Japanese Knotweed and Other Palynological Inferences from Soil Cores in the Woonasquatucket River Valley, Rhode Island

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Abstract

Japanese knotweed (*Polygonum cuspidatum* Sieb. & Zucc.), family Polygonaceae, was introduced to North America in the late 1800s and is currently regarded as an invasive species. It is a giant dioecious herb, reaching heights of 2 to 4 m in spring and is abundant in wetland areas throughout the eastern United States. It blooms in late summer when wind and insects spread its pollen. The pollen is characterized by a double-layered wall and possesses a transverse oblong pore in the equatorial region. The outermost wall is perforated and one set of columella separates the two wall layers.

The study area is located on the Woonasquatucket River in North Providence, Rhode Island (Fig. 1), and is underlain by glacial till estimated at 10,000 to 17,000 BP (U.S. Geological Survey, 2005). Nine organic-rich cores were collected along the floodplain of the river (Fig. 2). The floodplain is the probable site of a Revolutionary War powder mill raceway (Corcoran, 2006). The powder mill, built in 1776 to produce gunpowder for the colonies during the Revolutionary War, exploded in 1779.

Four of the dark brown to black, organic-rich soil cores, GM-03, GM-04, GM-08, and GM-09, were used for palynological analysis. The depths of the cores varied from 20 to 36 cm. Each core was sectioned into 2-cm intervals, processed, and analyzed to document first occurrence of Japanese knotweed as an age marker. Well-preserved, historical plant succession records are visible throughout the cores. Detailed palynological assessment made on core sample GM-04, for example, portrays an abundance of monolete spores in the basal 6 cm. Recovery weeds, arborescent angiosperms and bisaccate gymnosperms become increasingly important at higher intervals. Circular chunks of charcoal probably from the 1779 explosion were noted 8 cm from the top of the core. Pollen grains of Japanese knotweed were rare but noted in the upper 5 to 6 cm. This factor may be attributed to the lack of overbank deposition, a process usually acting to preserve pollen from reduced flooding during the late summer or early fall when their pollen is most prolific, or possibly Japanese knotweed did not become well established in the local area until recently.


Fig. 2. Core locations


Fig. 3. Dense stands of Japanese knotweed grow along the Woonasquatucket River

Introduction

The Woonasquatucket River was once a fast flowing, narrow river. In the early 19th century, textile mills were built along the banks of the river. The river channel was redirected to flow through the mills in raceways, which supplied water to operate mill machinery. Japanese knotweed (*Polygonum cuspidatum*) along with other sedimentary and geomorphic features can be used to help date the age of the sediments and locate contaminated sites for optimal remediation (Corcoran, 2006). The purpose of this study was to detect the first appearance of Japanese knotweed in four cores collected in the raceway of a Revolutionary War powder mill.

Japanese knotweed, an invasive species, was first introduced near Narraganset Bay, Rhode Island, as an ornamental in the late 19th century and is currently regarded as a serious pest throughout the United States and Canada. It is a perennial, upright, often shrubby dioecious species and can exceed 4 m in height (Hickman, 1993). Its numerous inconspicuous white flowers are situated in open, drooping panicles. It is widely distributed in much of the eastern U.S. occurring along riverbanks, wetlands, and hillsides. Dense stands of Japanese knotweed grow along the Woonasquatucket River (Fig. 3).

Processing Techniques

Each core was divided into 2-cm intervals. Six grams (dry-weight) of each palynomorph sample was treated using standard palynological preparation techniques. Chemicals used in processing include HF (49%), HCl (40%) and hot water mixture, 2.0 specific gravity $ZnCl_2$ solution, and an acetolysis mixture of acetic anhydride and sulfuric acid. The residue was sieved and separated into >90-µm, 25- to 90-µm, and 10- to 25-µm fractions before being placed into vials or mounted onto slides using elvacite. All intervals from core GM-04 were processed because each possessed excellent pollen preservation. A random 350-point count was made on each 2.0-cm interval to determine assessment of taxa, abundance of palynomorphic groups, and ecological inferences.

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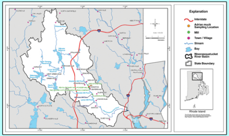

Fig. 1. Study area on the Woonasquatucket River in North Providence, Rhode Island

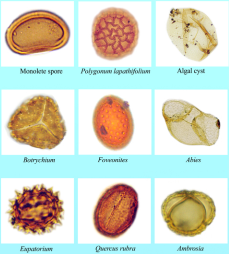

Fig. 6. Assorted palynomorph taxa from core GM-04


Fig. 4. Pollen morphology of *Polygonum cuspidatum* (Japanese knotweed)

Fig. 5. Circular chunks of charcoal occurring in the 8- to 10-cm interval, possibly from the 1779 powder mill explosion.

