is a ***possible risk*** species for the Netherlands due to its natural occurrence in temperate areas and its popularity in trade. Its protection status will however considerably reduce this risk.

Glyptemys muhlenbergii (Clemmys muhlenbergii)
Additional general info was taken from Smith, 2006. The bog turtle (Muhlenbergs schildpad) is a small (up to 11.5 cm carapace length) semi-aquatic turtle that can reach an age of over 30 years. The distribution range is limited to the Eastern states of the USA and consists of a number of disjunct areas with the Northernmost overlapping with the risk temperature areas indicated in Figure 21. Bogs, swamps and marshy meadows with clear, slow-moving streams and soft bottoms are the preferred habitat. Bog turtles occur from sea level to an elevation of over 1200m in the Appalachians. They are omnivorous and eat aquatic plants, seeds, berries, earthworms, snails, slugs, insects, other invertebrates, frogs, and other small vertebrates. They also occasionally eat carrion. Invertebrates such as insects are generally the most important food item. Their system of sex determination is unknown. Their IUCN red list status is endangered and the Bog turtle is a CITES Appendix I species and is protected under the United States Federal Endangered Species Act. Due to its characteristics, relative rareness and protection status it is only technically a ***possible risk*** species for the Netherlands.

Eastern-Asian species

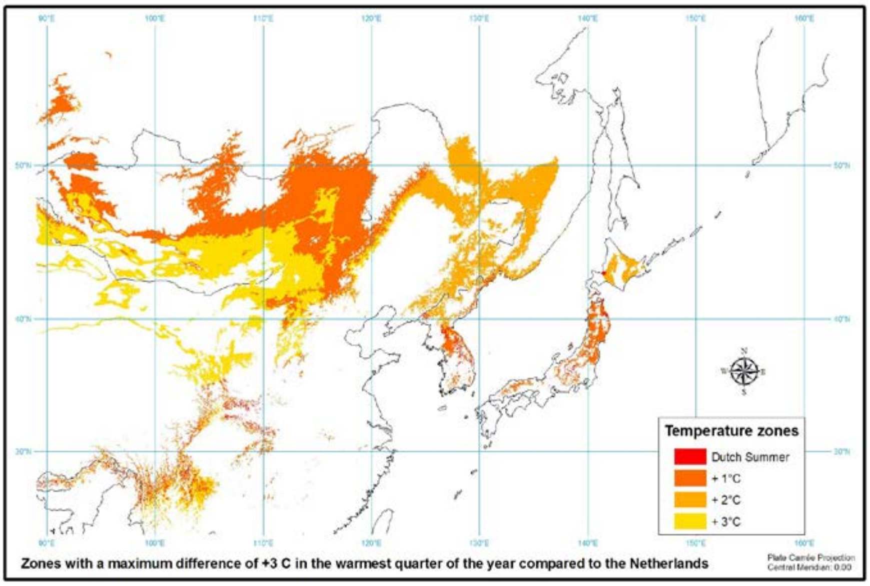

Figure 22
South-East Asian risk zones. The temperature zones are based on the Global Environmental Stratification (source: Metzger et al., 2011).

In trade or taken up in care centres

Pelodiscus sinensis

Additional general information: USGS fact sheet (Somma, 2004).
The Chinese soft-shelled turtle (Chinese weekschildpad of Chinese drieklauwschildpad) belongs to the family of Trionichidea or soft-shell turtles. It can reach a carapace length of approximately 25cm. The maximum lifespan is unknown. It is found in China, Taiwan, Korea, Manchuria, North Vietnam and Japan. It is difficult to determine its native range due to the long tradition of use as a food and 'tonic' and subsequent spread by migrating people. The Chinese soft-shelled turtle has been introduced to Malaysia, Singapore, Thailand, Timor, Batan Islands, Guam, some of the Hawaiian Islands and California. For its natural range the species is listed as vulnerable on the IUCN red list. The Northern parts of its Asian distribution overlap with the risk temperature zone indicated in Figure 22. In China the species is found in rivers, lakes, ponds, canals and creeks with slow currents. On Hawaii it is found in marshes and drainage ditches. The basking habit is not well developed. The Chinese soft-shell is mainly carnivorous and forages at night, taking crustaceans, mollusks, insects, fish, and amphibians. The Chinese Soft-shelled Turtle (*Pelodiscus sinensis*) is the turtle species raised on China's turtle farms. According to the data obtained from 684 Chinese turtle farms, they sold over 91 million turtles of this species every year; considering that these farms represented less than half of the 1,499 registered turtle farms in China, the nationwide total could be over twice as high (Haitao et al., 2008). Within Europe, the turtle is a popular pet, particularly in countries such as Italy and the Czech Republic. For the Netherlands it is a risk species because it has GSD, occurs naturally in relatively Northern areas with temperatures that can be reached in the Netherlands within a couple of decades. It is considered a ***risk*** species for the Netherlands due to the huge numbers in which the species is bred and traded for consumption. This makes trading them as pets an easy spin-off.

Australian species

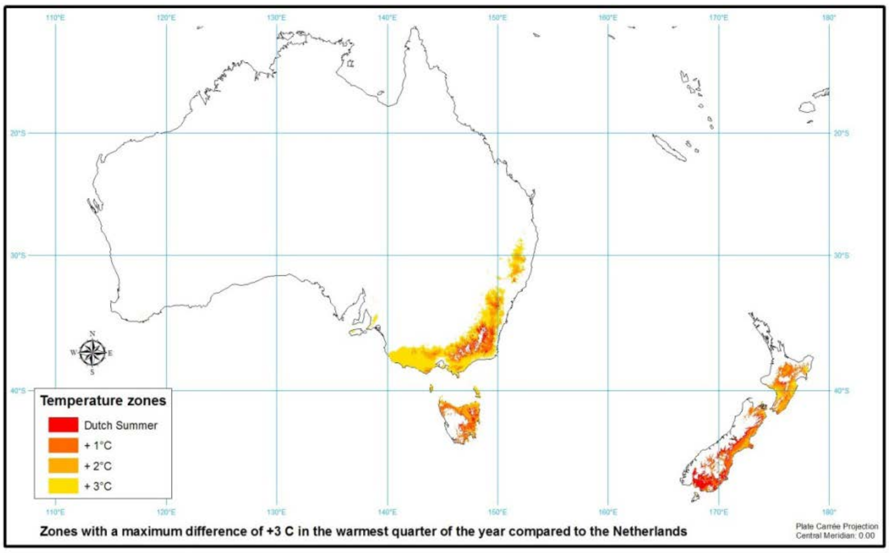

Figure 23
Australian risk zones. The temperature zones are based on the Global Environmental Stratification (source: Metzger et al., 2011).

