

# Online trading tools as a method of estimating propagule pressure via the pet-release pathway

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**Abstract** The increasing amount of internet trade in live animals has facilitated the sale and circulation of exotic species all over the world. This is an area of concern, as the deliberate or accidental release of pets is an important pathway by which exotic species are often introduced into new environments, often with negative effects on the local species and ecosystems. Internet trading sites were used to determine the distribution and magnitude of propagule pressure of red-eared slider turtles (RES; *Trachemys scripta elegans*) within the New Zealand pet trade. Sites were tracked daily from October 1, 2007 to September 30, 2009 and information on age, sex, season, and location was recorded. More than 1,500 sales and 80 reports of lost/found RES were recorded. Unsurprisingly, the highest number of sales and lost/found RES was in Auckland, the region with the highest human population. Females were more often reported as lost or found than males, despite a similar sex ratio of sales. The type and quality of information gathered in this manner is not perfect, as it only provides an estimate of minimum numbers of animals that are being traded/lost into the environment, but nonetheless, provides useful data when planning a management or

eradication plan for feral turtles in New Zealand. Of concern, our results highlighted areas where turtles were most often being released in New Zealand, being those areas predicted to be the most climatically-suitable for this species, and in which incubation conditions were most likely to be met. Monitoring online sales of exotic species provides useful demographic information, as well as an indication of propagule pressure via the pet-release pathway. This technique is applicable to other species and may be a useful tool to help determine locations at risk of the establishment of other exotic species.

**Keywords** Invasive species · Reptiles · Red-eared slider turtles · *Trachemys scripta elegans* · New Zealand · Pet trade

## Abbreviation

RES Red-eared slider turtle (*Trachemys scripta elegans*)

## Introduction

The internet has become an invaluable tool for facilitating commerce and communication worldwide. With its increased popularity, and ability to bring people from around the world into instant contact with one other, the opportunities to trade in live animals have increased. Monitoring of online auctions has

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helped determine the extent of trade in endangered wildlife around the world and within country borders (International Fund for Animal Welfare (IFAW) 2008) as well as identify websites advertising prohibited species (Martin and Coetzee 2011; Suiter and Sferrazza 2007). Another useful context in which information from online auctions could be used is to monitor the sale and movement of particular species to areas to which they are not native and may potentially establish invasive populations (Kay and Hoyle 2001; Walters et al. 2006; Derraik and Phillips 2010; Morrisey et al. 2011). Furthermore, online advertisements provide additional data, such as sex and age of a particular animal for sale or lost/found, which can provide demographic details of a potentially invasive species. Whether this publicly available information is useful as a prediction and monitoring tool for escapees/releases of a species of interest into the wild is unknown.

Invasive species are often implicated in severe economic and ecological impacts. There are several methods by which exotic species can be introduced into new environments; examples include importation for food, biocontrol, and the pet trade (Bertolino 2009; Kraus 2009; Krishnakumar et al. 2009). For reptiles, the pet-release pathway has been found to be the most important introduction pathway, measured by the total number of introduction events and the total number of successfully established introductions (Kraus 2009). To date, methods for predicting establishment potential of pest species mainly include climate-matching models, which identify climatically-suitable areas for a particular species based on the amount of overlap in the climate parameters from their native range (Kikillus et al. 2010; Peterson et al. 2008; Thuiller et al. 2005). While climate is an important factor in the establishment of a non-native species, dispersal ability, reproductive rate, and propagule pressure are also significant factors (Duncan et al. 2001; White et al. 2008; Williamson and Fitter 1996). Propagule pressure is defined as a measure of the number of organisms released into foreign environment, along with the number of release events (Lockwood et al. 2005). It is a consistent predictor in the success of invasive species, but this information is often unavailable and/or difficult to quantify (Rixon et al. 2005; Bomford et al. 2009; Hayes and Barry 2008). For the pet-release pathway, online trading may provide the

means to determine the degree of propagule pressure within a system, taken from the number of animals sold/lost and the areas from which they are being traded or lost into the local environment. Although most of the reptiles bought and sold via online trading sites in New Zealand remain in captivity, there is no such thing as a “zero escape risk” once an exotic species is held in containment (Shine et al. 2000).