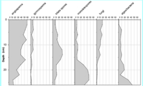

Fig. 7. Percentages of major taxonomic groups from core GM-04

Table 1. A partial list of palynomorphs found in core GM-04

Angiosperms	**Gymnosperms**
Acer rubrum	*Abies*
Alnus	*Pinus*
Ambrosia	TCT (undifferentiated (Taxaceae-Cuppressaceae-Taxodiaceae)
Arctostaphylos uva-ursi	
Betula	**Pterophyta (Ferns)**
Carya	*Azola*
Castanea dentata	*Botrychium*
Eupatorium	*Osmunda*
Fagus	Polypodiaceae
Helianthus	*Pteridium aquilinum*
Itea	
Iva	**Fern Allies**
Nuphar	*Lycopodium*
Nyssa	
Ostrya/Carpinus	**Bryophyta**
Poaceae	*Sphagnum*
Plantago	
Polygonum lapathifolium	**Fungi**
Myrica	*Foveonites*
Quercus rubra	
Quercus velutina	**Algae**
Salix	*Botrycoccus*
cf. *Stachys*	*Spirogyra*
Tilia	
Typha	**Cyanobacteria**
Ulmus/Zelkova	*Schizosporis*

Results

Palynological data from these core samples were helpful in documenting the first occurrence of Japanese knotweed as well as other historical information from the Woonasquatucket River area. Its pollen was rare but was recognized in the upper 2 to 4 cm in all four cores. Other occurrences were noted at 4- to 6-cm interval in core GM-04. Its pollen can be distinguished by a double-layered perforated wall. A layer of columellae separates the two wall layers and a transverse oblong pore occurs in the equatorial region (Fig. 4). Additionally, circular chunks of charcoal, possibly from the 1779 explosion of the powder mill, occur at the 12-cm interval (Fig. 5).

Palynomorphs obtained from GM-04 are well preserved and can be used to establish plant succession from a standing, open water condition to a drier, forested environment. The base of this core overlies till from the last glacial maximum. More than 50 different genera including assorted angiosperms, gymnosperms, trilete fern spores, monolete ferns, fern allies, bryophytes, algae, blue-green bacteria, and fungal elements have been identified (Table 1 & Fig. 6). Blue-green bacteria, algal forms, and monolete spores are dominant in the lower 8 cm (18- to 26-cm) and make up 51-75% of the total palynomorph counts (Fig. 7). *Ambrosia*, *Eupatorium*, *Plantago*, and other early pioneer plants are present throughout these lower intervals. Arborescent angiosperms such as *Fraxinus* and *Juglans* and gymnosperms of *Tsuga* occur at the 6- to 8-cm interval. The 16- to 18-cm interval possessed reworked organics from flooding and oxidized palynomorphs. Trilete spores are most prolific between the 10- to 16-cm interval and represent 19-30% of the point counts. Gymnosperms of *Pinus*, *Picea*, and Taxodiaceae (TCT) are low in abundance (0.3-8%) throughout the core but are most frequent in the upper 12 cm. Fungal spores, hyphae, and fruiting bodies are associated with abundant dispersed cuticles and are most common in the upper 6 cm. Modern forest representatives including *Liquidambar*, *Acer rubrum*, *Quercus rubra*, and *Fagus* are common in the upper 4 cm, whereas these intervals portray a substantial reduction in algal cysts and monolete and trilete spores (Fig. 7).

Discussion

Rare occurrences of Japanese knotweed were found in the top 4 to 6 cm of the core GM-04. Its occurrence serves as a useful stratigraphic marker. This information is determined partly on the round charcoal chunks that are possibly from the powder mill explosion in 1779. Assuming the top 10 cm of the core represents 225 yrs, then the top 6 cm would stand for approximately 100 - 135 yrs. This date would extend back into the late 1800s when Japanese knotweed was first introduced to North America. The sedimentation rate may not be consistent, however, because it probably increased with land clearance and development. The rare occurrences of Japanese knotweed pollen may be attributed to 1) seasonal blooming, 2) lack of overbank deposits, 3) being a dioecious plant, or that 4) the plant was not well established in that particular area until recently. This species blooms in late summer and early fall when heavy fall or winter rains could reduce its abundance in the core.

Excellent examples of ecological primary and secondary succession are clearly evident throughout the core. The high presence of monolete fern spores, blue-green bacteria, and algae in the lower 8 cm implies standing water and lots of sunlight. Drier meadows with an abundance of weedy annual plants are present throughout the lower third of the core and angiosperm riparian forests dominate the upper 8 cm. Genera and species pertaining to native plants of Rhode Island are present throughout core GM-04 including *Osmunda*, *Typha*, *Acer*, *Alnus*, *Betula*, *Carya*, *Fraxinus*, *Juglans*, *Nuphar*, and *Quercus* (U.S. Department of Transportation, 2006).

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