Not yet encountered

Chelodina longicollis

The Common snake-necked turtle (Australische slangenhalsschildpad) is a medium sized (shell up to 27.5 cm) turtle of largely unknown longevity. Growth rates and recorded minimum ages of over 30 years however suggest that it can become quite old (Kenneth et al., 2009). The species is found in eastern Australia from northern Queensland southward to southern South Australia, and on Fraser and Moreton Islands. The coastal part of its range completely overlaps the risk area indicated in Figure 23. *Chelodina longicollis* lives in slow-flowing rivers, streams, ephemeral swamps and lagoons. It is an opportunistic carnivore that taps a wide variety of sources - plankton, nekton, benthic macro-organisms carrion, and terrestrial organisms that fall into the water: oligochaetes, platyhelminths, snails, crustaceans, insects, fish, anurans (including eggs and larvae), and some algae (Georges et al., 1986). The species has GSD which basically makes it suitable for reproduction in colder areas, which is together with the overlap with the indicated risk area the reason for it being a ***possible risk*** species.

5.3 Species expected due to natural range extension

Emys orbicularis, the European Pond Turtle

Figure 24
The European pond turtle. © Rob Bugter.

Occurrence in the Netherlands

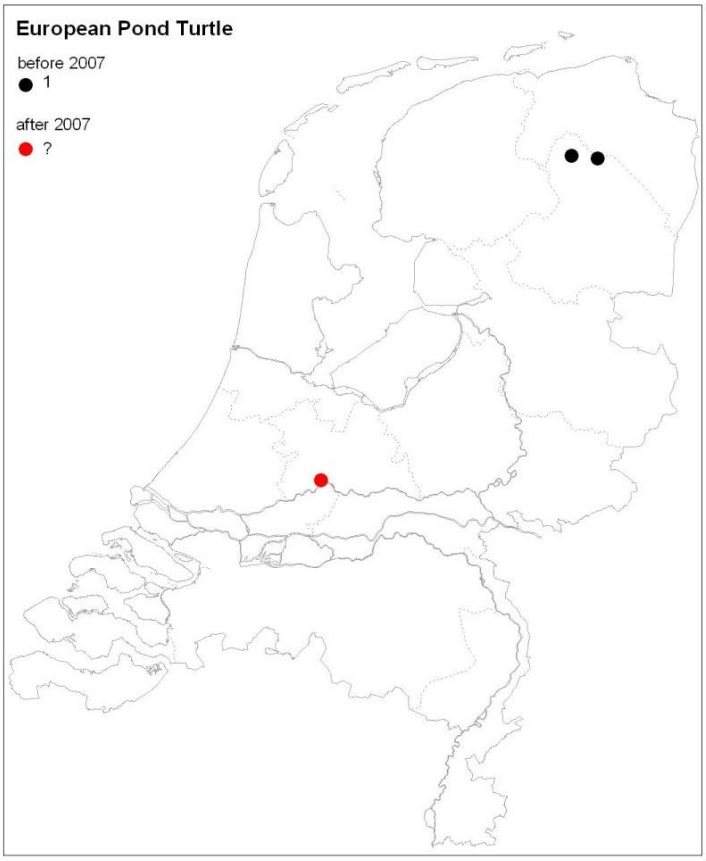

Figure 25
Observations of the European pond turtle in the Netherlands, before and after 2007.

Description
Dutch name: Europese Moerasschildpad

Family: Emydidae

Native distribution: Mainly Southern and Middle Europe (see Figure 3), but with extensions into Asia somewhat past the Caspian Sea and a couple of isolated sites in North-Africa.

Distribution outside native range: Isolated observations of species 'introduced' or discarded outside the range with suitable conditions (mainly from Northern Europe). The areas marked with 'introduced' in Figure 3 are probably colonized by the species on its own accord and must then be seen as belonging to its natural range. See also Figure 7.

Conservation status: IUCN red list: Lower Risk/near threatened. On Habitats Directive Annex IV.

Habits: European pond turtles are usually considered semi-aquatic. They lay their eggs on land, typically less than 150 m from the water. However, their terrestrial movements can span one km, and occasionally they are found traveling up to four km away from the water. Breeding occurs from March to May, depending on the latitude. Nesting occurs in May and June. Females use the same nest site as long as the site has not changed. If a female has to change her nesting site, it will typically select a site in close proximity. The basking habit is well-developed. European pond turtles are wary and dives into the water at any disturbance. These turtles often hide buried in the soft bottom or up under overhanging vegetation along the bank.

Habitat: Freshwater. European pond turtles live in slow-moving freshwater (sometimes brackish water) bodies, such as ponds, lakes, marshes, swamps, brooks, streams, rivers, and drainage canals, with soft bottoms (mud or sand) and abundant aquatic vegetation, especially overhanging the banks. They prefer wetlands surrounded by a large proportion of natural, wooded, landscape. Occasionally the species is also found in upland environments for feeding.

Hatching success:
The incubation period varies with latitude, and at the northern extent of the range a long, hot summer is needed for successful hatching to occur; thus the species may only successfully reproduce once in four or five years.

Laying season:	May-June
Peak laying season:	June
Incubation time:	8-14 weeks

Incubation temperature determines the sex of the hatchlings:

24-28 °C:	only males
>30 °C:	only females

Between 28 °C and 29.5 °C both sexes can develop. Thus the so called pivotal temperature for temperature-dependent sex determination is in general indeed around 28.5 °C. The young emerge in August to October or they may overwinter in the nest, surviving brief frost periods of up to - 6°C.

Food: European pond turtles are primarily carnivorous but eat plant material as well. It has been reported that an adult's diet starts from a carnivorous to a more herbivorous diet as it ages and grows in size. The amount of plant material consumption especially increases during the post breeding period. The species prefers crustaceans, insects, amphibians, small fish, worms and snails. Also carrion is part of their diet. Prey is actively stalked, and feeding may occur in or out of water.

Natural enemies:

Eggs: foxes, raccoon dogs, wild boar, crows
Juveniles: crows, herons, gulls, rats, large fish
Adults: badger, otter, eagles

Lifespan: At least 40 years.

Adult survival probability in the Netherlands: European pond turtles have been found in Dutch waters. So far there is no proof that the animals reproduce or survive severe winters in the Netherlands, but the species is expected to extend its natural range to the Netherlands before 2050.

Ecological impacts:

- This species hosts several species of parasites that may form a threat for other aquatic life, including *Haemogregarina stepanovi*, monogeneans of genus *Polystomoides*, vascular trematodes of genus *Spirhapalum* and many nematode species.
- May harm vulnerable populations of e.g. rare amphibians.

Dangers for humans: There are no known adverse effects of European pond turtles on humans.

Risk assessment:

Since conditions in the Netherlands are expected to become suitable for the European pond turtle before 2050 (see Figure 7), the species could possibly become established here. It does however not qualify as an invasive then: according to the European Commission guidance document on the strict protection of Animal species of Community interest under the Habitats Directive (EC 2007): *When a species or habitat spreads on its own to a new area/territory or when a species has been re-introduced into its former natural range (in accordance with the rules in Article 22 of the Habitats Directive), this territory has to be considered part of the natural range* (see also Trouwborst and BastMeier, 2010).

Although there will not be much difference between the ecological and human health risks attached to the immigration of the European pond turtle and a real exotic species becoming established, the European pond turtle technically cannot becoming an invasive and therefore it does not qualify as a risk species within the context of this study.

