Invasive Scots Pine, *Pinus sylvestris*, Replacing Corema, *Corema conradii*, Heathland in the Annapolis Valley, Nova Scotia

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Examination of air photos from 1930, 1970 and 2002 revealed stands of the European Scots Pine (*Pinus sylvestris*) invading remnants of natural Corema (*Corema conradii*) heathland in the Annapolis valley. To document the impact of the introduced pines, four natural habitats were compared with two adjacent habitats already invaded by the pines. All surveyed habitats had been dominated by Corema heath based on air photos taken in 1930. Twenty 1 m^2 quadrats were used to record presence and cover of vascular plants at each site. The invasive alien pines reduce the native cover to 12%. Vascular plant biodiversity is reduced to less than 42% and the cover of the heathland dominant, *Corema conradii*, is reduced from over 100 % to less than 2%. with *Deschampsia flexuosa* becoming the dominant species. The modified ecosystem and loss of biodiversity has economic impacts through loss of pollinators of agricultural crops and loss of germplasm of native crop relatives.

Key Words: Scots Pine, *Pinus sylvestris*, Corema, *Corema conradii*, invasive, alien, heathland, barrens, Nova Scotia, Canada.

Scots Pine (*Pinus sylvestris* L.) is native to much of Europe and northern Asia and has been introduced and become naturalized throughout the temperate regions of the world. It is the most widely distributed of the world's pines (e.g., Farrar 1995) and is used for landscaping, shelterbelts, soil stabilization and general reforestry purposes. Not only is it used for all of these purposes in Canada but is also cultivated extensively for use as Christmas trees. In some parts of Canada it has spread from cultivation and invaded natural habitats (Catling 1997).

One of the places where a significantly deleterious invasion is occurring is in the remnants of the heathland ecosystem dominated by Corema (*Corema conradii* Torr.) on the sand plains of the Annapolis valley, Nova Scotia. These threatened plant communities are already deteriorating due to succession of the vegetation to forest apparently as a result of the lack of fires. Mesic sites are the most susceptible. Although native woody vegetation is slow to invade the drier sites, Scots Pine has proved to be a very aggressive invader that forms dense stands that exclude most other plant species.

Here we document the conversion of natural heathland to Scots Pine wood and provide an indication of the vegetation changes that have likely occurred through a comparison of invaded and non-invaded sites. This will permit a better understanding of vegetation dynamics in the heathland and will provide the information needed for effective management.

Methods

Documenting invasion of Scots Pine

Through examination of air photos from 1930, 1970 and 2002 aerial surveys (Figure 1) and examination of sites in 2003, specific areas of heathland that have been invaded by Scots Pine can be clearly identified providing an opportunity to assess the impact of the invading pines. These areas have evidently not been subject to other unnatural disturbances so that the differences in vegetation between them and the adjacent heathland are due to Scots Pine invasion. The stands of Scots Pine on the heathland appear to have originated from seed dispersed from trees planted around buildings or in plantations nearby. Isolated older Scots Pines 10-30 years of age produce seed readily and are frequently surrounded by younger trees 1- 15 years old which grow with further recruitment to form a dense stand within another 15-20 years.

Assessing impact of Scots Pine

The conversion of natural heathland to Scots Pine and specifically the impact of Scots Pine was assessed through comparison of invaded heathland with adjacent natural heathland with various amounts of native tree cover. The study area was located at approx. 45.0166°N, -64.8833°W between Auburn and Kingston in Annapolis County, Nova Scotia. On 26 June 2003, presence and cover of vascular plant species was recorded in six habitats within an area that was essentially open heathland 50 years earlier based on aerial photographs on file at Nova Scotia Department of Natural Resources (Figure 1). Of the six habitats sampled four were dominated by native species of open heathland and two were dominated by Scots Pine which had invaded parts of the heathland. The two open heathland sites described were immediately adjacent to the Scots Pine stands and the introduced pines were extending into the open heathland area. The two heathland sites with Red Pine (*Pinus resinosa* Ait.) had