The red-eared slider turtle (RES; *Trachemys scripta elegans*) is a popular pet around the world, and through the “pet-release pathway” (Kraus 2009) has established invasive populations on every continent, save Antarctica (Ernst and Lovich 2009; Lever 2003), and is classified as one of the world’s worst invasive species (Invasive Species Specialist Group (ISSG) 2004). New Zealand is one of the few countries in which RES have not yet established, although climate-matching models suggest that northernmost New Zealand is climatically suitable for successful reproduction and population persistence (Kikillus 2010). Due to a ban on import of RES into the country, coupled with strict biosecurity measures at all ports of entry, New Zealand may be considered a closed system meaning that the only method by which RES can get into the wild in this country is via accidental or deliberate release of existing pets. While RES are no longer permitted to be imported into New Zealand, the domestic trade in these animals is unregulated (i.e. there are currently no permits required in order to own, breed, or sell RES) under the Hazardous Systems and New Organisms Act 1996.

The goal of this paper is to determine whether online trading resources are useful tools for determining the degree of propagule pressure on a system and thus the establishment potential of a species. Specifically, we used RES (one of the “World’s Worst Invaders”) and New Zealand (a closed system in which RES have not established) as our representative systems. In particular, we aimed to: (1) determine minimum estimates for the number of RES currently being traded in New Zealand and where and at what rate these animals are being released into the wild; (2) determine the potential population structure of both traded and released animals; (3) determine whether online sales data accurately predicts collected records of released RES; and (4) provide details of the usefulness of online auction sites as a predictor of propagule pressure in the local environment.

## Methods

### Study species

Red-eared sliders are native to the Mississippi Valley area of the United States of America, but due to the pet trade, they have become the most widespread freshwater turtle in the world (Ernst and Lovich 2009). For this reason, the importation and possession of RES is banned in many countries (Bringsøe 2006; Kitowski and Pachol 2009). Sexual maturity in RES appears to be size-related rather than age-related, with males reaching maturity when their shell is approximately 10 cm in length, and females at about 17 cm (Newbery 1984). Adult RES exhibit sexual dimorphism, with males being smaller than females, and possessing longer foreclaws, thicker tails, and a more concave plastron (Gibbons and Lovich 1990; Thornton 1999). However, sexual dimorphism is often not apparent before ~2 years of age (Gibbons and Lovich 1990; Thornton 1999). Females are capable of storing sperm for over a year and may lay up to three clutches of eggs per year with between 5 and 24 eggs per clutch (Bringsøe 2006; Thornton 1999; Tucker 2001). In southern hemisphere areas where RES have established invasive populations the breeding season (including courtship, nesting, and hatching) spans from August to February (Newbery 1984).

### Data collection

Data on RES sales were collected over 2 years (beginning at the start of October 2007 to the end of September 2009) using the New Zealand online auction site, TradeMe ([www.trademe.co.nz](http://www.trademe.co.nz)). TradeMe is the most popular online auction site in New Zealand, with more than 2.5 million registered members (TradeMe 2010). The TradeMe site was checked daily using the search terms “turtle”, “red-eared slider”, and “red necked turtle” to identify sales of RES and classified advertisements for lost and found pet RES. Sales were only included if a purchase price was able to be confirmed (i.e., a winning bid was made or a fixed-price offer was available). Other factors recorded were: date, age (if specified), sex (if specified, or able to be determined from the associated photo), and location. Age designations were split into four categories: “juvenile”  $\leq 1$  year of age, “subadult” = between 1 and 2 years of age, “adult”  $\geq 2$  years of age, and “unspecified”.

Data on lost or found RES (unconfined turtles within the New Zealand environment; hereafter referred to as “released”) were obtained using a wider time-frame (1999–2010) and multiple sources in order to obtain a large dataset. These included TradeMe ( $n = 51$ ), “Pets on the Net” ([www.petsonthenet.co.nz](http://www.petsonthenet.co.nz); a website where lost and found pets are listed;  $n = 14$ ), newspaper reports/journal articles ( $n = 4$ ), regional council records ( $n = 11$ ), and personal reports to KHK from members of the public ( $n = 3$ ). Information regarding human population within 14 geographic regions in New Zealand was obtained from the 2006 Census results via Statistics New Zealand (<http://www.stats.govt.nz>).