6 Dutch risk areas and habitats

Since all the risk species are aquatic, the areas in the Netherlands most at risk for turtle invasions are obviously water systems suitable for turtles. Waters that also have a high ecological status are the ones with the highest impact risk. Although exotic turtles now occur in all kinds of water bodies, present distribution is probably stronger linked to the point-of-release than to the actual habitat preference of the animals. Suitable turtle habitats are best indicated by the Dutch Nature types 'wetlands' and 'brooks' which are represented in the map in Figure 26.

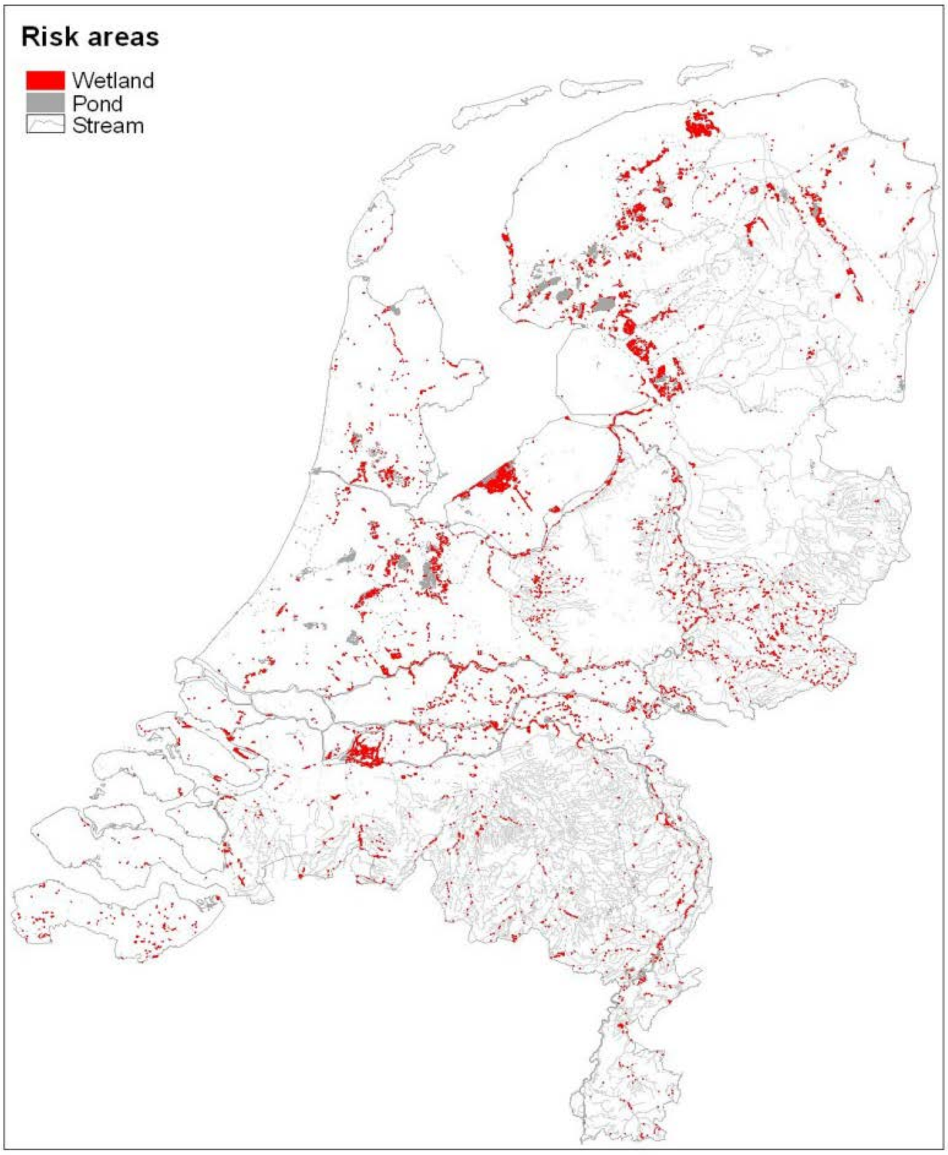

Figure 26
Overview of the Dutch risk areas for turtle invasions.

Risk areas consist of ecologically vulnerable water systems and of areas of larger, more robust systems of ecological interest where it will be difficult to recapture unwanted animals. The most vulnerable systems in an ecological sense are probably systems with a high ecological status like ponds or brook systems with endangered species (e.g., amphibians like the tree frog, crested newt, or common spade foot toad). Areas in which recapture of turtles will probably be difficult are for instance 'De Biesbosch', 'De Oostvaardersplassen', and the 'Wieden-Weerribben' area. All these areas however lie in parts of the Netherlands where climatic conditions can be expected to become suitable relatively late (see Figure 6). The areas likely to be first at risk will therefore be the brook systems in Limburg and Brabant.

7 Options for prevention, elimination and management

There is very little reported in scientific literature on the prevention of invasions or damage by invasive turtles, and neither on the elimination or management of invasive turtle populations. On the internet however many web pages on turtle control and prevention of turtle damage can be found, primarily concerning North America. This overview is mainly based on the webpage 'control and management of turtles' from the Internet Center for Wildlife Damage Management (ICWDM). Although most experience is gained in relation to local species, the methods will be applicable for control of invasive turtles as well. See also the general guidelines for the prevention of biodiversity loss published by IUCN-SSC-ISSG (2000).

Prevention of invasions
Since the most common pathway for the introduction of exotic turtles into nature is undoubtedly the discarding of pets, the obvious ways for prevention are trade control and the prevention of such discarding. The species providing the highest risk could for instance be banned from trade or additionally taxed. Persuading whole-sellers not to carry risk species any longer could also be an option, as well as a publicity campaign amongst pet and animal food dealers and their customers to make them aware of the dangers of discarding animals. A buy-back option and/or making people aware of the possibility of turning turtles in at care centres (Teillac-Deschamps et al, 2009) could also help. In addition, the possibility and effectiveness of encouraging or allowing trade in just one of the sexes of a species could be investigated.

Since there are no successfully reproducing invasive turtle populations present in any area close to the Netherlands, natural immigration from neighbouring countries does not present a risk. However, as invasions of other species have shown, possible future immigrations / range extensions from abroad are hard to prevent. However, the methods to prevent or manage this type of immigrations are exactly the same as the methods described for population elimination and management below.

Prevention of damage
Damage by invasive turtles can occur at three levels: the ecological-, economical- and health level (see also Chapter 3). Ecological damage contains direct effects as predation and competition for resources, and indirect effects via the spread of diseases that influence natural species in the ecosystem. However, not much information is available on this topic. This does not automatically mean that turtles do not present a problem in a (new) natural environment since the limited information available shows potential negative effects on native turtles and tadpoles. Exotic turtles could for instance quite possibly harm populations of rare native pond species like the Spadefoot toad when introduced to vulnerable ponds. When specimens are observed in such ponds they should be removed as quick as possible.