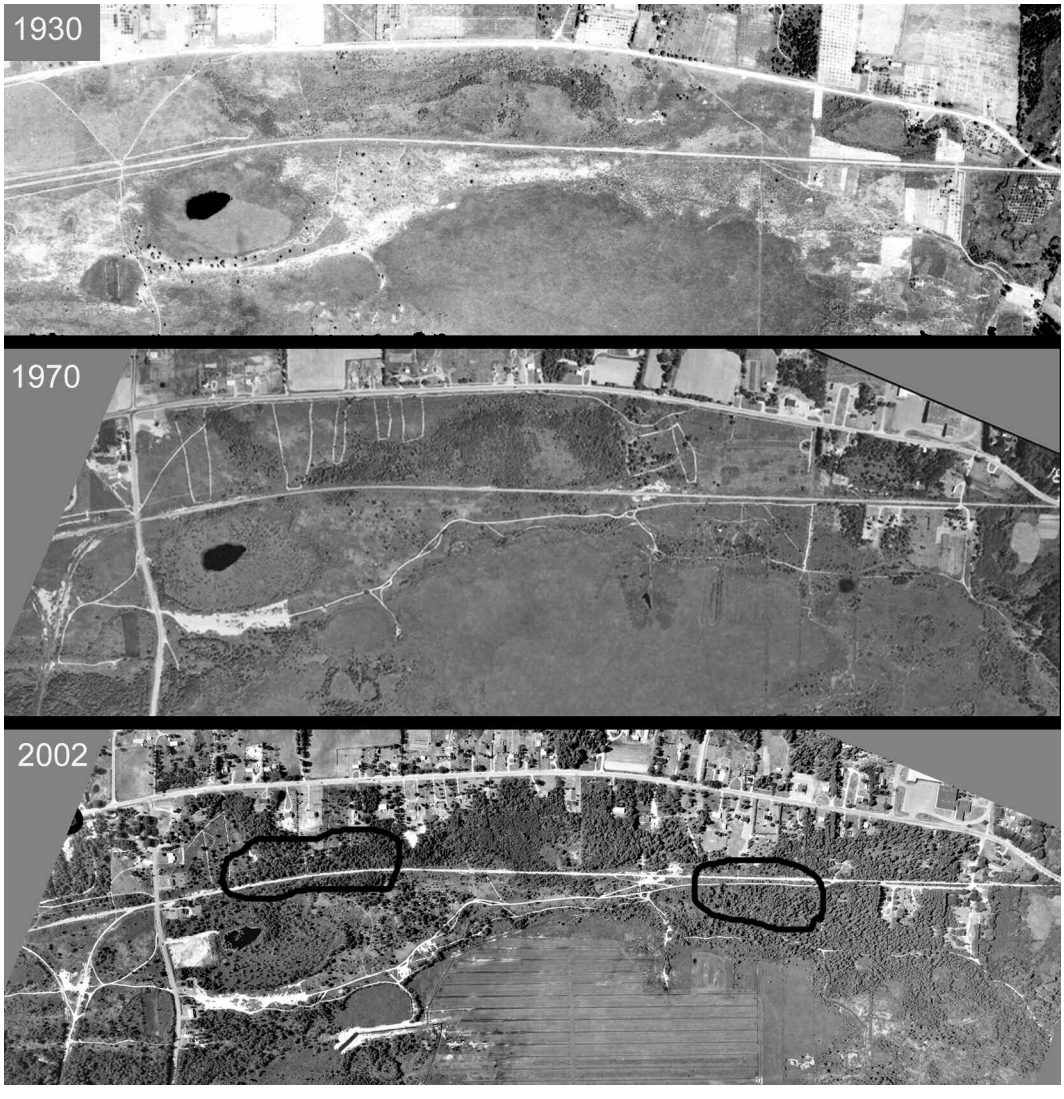

FIGURE 1. Airphotos showing a portion of the heathland on the west side of Auburn (approx. 45.0166° N, - 64.8833° W) in 1930, 1970 and 2002. The stands of *Pinus sylvestris* where ground flora was evaluated are delineated with a black line on the 2002 photo. In 1930 heathland existed where these stands now occur. The Scots Pine stands were just starting to develop in 1970.

adjacent open heathland. All sites sampled were evidently Corema-dominated heathland in 1930 (Figure 1).