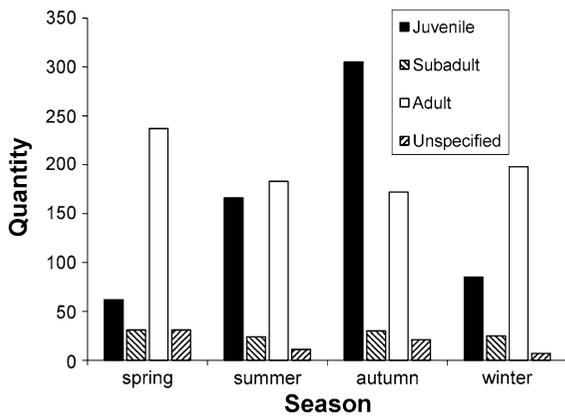
For comparative purposes, sales and releases of two other common pet exotic reptiles, the blue-tongue skink (*Tiliqua scincoides*) and the inland bearded dragon (*Pogona vitticeps*), were also recorded during this time frame.

## Results

Between October 2007 and October 2009, 1588 RES were sold on TradeMe with a total value of 170,956 NZD. The greatest number of sales for RES occurred in May in both years, with hatchling turtles accounting for the majority (65 %) of sales in this month. Overall, however, adult RES comprised the largest portion of the sales, with 50 % of turtles sold being over 2 years of age (Fig. 1). Many turtles sold were of unspecified sex (58 %). For advertisements in which the sex of the turtle was specified, or able to be identified from the associated photo, 55 % were males and 45 % were females (Table 1).

There was a moderate correlation between human population and number of RES sold (Spearman  $\rho = 0.653$ ,  $df = 12$ ,  $P = 0.011$ ). The Auckland region had the highest number of RES sold ( $n = 321$ ) and the highest human population size (1.3 million people), however, the West Coast region with a population of ~31,000 people had 156 turtles sold, which is in the top four for quantity of RES sales within New Zealand (Fig. 2).

Between 1999 and 2010, 83 lost or found RES were reported throughout New Zealand, spanning locations from the Northland region to Otago (Fig. 3). Across all years, most released turtles reports were listed in summer (December to February; 45 %), followed by



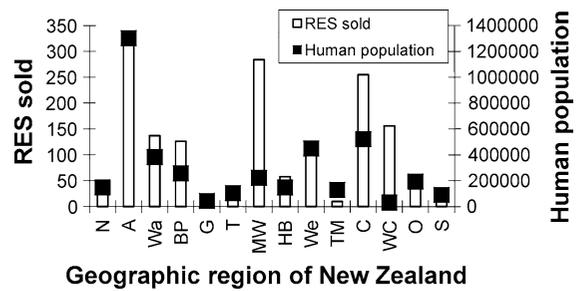
**Fig. 1** Sales of red-eared slider turtle (*T. scripta elegans*) by age classes and season (October 2007 to October 2009) from [www.trademe.co.nz](http://www.trademe.co.nz). Spring = September to November, summer = December to February, autumn = March to May, and winter = June to August. juvenile  $\leq 1$  year, subadult = 1–2 years, adult  $\geq 2$  years. N = 1,588

spring (September to November; 31 %), autumn (March to May; 20 %), and very few in winter (June to August; 4 %). Adult RES comprised the majority of released turtle reports (72 %) (Fig. 4) with females significantly more likely to be lost or found than males [32+ out of 55 released turtles being female, one-tailed  $P = 0.039$  in a post hoc binomial test, with  $n = 55$  and probability of being female (from sales data) = 0.455, (Tables 1 and 2)]. Very few juveniles (1 %) were reported as lost or found.

There was also a correlation between number of RES sales and the number of RES reported as lost or found within New Zealand (Spearman  $\rho = 0.660$ ,  $df = 12$ ,  $P = 0.010$ ). The majority of released RES reports were from the Auckland region (46 %). However, other areas of high sales (e.g. Manawatu-Wanganui and Canterbury) had relatively low numbers of RES reported lost or found, whereas the Wellington and Hawkes Bay regions had a large proportion of RES lost or found (Fig. 5).