Although there was no real evidence found in literature or on the internet, according to the ICWDM website turtles can undoubtedly cause some economic damage in commercial fish ponds by eating the fish and competing with fish for food. On the other hand they are also useful because they kill diseased and weakened fish, and clean up dead or decaying animal matter. Aquaculture ponds are however not the preferred permanent habitat of turtles, since the heavy clay used to construct the ponds is unsuitable for nesting. Economic damage could also possibly occur when turtles would damage dykes by burrowing holes for hibernation, as was suspected by some observers in the Netherlands. There was however no evidence for the possibility of such damage found in an internet survey and the occurrence of this behaviour in the Netherlands could not be verified.

There are multiple options for the prevention of damage by turtles which can be summarized by either protecting the object that could sustain damage against the resident turtles or removing the unwanted turtles. If the main problem caused by invasive turtles is possible damage to, for instance, dykes then the protection of dykes is an option, if removal of the turtle(s) is unwanted or not achievable. For the Netherlands, potential damage to dykes could for instance be prevented by constructions like metal nets or concrete, as has been tested in relation to the prevention of muskrat damage. If there is risk of injuries due to a local snapping turtle that has not been caught yet, warning signs informing the public could be a temporary option.

Population elimination and management (damage control) methods

Methods to minimize damage by keeping populations small are basically the same ones that can be used to prevent range extensions or elimination attempts. The most appropriate ones for the Dutch situation are described below.

Draining and seining

A powerful damage control method for box, pond, and marsh turtles is to drain the habitat in which the turtles have been detected. This however can only practically been done in more or less relatively small hydrologically isolated habitats of rather low ecological status. This is due to the fact that interconnected habitats cannot be drained easily and the draining of natural habitats with a high ecological status may negatively impact many local species. In the latter case a good assessment is needed whether the negative impact of the removal process is worth the benefits of a turtle-free water body. Ponds that are used for the production of fish are routinely harvested by seining (fishing with a seine net). The seining process will also capture turtles. Consequently, these captured turtles can be removed. The same method can be used for Dutch ponds and ditches.

Trapping

Control of turtle populations is mostly primarily through trapping. Trapping can be used quite effectively to reduce local populations of these species. The best place to trap turtles is in the quiet water areas of streams and ponds, or in the shallow water of lakes. Soft-bottom areas near aquatic vegetation are excellent spots. The best seasons for trapping are spring, summer and early fall. Most turtles hibernate through the winter and do not feed, making trapping ineffective. Methods of trapping are described for various types of turtles in ICWDM (1994). Traps should be baited with fresh fish or red meat. Catfish heads and cut carp are regarded as two of the best baits available for trapping turtles. Baits should be suspended in traps on a bait hook or placed in bait containers for maximum effectiveness. In areas where turtle populations are high, it is often necessary to check traps two or three times per day and add fresh bait, since turtles are capable of consuming large quantities of bait rather quickly. For the Netherlands turtle trapping could be added to the task of muskrat trappers although it might result in a higher checking frequency than currently done. Although unintended capture of other species is to be expected as a side-effect this is not expected to be a large problem.

Shooting
Shooting can also be used as a means of reducing populations in ponds and lakes. This technique, however, turned out not to be very effective in the USA (no explanation offered on the website, but due to the fact that turtles have to be sighted first and that shooting one will cause the others to flee, the efficiency in an area with many turtles is probably very low). For the Dutch situation it can be an optional method if: 1) the animal in question is a threat to human safety and trapping is not achievable/successful and 2) there is no risk for humans or other fauna. Although turtles are quite shy and will easily flee, they do have to warm up in the sun making them quite visible and therefore a potential target for shooting. If just one or only a few turtles have to be removed urgently, shooting could therefore be an option.

Costs of prevention, elimination or management
The costs involved in preventing turtles to become invasive or to eliminate or decimate already established populations are not easy to estimate. In case of prevention the costs involved are determined by the costs of implementing regulations or publicity campaigns and the attached costs for monitoring and inspecting trade, care centres and pet dealers. Since it is impossible to assess in how far this will involve extra costs compared to 'normal' procedures a realistic cost estimate cannot be made.

To eliminate or decimate a local turtle population, a specific turtle capture campaign of about two weeks could be used. The costs of one such campaign (for a wetland location of relatively limited size) are estimated in Table 7. Roughly, one such campaign is estimated at a bit less than € 5,000. Considering that the Red-bellied Slider alone is already present in 258 5x5 km squares ('uurhokken', see Annex 3) and at least one such campaign would be needed per square for removal, the costs could easily become gigantic. However, a national campaign of turtle catching could probably be combined with regular muskrat capture campaigns quite easily, which would considerably reduce costs. Also, the gradual removal of the specimens already in Dutch nature at the moment, could easily be achieved by using volunteers of organizations like RAVON, who could catch the animals whenever possible during their normal field visits.

Table 7
Cost estimate of a turtle removal attempt for one particular Dutch wetland location.

Estimated price per trap		€ 150	
No traps/action	5	€ 750	Traps total
Labour per hour		€ 70	
	Hours	Cost	
Trap placement	4	€ 280	
Trap checking	28	€ 1,960	Two hours every day for two weeks
Organization	8	€ 560	
Transport	8	€ 560	
Trap removal	4	€ 280	
Trap cleaning and storage	4	€ 280	
	56	€ 3,920	Labour total
		€ 4,670	Grand total

Conclusions
Establishment of exotic turtles in Dutch nature can be averted by preventing the discarding of large numbers of these animals. This can be achieved by trade regulation measures and by publicity campaigns targeting both pet dealers and their customers to prevent on the one hand the selling in large quantities of risk species and on the other hand the discarding itself. The turtles already present in Dutch nature could possibly be gradually removed by professional musk-rat trappers and / or volunteer organizations.

When established populations need to be eliminated or decimated, turtles can relatively easy be removed using non-destructive traps or seining. For large Dutch wetlands the best method is to use life-traps to remove them. When trapping efficiency is low, and/or the last remaining turtles are too keen to be trapped, then shooting might be an additionally method to remove the last individuals. Trapped turtles should be transferred to zoo's / rehabilitation centres or destructed. Returning an exotic turtle to its original distribution area should not be considered as an option due to on the one hand the risk of introducing Dutch diseases and parasites there and the resistance that can therefore be expected, and on the other hand the probably high costs.

8 Conclusions and recommendations

8.1 Risk of species becoming invasive

Ecological suitability for Dutch conditions is obviously the main factor determining the *potential risk* of a species to become invasive in the Netherlands. But the *actual risk* is clearly determined by the risk of such a species being introduced to Dutch nature in sufficient numbers to actually become established. At the moment there are no populations of invasive turtle established anywhere close enough to the Dutch borders to present a risk of invasion through range expansion. The main risk of mass introductions is therefore through pet discarding.

That pet release is a key risk factor is illustrated by the fact that a massively traded species, the Red-eared Slider (*Trachemys scripta elegans*), has been able to get a foothold in countries all over North-Western and even Northern Europe solely through introductions, without being able to reproduce (e.g. NOBANIS). The presence of ecologically more likely but less traded species like the Painted Turtle *Chrysemys picta* and the Snapping Turtle *Chelydra serpentina* on the other hand is limited to single occurrences in only a few locations (e.g. DAISIE, 2011). This clearly shows that trade volume and the subsequent possible dumping of unwanted pet turtles are the important risk factors in determining the likelihood of potentially suitable species to really become invasive. Consequently, these are the factors that deserve the most attention in prevention and management.