Site 1, an open heathland approx. 90% open in aerial view with scattered White *(Pinus strobus* L.), Red, and Scots pine and site 5, the adjacent Scots Pine stand was located at 45.0107°N, 64.8960°W. Site 2, the other open heathland, also approx. 90% open, and site 6, the adjacent Scots Pine stand was located at 45.0157°N, -64.8803°W. Site 3, an open heathland, 60% open in aerial view, with Red Pine 50 years old was located at 45.0014°N, -64.9419°W. Site 4, the semi-open 60-70 year-old Red Pine stand, approximately 20% open in aerial view was located at approximately 44.9916°N, 64.9750°W.

At each site the habitat was delineated and within it a transect was selected at random using a compass line derived from random numbers. Presence and cover was recorded for each species in each of 20 one m^2 quadrats at 5 m intervals along the transect line. Cover was estimated as ½ the surface area of each species rather than a simple aerial view and thus could exceed 100% of the surface of the square metre sampled. This method

FIGURE 2. Natural heathland on the west side of Auburn (approximately 45.0166° N, 64.8833° W) with ground cover dominated by Corema (*Corema conradii*) and scattered native Red Pine (*Pinus resinosa*).

provided a maximally accurate description of biomass. Species up to 2 m tall (including trees) were recorded. In a very few cases where a large tree trunk was in a selected quadrat, the position of the quadrat was moved (up to ½ m) to avoid the trunk. For comparison, the mean frequencies and covers for each pair of communities was calculated and expressed as a percentage of that of the open heath. Voucher specimens are in the collection of Agriculture and Agri-Food Canada in Ottawa (acronym DAO).

Results and Discussion

Native Red Pine and White Pine exist as scattered trees in open heathland (Figure 2) and the mature trees are rarely accompanied by nearby saplings and seedlings, presumably due to difficulty of establishment and specific requirements such as suitable mineral substrate. In contrast mature Scots Pines are usually surrounded by saplings and seedlings, many of which survive to form a dense stand, and the trees can establish in organic soils.

Red Pine forming stands in open heath (Figure 3) may result in a reduction of low heathland cover to 47.5%, as well as a reduction of diversity to 75.7% (Tables 1 and 2). The dense stands of Scots Pine that develop can cause a much greater reduction of cover and biodiversity with cover reduced to 12.0% and diversity reduced to 42.4% (Figures. 4 and 5). *Corema*, the dominant of open heath is reduced from over 100 % cover to less than 2 % cover in stands of Scots Pine (Figure 5). Other than Scots Pine, invasive alien species were not prominent in the sites studied and they did not increase in the presence of Scots Pine (Tables 1 and 2).

After invasion by Scots Pine forest, *Deschampsia flexuosa* replaces *Corema conradii* as the dominant vascular plant and ground cover is greatly reduced (Tables 1 and 2). Significant species, including *Amelanchier lucida* Fernald, *Vaccinium angustifolium* Ait., and species of *Rubus*, all of which provide food for pollinators that service local crops (apples, blueberries, etc) are severely reduced after invasion by Scots Pine. These same species and several others are also potentially important as sources of genetic variation for crop improvement.

The numbers of immature Scots Pines in open heathland ranged from 80–350 per acre and were 99 % of the trees on open heath adjacent to the Scots Pine stands. Native pines and other trees apparently invade the drier

TABLE 1. Frequency of species less than 2 m high in three major associations, open heath, Red Pine heath and Scots Pine forest. The recording was done in 2003 in an area that was a natural heathland dominated by Corema with Red and White Pines 50 years earlier. Introduced species are indicated with an asterisk (*) following the species name.