**Table 1** Sex and age class of red-eared sliders (*T scripta elegans*) sold on the online trading site TradeMe (October 2007–October 2009). (juvenile  $\leq 1$  year, subadult = 1–2 years, adult  $\geq 2$  years)

Sex	Age bracket				Total
	Juvenile	Subadult	Adult	Unspecified	
Female	3	28	273	1	305
Male	9	22	334	1	366
Unspecified	606	60	183	68	917
Total	618	110	790	70	1,588



**Fig. 2** Sales of red-eared slider turtles (RES; *T. scripta elegans*) in relation to geographic region of New Zealand and human population density on [www.trademe.co.nz](http://www.trademe.co.nz) during October 2007–October 2009. N,Northland; A,Auckland; Wa,Waikato; BP,Bay of Plenty; G,Gisborne; T,Taranaki; MW,Manawatu-Wanganui; HB,Hawke’s Bay; We,Wellington; TM,Tasman/Marlborough/Nelson; C,Canterbury; WC,West Coast; O,Otago; S,Southland

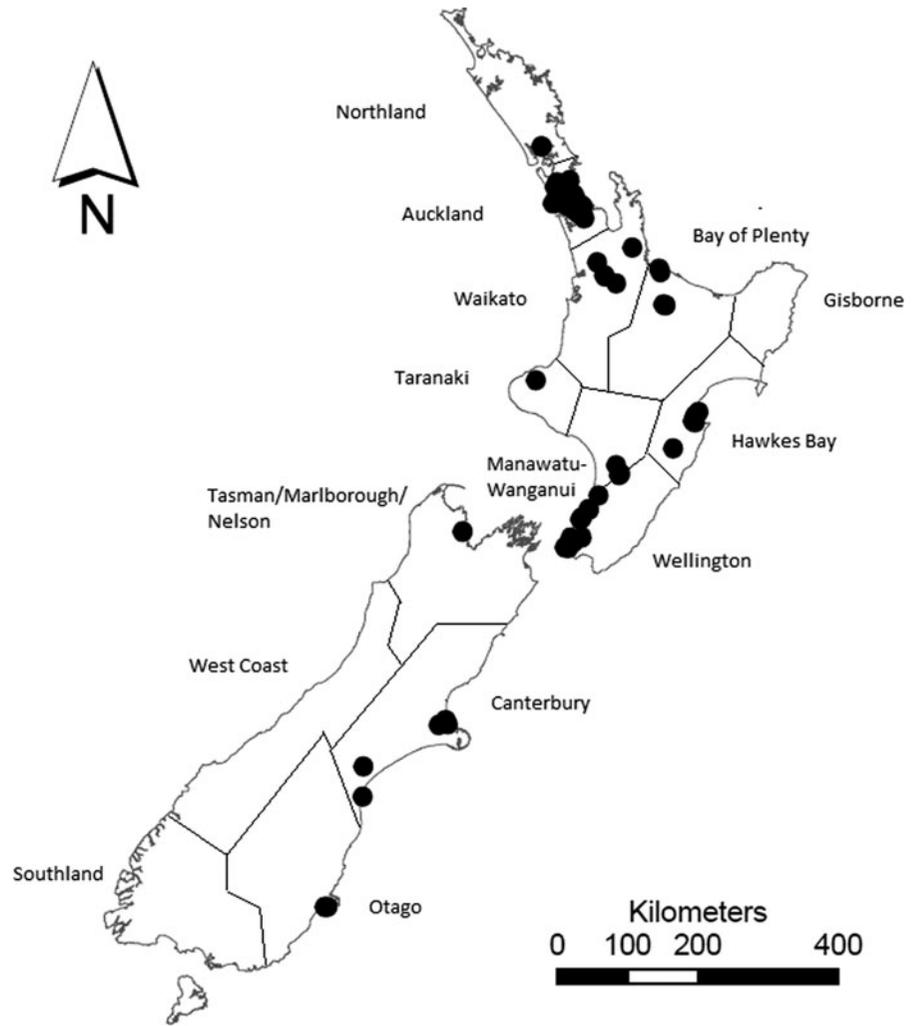
In comparison, within the same 2 year period, 134 blue tongue skinks were sold and none reported missing, and 144 inland bearded dragons were sold and two specimens reported missing in the Auckland region.