8.2 Managing the problem

8.2.1 Preventing introductions

Regulation and monitoring of sale and return
Since large scale discarding of pets is clearly a by-product of the large scale pet trade channelled through whole sellers and not of the specialist pet trade, it is logical to aim measures mainly at the first group.

One of the most rigorous prevention measures possible is to ban all species that seem ecologically suitable for present and future Dutch conditions from trade. However, apart from unnecessarily hampering the pet trade with a measure that will probably especially affect the specialist shops (i.e. the wrong group) this measure could even backfire. Banning the trade in known risk species would very likely shift it to other ones for which the risk of large scale introductions is unpredictable. It might therefore be wiser to try to contain and minimize the presently known risks.

A preferable option would probably be to regulate and monitor trade through the introduction of a permit system for official (licensed shops and whole seller) trade, preferably for all species but certainly for trade in large quantities. Such a system could be used to keep whole sale trade limited to very 'warm' species and/or species of which the risks are known to be small. In any case it would allow a careful monitoring of traded quantities. In addition, the 'return' of specimen to care centres or shops should be monitored carefully because it gives an early indicator of developing problems.

Prevention of discarding
The real danger is however not in large quantity trade itself, but in the associated discarding of the animals. The most effective prevention measures are therefore the ones minimizing this discarding or reducing its effects. This could be achieved by investing in both improving and increasing 'return' options and by increasing awareness of these options among pet buyers. An obligation to provide every buyer with a brochure about the risks of discarding and the options for 'return' could for instance be incorporated in a permit (although convincing traders to do it voluntary would probably be preferable). Another option could be to convince or oblige traders to accept returned turtles for resale and/or install a kind of pay-back or deposit system. It is however crucial that care centres are able to accept all animals offered to them and have a solution for their increasing numbers.

Figure 27
Care centres can play a very important role in educating future as well as present turtle keepers. © Fabrice Ottburg.

8.2.2 Reducing impacts

Better the devil you know...
The Yellow-bellied Slider, the Cumberland Slider and the False map turtle are the three species that, judging by the numbers discarded and recorded in care centres, are the presently popular pet species. Due to the banning of imports of the Red-Eared slider, the trade has apparently moved to two other sub-species of *T. scripta* that can cross-breed with it. The other popular species, the False map turtle, will probably be able to reproduce under Dutch conditions much earlier than the sliders. The effect of the banning of the Red-Eared Slider is therefore questionable and with that the advisability of banning any other known risk species. As trade will only move to species of which the risks are far less clear, it might be much wiser to focus on controlling the presently known risks instead. It is therefore suggested to monitor and regulate turtle trade with a permit system, to reduce the numbers introduced to nature by measures as discussed in the previous section and to reduce possible impacts by measures discussed in the following sections.

Reduce numbers in nature
Since the combined numbers of *T. scripta* subspecies present a considerable risk (interbreeding, coincidental genetic match resulting in earlier successful breeding) their gradual removal from nature is recommended. This could for instance be done by recruiting volunteers to catch any turtle they come across and turn it

into a care centre. It would however be wise to accompany such an action by a publicity campaign explaining its necessity, to create public awareness and understanding. Only in a very limited number of cases (e.g., dangerous or contagious animals presenting a risk to human health, the last remaining turtles which cannot be caught otherwise) will shooting the animals be an option.

Other possible risk reductions

The ecological impact of the turtles that are already present in Dutch nature (or any other European country) is not well documented. For the Netherlands there are as yet no alarming reports of negative impacts. This can perhaps be explained by the fact that the current habits occupied by the turtles are mainly urban water bodies. These water bodies are usually of a low ecological status and accordingly only contain generalist species that can easily deal with turtle impacts. There are three ways in which turtle presence could indeed become a problem:

1. Turtles successfully reproduce. Although this may take another 40 years, if levels of introduction stay the same successful reproduction is only a matter of time. Apart from reducing the introduction volume (see above), there are possibly also other ways to limit reproductive risk. One of the ways could be to use the TSD system to our advantage and only allow the sale of one of the sexes. As this could lead to higher prices pet trade might be somewhat hampered but would still be possible.
2. Turtles introduce exotic parasites or diseases. As is discussed in Section 5.7 this risk is not clear nor assessed as very large at this point, but if such an event occurred the impact on native fauna could be devastating. A possible measure is the routinely screening of all imports for diseases like the fungus *Batrachochytrium dendrobatidis* causing the dangerous chytridiomycose in amphibians, and/or the preventive treatment against parasites of all specimens imported.
3. Turtles migrate or are introduced to vulnerable habitats. At the moment, the presence of turtles in Dutch nature is mainly limited to easily accessible and ecologically not vulnerable sites like park ponds, ditches and canals in or close to build up areas. Ecologically more valuable and vulnerable waters are usually located in more secluded, more natural areas and therefore probably less popular as release site. But if turtles would migrate or be introduced to sites with for instance rare and vulnerable amphibians like the common Spadefoot Toad *Pelobates Fuscus* or the Tree frog *Hyla arborea*, they could do a great deal of harm. Most vulnerable sites are usually quite well monitored and consequently turtles found here should immediately be caught and removed.

8.3 Recommendations

- Introduction of a permit system that allows careful monitoring (now) as well as directing trade (screening, numbers, etc. could be made conditions in future).
- Increase options and awareness on 'returning turtles' and the dangers of dumping. Sell turtles accompanied by information of how to get rid of them again. Investigate the options for a 'turtle deposit' to be refunded on return.
- Investigate the possibilities for and the pros and cons of prohibiting trade in species most likely to do damage and for a trade covenant with whole sellers and pet shops.
- Start an initiative to gradually reduce the presence of turtles in Dutch nature.
- Ask volunteers and researchers that monitor vulnerable sites to immediately remove any turtles they come across.
- Investigate the usefulness of screening turtles on parasites and diseases before they are sold.
- Investigate sex ratio in field and trade, and how the last one could be regulated.
- Investigate how many turtles are found in ecologically valuable sites, and what their influence there is.

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Appendix 1 Trapping methods

Source: Webpage *'control and management of turtles'* from the Internet Center for Wildlife Damage Management (ICWDM).
The numbering of figures in this annex follows the website numbering and therefore starts at number 2.
Acknowledgements for Figures 2 through 4: from Wildlife Damage Control Handbook (1969), Kansas State University, Manhattan. Adapted by Emily Oseas Routman.