Species	Open Heath		Red Pine Heath		Scots Pine	
	1	2	3	4	5	6
Acer rubrum L.	–	–	10	–	–	5
Amelanchier lucida Fern.	25	55	5	–	–	5
Amelanchier laevis Wieg.	–	5	5	–	–	–
Arctostaphylos uva–ursi (L.) Spreng.	20	15	10	25	–	–
Aronia melanocarpa (Michx.) Ell.	30	–	–	–	–	–
Betula populifolia Marshall	10	–	–	–	–	–
Carex tonsa (Fern.) Bickn. var. *rugosperma* (Mack.) Crins	15	–	5	–	–	–
Comptonia peregrina (L.) Coult.	15	20	5	5	–	–
Corema conradii Torr.	95	95	60	35	30	–
Cypripedium acaule Aiton	–	–	20	25	–	–
Danthonia spicata (L.) Beauv.	–	25	–	–	–	–
Deschampsia flexuosa (L.) Trin.	20	55	55	50	65	75
Dichanthelium acuminatum (Sw.) Gould & Clark ssp. *fasciculatum* (Torr.) Freckman & Lelong	5	–	–	–	–	–
Dichanthelium depauperatum (Muhl.) Gould	5	–	–	–	–	–
Festuca filiformis Pourret *	–	30	–	–	–	–
Gaultheria procumbens L.	5	5	–	–	–	5
Gaylussaccia baccata (Wang.) K. Koch	–	–	–	10	–	–
Hieracium pilosella L. *	–	–	5	–	–	10
Hudsonia ericoides L.	10	–	–	–	–	–
Hypericum perforatum L. *	5	–	–	–	–	–
Juniperus communis L.	5	–	–	–	–	5
Kalmia angustifolia L.	10	20	–	–	–	–
Maianthemum canadense Desf.	–	–	55	–	–	5
Melampyrum lineare Desr.	–	20	30	20	5	–
Monotropa hypopithys L.	–	–	–	–	5	–
Pinus resinosa Ait.	–	–	–	5	–	–
Pinus strobus L.	–	–	15	–	–	–
Pinus sylvestris L. *	15	15	–	–	5	–
Pteridium aquilinum (L.) Kuhn.	–	10	–	–	–	–
Quercus rubra L.	–	–	5	–	–	–
Rubus vermontanus Blanch.	5	5	–	–	–	–
Rumex acetosella L. *	10	–	–	–	–	–
Solidago bicolor L.	15	35	5	–	10	–
Solidago juncea Ait.	–	5	–	–	–	–
Trientalis borealis Raf.	–	–	35	–	–	5
Vaccinium angustifolium Ait.	50	70	90	80	20	10
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	–	5	–	–	–	–
Total native species	17	16	16	9	6	8
Total introduced species	3	2	1	0	1	1
Total species	20	18	17	9	7	9
Mean community frequency	16.5		12.5		7.0	
% of mean open heath frequency	100.0		75.7		42.4	

TABLE 2. Mean cover of species less than 2 m high in three major associations, open heath, Red Pine heath and Scots Pine forest. The recording was done in 2003 in an area that was a natural heathland dominated by Corema with Red and White Pines 50 years earlier. Introduced species are indicated with an asterisk (*) following the species name.

Species	Open Heath		Red Pine Heath		Scots Pine	
	1	2	3	4	5	6
Acer rubrum L.	–	–	0.10	–	–	0.45
Amelanchier lucida Fern.	4.80	13.55	0.05	–	–	0.50
Amelanchier laevis Wieg.	–	2.00	0.15	–	–	–
Arctostaphylos uva-ursi (L.) Spreng.	1.60	11.50	1.15	9.9	–	–
Aronia melanocarpa (Michx.) Ell.	3.55	–	–	–	–	–
Betula populifolia Marshall	2.35	–	–	–	–	–
Carex tonsa (Fern.) Bickn.var. *rugosperma* (Mack.) Crins	0.50	–	0.05	–	–	–
Comptonia peregrina (L.) Coult.	4.75	1.85	1.25	0.25	–	–
Corema conradii Torr.	105.00	110.25	13.65	6.10	1.50	–
Cypripedium acaule Aiton	–	–	0.35	0.60	–	–
Danthonia spicata (L.) Beauv.	–	0.25	–	–	–	–
Deschampsia flexuosa (L.) Trin.	0.50	1.50	11.10	14.10	17.65	13.40
Dichanthelium acuminatum (Sw.) Gould & Clark ssp. *fasciculatum* (Torr.) Freckman & Lelong	0.05	–	–	–	–	–
Dichanthelium depauperatum (Muhl.) Gould	0.05	–	–	–	–	–
Festuca filiformis Pourret *	–	0.30	–	–	–	–
Gaultheria procumbens L.	1.50	0.20	–	–	–	0.40
Gaylussaccia baccata (Wang.) K. Koch	–	–	–	2.85	–	–
Hieracium pilosella L. *	–	–	0.10	–	–	0.45
Hudsonia ericoides L.	0.75	–	–	–	–	–
Hypericum perforatum L. *	0.12	–	–	–	–	–
Juniperus communis L.	2.50	–	–	–	–	0.35
Kalmia angustifolia L.	5.90	2.95	–	–	–	–
Maianthemum canadense Desf.	–	–	11.80	–	–	0.35
Melampyrum lineare Desr.	–	0.80	0.35	5.95	1.00	–
Monotropa hypopithys L.	–	–	–	–	0.10	–
Pinus resinosa Ait.	–	–	–	0.05	–	–
Pinus strobus L.	–	–	0.35	–	–	–
Pinus sylvestris L. *	3.00	2.6	–	–	0.25	–
Pteridium aquilinum (L.) Kuhn.	–	2.9	–	–	–	–
Quercus rubra L.	–	–	0.05	–	–	
Rubus vermontanus Blanch.	0.24	0.60	–	–	–	–
Rumex acetosella L. *	3.20	–	–	–	–	–
Solidago bicolor L.	0.25	2.10	0.05	–	0.50	–
Solidago juncea Ait.	0.10	0.25	–	–	–	–
Trientalis borealis Raf.	–	–	0.95	–	–	0.05
Vaccinium angustifolium Ait.	5.65	31.45	29.5	43.95	2.50	0.45
Viburnum nudum L. var. *cassinoides* (L.) Torr. & Gray	–	0.10	–	–	–	–
Total for all species	146.26	185.15	71.05	83.75	23.50	16.40
Mean community cover		162.89		77.35		19.6
% of mean open heath cover		100.0		47.5		12.0