**Discussion**

Turtle sales and released turtles

Over the course of 2 years we recorded the sale of over 1,500 RES within the online pet trade in New Zealand, with the majority (20 %) sold in the Auckland region. We also found more than 80 reports for lost or found (i.e. “released”) RES from 1999 to 2010. Again, these were mostly from the Auckland region (46 %). Over half of all RES sold on TradeMe were adults. Similarly, most reported released individuals were adults with both sexes represented. Thus, individuals capable of breeding are being seeded regularly into the

**Fig. 3** Map of geographical regions of New Zealand and reports of released red-eared slider turtles (*T. scripta elegans*) (1999–2010), denoted by *black dots* (N = 83)



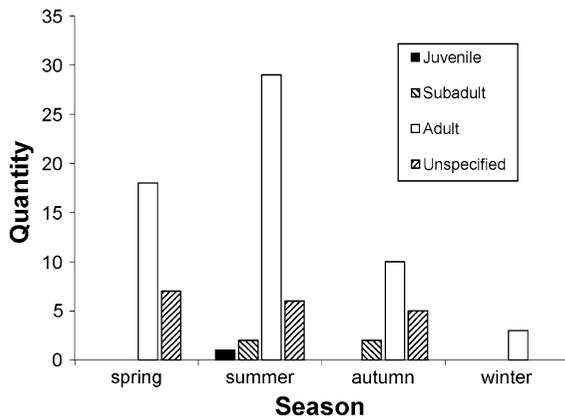
New Zealand environment, and most of these into the climatically suitable (Kikillus et al. 2010) Auckland region.

Our online trading data adds to a high-risk scenario for establishment of RES within the Auckland region. However, as most releases are in summer, the turtles would need to survive a winter season before potentially mating (males) or laying eggs (sperm-storing females), which may reduce the seed populations. Furthermore, male RES are more likely to move between aquatic habitats in search of mating opportunities (Morreale and Gibbons 1986; Thomas and Parker 2000; Tuberville and Gibbons 1996), which may further expose them to potential dangers. It is also encouraging that the Auckland Regional Council (ARC) has classified the red-eared slider as a

“Research Organism”, a category in which an animal’s potential impact on the environment requires further research, and also as a pest “only where they are not held in secure containment” (Auckland Regional Council 2007). The two species of lizards incorporated into this study (blue-tongue skinks and bearded dragons) are also classified as “Research Organisms” by the ARC, despite the fact that lower quantities of these species, in comparison to RES, appear to be traded throughout the country and released into the local environment.

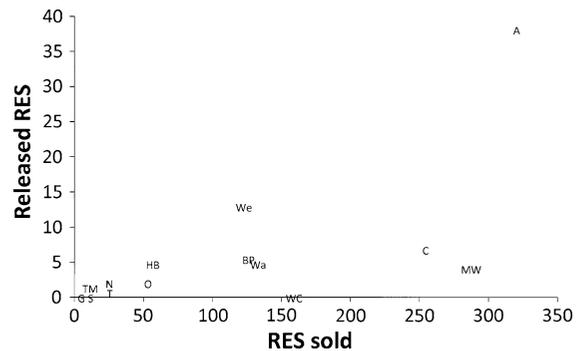
#### Usefulness of online trading tools

The information available online provides a “population profile” for RES in the New Zealand pet trade,



**Fig. 4** Released red-eared slider turtles (*T. scripta elegans*) by age classes and season in New Zealand (1999–2010). Spring = September to November, summer = December to February, autumn = March to May, and winter = June to August. juvenile  $\leq 1$  year, subadult = 1–2 years, adult  $\geq 2$  years). N = 83

and provides details of locations with high sales of RES. Similarly, data on locations where RES are predominantly lost and the seasonal trend in losses can be obtained from these and other sources. These types of data are useful when planning an eradication or management plan for feral RES in New Zealand, as they allow higher risk locations to be pinpointed. Bomford (2003) concluded that the degree of propagule pressure is a consistent factor in the successful establishment of invasive species; however this information is often unavailable or difficult to quantify. Our study allowed us to determine a minimum value for propagule pressure, and allows for comparison with other species to estimate the “relative propagule pressure” for the purpose of risk analysis and prioritization. According to our findings, RES have a higher degree of propagule pressure in relation to other popular exotic reptile pets, and the greatest risk of establishment, and therefore management efforts