Snapping and Soft-Shell Turtles
While snapping turtles are in hibernation, they often can be taken in quantities from spring holes and old muskrat holes, under old logs, and in soft bottoms of waterways. Turtle collectors rely on their hunting instincts and experience to locate hibernating turtles. When one is found, it pays to explore the surrounding area carefully because snappers often hibernate together. The method for capture, known as 'noodling' or 'snagging' requires a stout hook. One end of an iron rod is bent to form a hook and sharpened; the other end of the rod is used for probing into the mud or soil to locate the turtles. The hunter probes about in the mud bottom until a turtle is located (which feels much like a piece of wood) and then pulls it out with the hook. Turtles are inactive during the winter and offer little resistance to capture, although the landing of large ones may be difficult even for experienced hunters. Snappers and soft-shelled turtles are sometimes taken on set lines baited with cut fish or other fresh meat. One recommended device is made by tying 4 or 5 feet (1.2 or 1.5 m) of line to a stout flexible pole, 6 to 8 feet (1.8 to 2.4 m) long. About 12 inches (30.5 cm) of No. 16 steel wire is placed between the line and the hook, preferably a stout hook about 1 inch (2.5 cm) across between barb and shaft. The end of the pole is pushed into the bank far enough to make it secure at an angle that will hold the bait a few inches (cm) above the bottom. Snappers and soft-shelled turtles may also be taken readily in baited fyke or hoop nets (Figure 2).

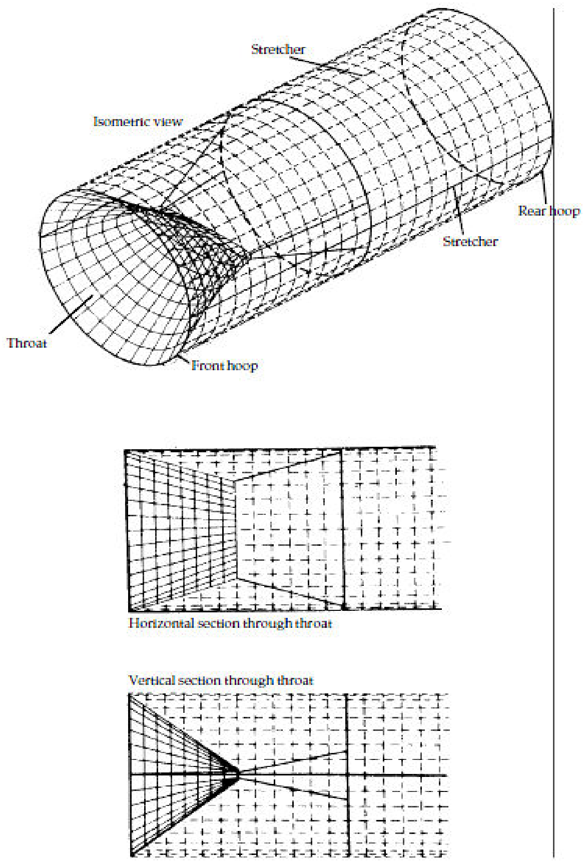


Figure 2
Hoop-net turtle trap.

These barrel-shaped traps may sometimes be purchased on the market or made from 3-inch (7.6-cm) square mesh of No. 24 nylon seine twine. The trap should be 4 to 6 feet (1.2 to 1.8 m) long from front to back hoop. The three to five hoops per trap be approximately 30 inches (76 cm) in diameter, made of wood or 6-gauge steel wire with welded joints. The funnel-shaped mouth should be 18 inches (46 cm) deep from the front hoop to the opening inside. The entrance opening of the funnel should be 1 inch x 20 inches (2.5 x 51 cm). The corners of the opening are tied by twine to the middle hoop. The rear or 'box' end may be closed with a purse string. After the hoops have been installed, the net should be treated with a preservative of tanbark, cooper oleate, tar, or asphalt. To keep the trap extended, stretchers of wood or steel wire, about 9 gauge or larger, are fastened along each side. Coarse mesh poultry wire may be substituted for the twine. If this is done, the frame will be approximately 30 inches (76 cm) square. The shape and dimensions of the entrance as specified should be the same in all traps, as it is easily negotiated by the turtles. The dimensions of the trap may be altered for ease of transportation. A door may be installed in the top to facilitate baiting and removal of turtles. Entrance funnels may be placed on each end if desired. Fyke or hoop turtle traps should be set with the tops of the hoops just out of the water. This will permit the turtles to obtain air and lessen their struggles to escape, and will enable other turtles to enter the trap more freely. It is necessary to set traps this way if the turtles are to be taken alive. Traps set in streams must be anchored. If the water is too deep for the top of the trap to be out of the water, short logs can be lashed to each side to float the trap. Turtles enter more readily when the mouth of the trap is set downstream.

Box, Pond, and Marsh Turtles
Because of their habits, these species must be captured with methods different from those for snapping and softshelled turtles. They cannot be taken in numbers during the winter, like snappers, because they do not congregate in their hibernating places. In the summer some species are gregarious, crowding together in numbers on projecting logs and banks. By taking advantage of this fact, these basking species may be taken by trapping in a box sunk in a place the turtles are using. The turtles crawl up onto the top of the box to bask in the sun, and many of them fall into the trap (Figure 3).
The top frame of the box may be constructed from discarded telephone poles, imperfect ties, or logs about 8 inches (20 cm) in diameter. Old natural unpainted wood is preferred. The logs are mitered at each end to fit together, and the inside enclosure made to measure 2 to 3 feet (61 to 91 cm) square. About half of each log from the top centre to the inside under centre is lined with zinc or galvanized metal. Turtles that have dropped into the trap are unable to climb over the zinc or galvanized metal covering.

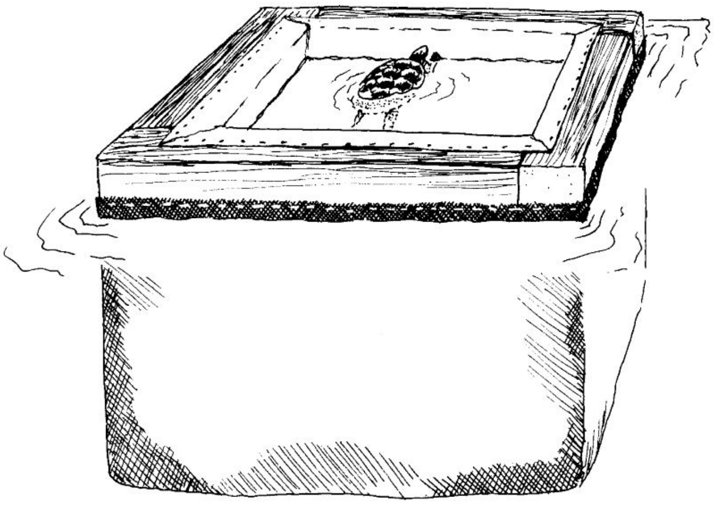


Figure 3
Sink box turtle trap.

From the outside water edge to the top of each log, cleats can be nailed or the logs made rough, so turtles can easily climb on top. Galvanized mesh wire can be fastened to the logs with staples, hooks, or wire to form a wire basket fitting the opening between the logs. One-inch (2.5-cm) mesh is about right if all sizes of turtles are to be trapped. If only larger specimens are sought, however, a 3-inch (7.6-cm) mesh can be used. The trap should be fastened to a stump or some other permanent anchor. Some trappers prefer to use bait; others leave the traps unbaited. For the capture of snapping and soft-shelled turtles, the trap can be modified by installing funnel-like entrances on one or two sides as described for the hoop traps.