FIGURE 3. Open Red Pine stand northwest of Kingston (approximately 44.9916° N, 64.9750° W) with heath vegetation dominated by blueberry (*Vaccinium angustifolium*).

open heathland very slowly or not at all, whereas the European Scots Pine is an aggressive invader that forms dense stands. These not only reduce the biodiversity of native vascular plant species, but they also eliminate the native open heathland ecosystem. Management of Scots Pine will be necessary to protect representative sites.

The threat of Scots Pine to natural ecosystems is apparently best documented in New Zealand where "wilding" (escaped from cultivation) conifers have had a major impact on the natural landscape. Of these conifers, Scots Pine is rated among the species having the greatest impact on the natural ecosystem and substantial effort has been directed to control and management (e.g., Langer 1992).

In the United States, various agencies have recommended against the planting of Scots Pine due to its invasive tendency, but, as is the case for Canada, quantification of impact is very limited. The lack of detail is in direct contrast to the abundance of anecdotes. For example it has been noted that: "to appreciate the problem of invading alien trees and shrubs in Canada, one need only consider the planting of Scots Pine (*Pinus sylvestris*) in native open habitats that have become thoroughly choked with this aggressive weed tree" (Catling 1997). Scots Pine was featured as one of 16 invasive aliens of wetland habitats in Canada and one of 40 invasives of upland habitats in Canada (White et al. 1993). It has also been mentioned in the context of serious invasives in various provinces (e.g., Kaiser 1983; Riley 1989; Urban Forest Associates Inc. 2002). and environmental organizations have advised against its use as an ornamental.

The demonstrated impact on a portion of the declining Nova Scotian heathland ecosystem is significant as one of the first quantified examples of impact of invasive alien Scots Pine in North America. It should serve as a basis for monitoring impacts in Nova Scotia and elsewhere. Clearly the concerns that have been widely expressed by environmental organizations and field biologists for impact of invasive alien Scots Pines are justified.

In addition to reduction of Corema heathland due to succession and invasive Scots Pine, there has also been substantial reduction due to urban and agricultural development (Figure 1) and decline of this ecosystem has been rapid over the past few decades. The need to protect representative examples is well known. The

FIGURE 4. Scots Pine (*Pinus sylvestris*) of many different age classes invading open heathland dominated by Corema (*Corema conradii*) on the west side of Auburn (approximately 45.0083° N, 64.8916° W).

FIGURE 5 Dense stand of Scots Pine (*Pinus sylvestris*) with ground covered mostly by pine litter on the west side of Auburn (approximately 45.0166° N, 64.8833° W).

remnants of this ecosystem provide pollinators for adjacent fruit crops and contain distinctive variants of native crop relatives that could be valuable in crop improvement and diversification (see above and Catling et al. 2004). Thus they are sources of valuable biodiversity. The perpetuation of this important ecosystem will require not only a system of protected sites but also management of succession and invasive aliens, particularly Scots Pine.

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