**Fig. 5** Comparison of sales of red-eared slider turtles (RES; *T. scripta elegans*) on the online trading site, [www.trademe.co.nz](http://www.trademe.co.nz), during October 2007–October 2009 (n = 1,588) in relation to released RES reports (1999–2010) (n = 83) and region. N Northland, A Auckland, Wa Waikato, BP Bay of Plenty, G Gisborne, T Taranaki, MW Manawatu-Wanganui, HB Hawke’s Bay, We Wellington, TM Tasman/Marlborough/Nelson, C Canterbury, WC West Coast, O Otago, S, Southland

should potentially focus on RES over and above other exotic reptiles traded within New Zealand. As border security and intentional releases come under tighter scrutiny worldwide, the pet release pathway may assume greater importance; therefore the monitoring of internet sales and reported losses is a valuable way of collecting information on the unregulated pet trade, and, for closed systems, provides important data on minimum propagule pressures imposed on ecosystems.

In general, online sales data accurately predicted records of released RES throughout the rest of New Zealand, but not all geographic regions fell neatly into this pattern. For example, New Zealand’s West Coast region had the highest number of RES sales per number of human inhabitants, but no RES were reported as lost or found. This is likely because the majority of turtles sold from the West Coast were by a single breeder operating in the area, and breeders may be less likely to lose valuable animals and also ship

**Table 2** Sex and age class of reported released red-eared sliders (*T. scripta elegans*) in New Zealand (1999–2010). (juvenile  $\leq 1$  year, subadult = 1–2 years, adult  $\geq 2$  years)

Sex	Age bracket				Total
	Juvenile	Subadult	Adult	Unspecified	
Female	0	1	31	0	32
Male	0	3	20	0	23
Unspecified	1	0	9	18	28
Total	1	4	60	18	83

animals throughout the country (K. H. Kikillus, personal observation). Furthermore, in cooler, wetter parts of the country (such as the West Coast) people may keep their pet turtles indoors (as opposed to an outdoor garden pond) which will likely lead to a lower probability of escape into the environment. In addition, cooler weather will reduce activity level of the reptiles so they are less likely to escape. Hawkes Bay and Wellington had the largest number of reported RES releases per number of human inhabitants, but this did not match with the rate of sold RES in these regions. This may be attributed to scenarios such as pet owners in Hawkes Bay and Wellington being more likely to lose their turtle than pet owners in other regions, or perhaps being more likely to report their turtle missing online than pet owners from other areas. Additionally, just because an animal is sold in a particular area, does not mean it remains in the area after the sale. Many vendors of RES offer shipping options to potential buyers, and turtles are regularly couriered throughout the country (K. H. Kikillus, personal observation).

Our online sales data provide an estimate of the number of turtles being sold online, however, it is inevitably an underestimate of the actual number of turtles being sold within New Zealand. Turtles that are sold privately or in pet shops are not included in this analysis. Similarly, the reports of released RES are an underestimate, as not every RES owner will post an online classified advertisement if their pet goes missing, while other owners may illegally release their unwanted pets. Therefore, many unaccounted RES are likely to be found living in the wild throughout New Zealand. As RES have become invasive in many areas outside of their native range (e.g. South America, Europe, Asia, Australia) (Lever 2003), the number of individuals being seeded into the wild in New Zealand is a concern.

Although not perfect, the data provided here are valuable, as they can be used to focus in on areas of concern for management purposes. We recommend education campaigns be targeted at prospective turtle owners (as well as current owners who may be unaware) to inform them that turtles are a long-lived commitment, similar to the “Habitattitude” campaign in the USA ([www.habitattitude.net](http://www.habitattitude.net)). These advertisements may help to prevent impulse purchases of turtles, as well as help RES to shed the reputation of being a “disposable pet” and reduce the potential to

establish in New Zealand. The increase in exotic species establishment is “primarily driven by cultural and social imperatives”, as opposed to biological ones, therefore solutions to this issue must also be “cultural, social and political” (Reed and Kraus 2010).

In this case study, online trading has enabled better understanding of the dynamics and structure of the RES pet trade in New Zealand, as well as identifying minimum estimates for the rates and areas where animals are being seeded into the wild. This technique is applicable to other species, especially within closed systems such as New Zealand where additional specimens are not being imported, and may be a useful tool in understanding and managing the risk of establishment associated with the pet-release pathway.

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