Another type of trap consists of a box with an inclined board leading up to it. The turtles climb up on the board to bask and drop off into the box. Figure 4 shows the same trap with pivotal boards placed so that turtles crawling out on the boards overbalance on the terminal end and are dropped into the box.

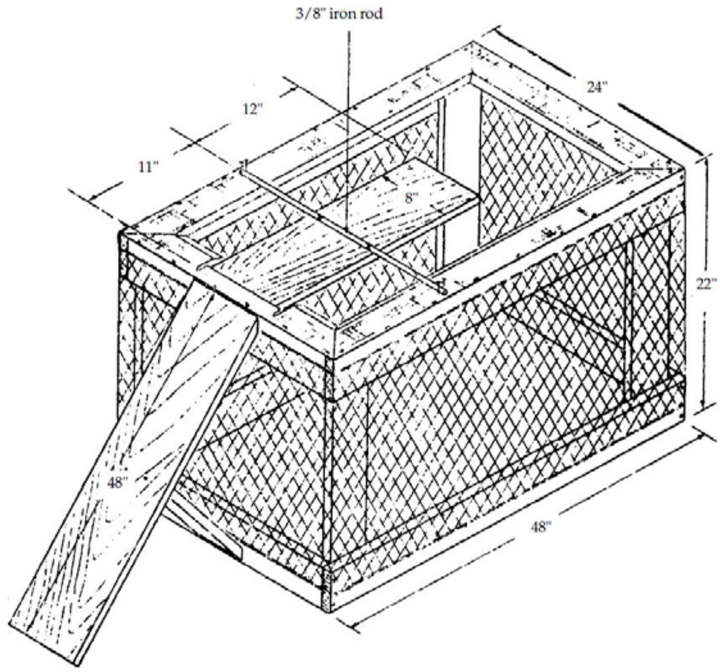


Figure 4
Sink box turtle trap with pivotal boards.

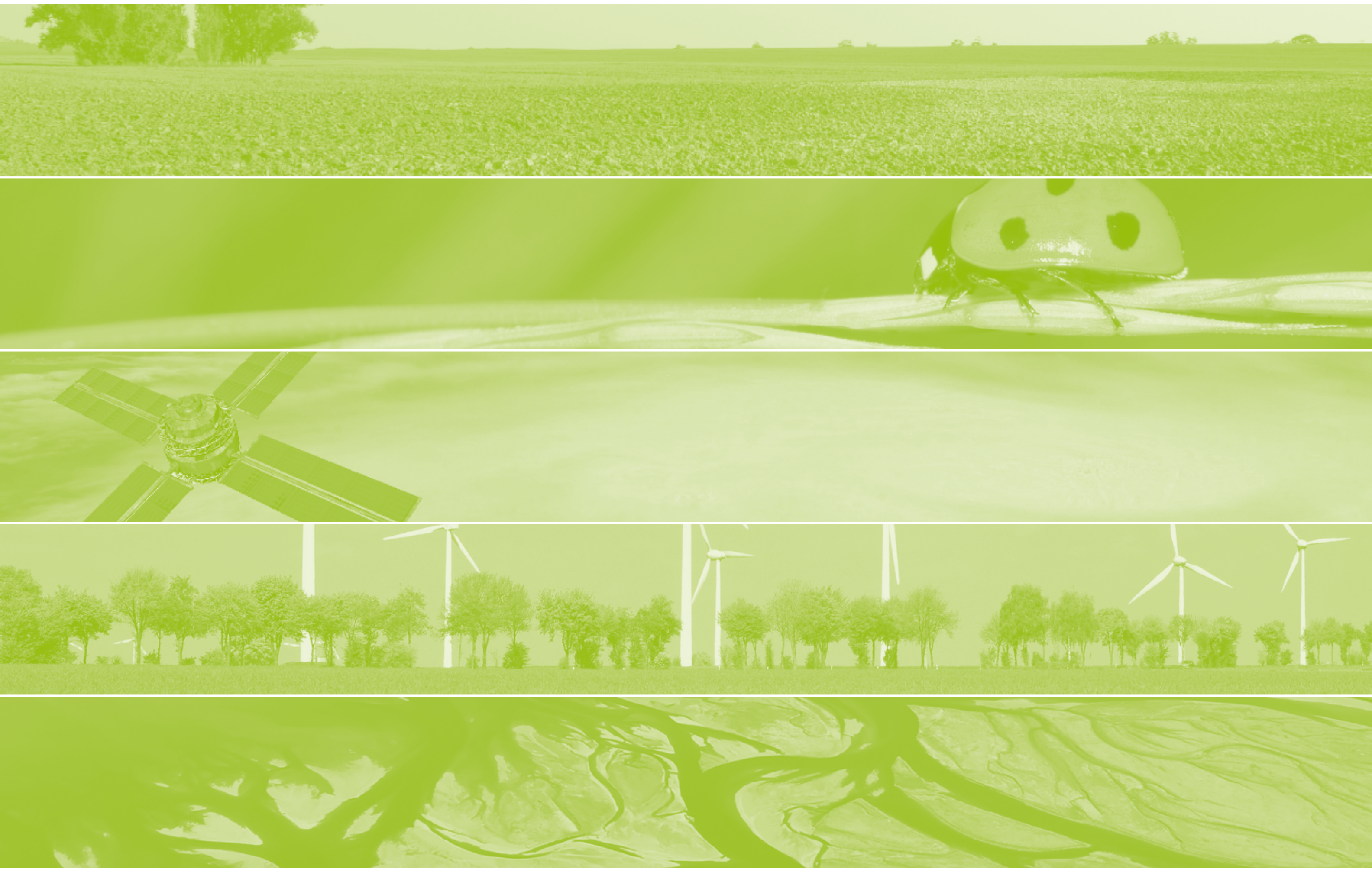
Appendix 2 Species in care centre custody

Number	Scientific name	Dutch name	English name	Aquatic semi-Aquatic or Terrestrial	Turtle care centre 'Stichting Schildpaddencentrum Nederland' period 1979-2009	Turtle care centre 'Stichting Schildpaddencentrum Nederland' period 2007-2009	Numbers registered at the Ministry ELI (LNV) period 2007-2009
1	*Apalone spinifera*	Drieklauw weekschildpad	Spiny Softshell turtle	Aquatic	0	0	1
2	*Chelydra serpentina*	Gewone bijtschildpad	Snapping turtle	Aquatic	1	0	1
3	*Chinemys reevesii = Mauremys reevesii*	Chinese driekielschildpad	Reeve's turtle	Semi aquatic	5	1	3
4	*Chrysemys picta bellii*	Westelijke sierschildpad	Western painted turtle	Aquatic	7	0	3
5	*Chrysemys picta dorsalis*	Zuidelijke sierschildpad	Southern painted turtle	Aquatic	2	0	0
6	*Chrysemys picta picta*	Oostelijke sierschildpad	Eastern painted turtle	Aquatic	1	0	2
7	*Cuora a. amboinensis*	Ambonese waterdoosschildpad	Southeast Asia box turtle	Semi aquatic	4	0	1
8	*Cuora f. flavomarginata*	Geelrandwaterdoosschildpad	Yellow-margined box turtle	Semi aquatic	3	0	1
9	*Cuora galbinifrons*	Indochinese waterdoosschildpad	Indochinese box turtle	Semi aquatic	2	0	0
10	*Cyclemys dentata*	Javaanse bladschildpad	Asian leaf turtle	Semi aquatic	3	0	1
11	*Emydura subglobosa = Emydura albertisii*	Roodbuik spitskopschildpad	Red-bellied short-neck turtle	Aquatic	1	0	0
12	*Emys orbicularis*	Europese moerasschildpad	European pond turtle	Aquatic	2	0	1
13	*Geochelone carbonaria*	Kolenbrander- of Roodvoetschildpad	Red-footed tortoise	Terrestrial	4	7	5
14	*Geochelone denticulata*	Woud- of Geelvoetschildpad	South American yellow-footed tortoise	Terrestrial	2	2	4
15	*Geochelone pardalis*	Panterschildpad	Leopard tortoise	Terrestrial	5	2	3
16	*Geochelone sulcata*	Sporenschildpad	African spurred tortoise	Terrestrial	2	1	1
17	*Geoclemys hamiltoni*	Driekiel stralenschildpad	Spotted pond turtle	Aquatic	1	0	2
18	*Geoemyda spengleri*	Gezaagde aardschildpad	Black-breasted leaf turtle	Semi aquatic	1	0	0
19	*Graptemys geographica*	Landkaartschildpad	Common map turtle	Aquatic	13	0	4
20	*Graptemys n. nigrinoda*	Landkaarschildpad	Black knobbed map turtle	Aquatic	8	0	0
21	*Graptemys pseudogeographica*	Landkaartschildpad = Zaagrugschildpad	False map turtle	Aquatic	22	0	0
22	*Graptemys pseudogeographica kohnii*	Kohn's landkaartschildpad	Mississippi map turtle	Aquatic	44	30	25
23	*Graptemys versa*	Texas landkaartschildpad	Texas map turtle	Aquatic	5	0	0
24	*Heosemys grandis*	Reuzenaardschildpad	Giant Asian pond turtle	Aquatic	1	0	0
25	*Indotestudo elongata*	Geelkoplandschildpad	Elongated tortoise	Terrestrial	1	0	0
26	*Kinixys belliana belliana*	Gladrandklepschildpad	Bell's hinge-back tortoise	Terrestrial	1	0	2
27	*Kinixys homeana*	Stekelrandklepschildpad	Home's hinge-back tortoise	Terrestrial	1	0	0
28	*Macroclemys temminckii*	Gierschildpad	Alligator snapping turtle	Aquatic	1	0	0
29	*Mauremys c. caspica*	Kaspische beekschildpad	Caspian turtle	Aquatic	4	0	2
30	*Mauremys leprosa*	Moorse beekschildpad	Mediterranean turtle	Aquatic	1	0	2
31	*Mauremys mutica*	Driekielwaterschildpad	Yellow pond turtle	Aquatic	3	0	0
32	*Pelodiscus sinesis = Trionyx sinensis*	Chinese weekschildpad	Chinese soft-shelled turtle	Aquatic	1	0	1
33	*Pelomedusa subrufa*	Afrikaanse moerasschildpad	African helmeted turtle	Aquatic	3	3	0
34	*Pelusios s. subniger*	Oost-Afrikaanse zwarte klapborstschildpad	East African black mud turtle	Aquatic	11	0	1
35	*Platemys platycephala*	Roodkopdeukschildpad	Twist-necked turtle	Semi aquatic	0	0	1
36	*Pseudemys concinna hieroglyphica*	Hierogliephensierschildpad	River cooter	Aquatic	25	0	2
37	*Pseudemys f. floridana*	Florida sierschildpad	Common cooter	Aquatic	17	0	2
38	*Pseudemys nelsoni*	Amerikaanse moerasschildpad	Florida red-bellied turtle	Aquatic	16	0	7
39	*Pseudemys rubriventris*	Roodbuiksierschildpad	American red-bellied turtle	Aquatic	6	0	0
40	*Pyxidea mouhotii*	Indische doornschildpad	Keeled box turtle	Terrestrial	1	0	0
41	*Rhinoclemmys pulcherrima*	Sieraad schildpad	Ornate Wood turtle	Terrestrial	0	0	1
42	*Sacalia bealei*	Chinese pauwoogschildpad	Beal's eyed turtle	Aquatic	4	0	0
43	*Siebenrockiella crassicollis*	Zwarte dikkopschildpad	Black marsh turtle	Semi aquatic	1	0	1
44	*Sternotherus m. minor*	Dikkopmuskusschildpad	Loggerhead musk turtle	Aquatic	4	0	0
45	*Sternotherus odoratus*	Muskusschildpad	Common musk turtle	Aquatic	1	0	1
46	*Terrapene c. carolina*	Carolina doosschildpad	Box turtle	Terrestrial	20	2	0
47	*Terrapene carolina major*	Grote doosschildpad	Gulf coast box turtle	Terrestrial	3	0	0
48	*Terrapene carolina triunguis*	Drieteendoosschildpad	Three-toed box turtle	Terrestrial	5	0	0
49	*Terrapene o. ornata*	Sierdoosschildpad	ornate box turtle	Terrestrial	2	0	0
50	*Testudo g. graeca*	Moorse landschildpad	Spur-thighed tortoise	Terrestrial	24	32	36
51	*Testudo hermanni boettgeri*	Griekse landschildpad	Eastern Hermann's tortoise	Terrestrial	18	14	14
52	*Testudo horsfieldii*	Vierteenlandschildpad	Russian tortoise	Terrestrial	16	13	14
53	*Trachemys decorata*	Decoratieve sierschildpad	Hatian slider	Aquatic	52	0	33
54	*Trachemys scripta callirostris*	Pauwoogschildpad	Colombian slider	Aquatic	1	0	0
55	*Trachemys scripta elegans*	Roodwangsierschildpad	Red-eared slider	Aquatic	399	184	176
56	*Trachemys scripta ornata*	Pauwoogsierschildpad	Mesoamerican slider	Aquatic	2	0	0
57	*Trachemys scripta scripta*	Geelbuikschildpad	Yellowbelly slider	Aquatic	163	164	123
58	*Trachemys scripta troostii*	Geelwangschildpad	Cumberland slider	Aquatic	31	0	14
59	*Trionyx ferox = Apalona ferox*	Florida weekschildpad	Florida softshell turtle	Aquatic	5	0	0

Appendix 3 Increase in occurrence

Overview of the number of 5x5 kilometres squares (uurhokken) in which the four most occurring species were found from 2000 to 2008, the last year for which complete data is available. Based on observations registered in the RAVON database.

Year	*Trachemys scripta scripta*	*Trachemys scripta troostii*	*Trachemys scripta elegans*	*Graptemys pseudogeographica*
	(Yellow bellied slider)	(Cumberland slider)	(Red-eared slider)	(False map turtle)
2000			24	
2001			20	
2002			33	
2003			48	
2004		6	116	1
2005	1		113	1
2006	6	2	243	5
2007	17	11	233	7
2008	17	21	258	6



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