body of previous research results. Only with such integration and increased co-operation will more effective control of St. John's wort populations in both natural ecosystems and perennial pastures be achieved. Whilst much has been learned and applied in the last 60 years, much remains to be done. It is the task of this workshop to achieve by consensus a priority list of tasks for the next six years that may be achievable by the CRC and its co-operating research agencies.

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History of the introduction and spread of St. John's wort (*Hypericum perforatum* L.) in Australia

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Abstract

***Hypericum perforatum* has been introduced into Australia a number of times, the first being more than 100 years ago. It was cultivated in the Melbourne and Adelaide Botanic Gardens in 1858 and 1859, respectively, for potential use in home gardens. The earliest recorded outbreak of the wort was in 1880 at Bright, Victoria; i.e. escaped from a local garden where it was planted for medicinal purposes. Another outbreak occurred at Coromandel Valley in the Adelaide hills, possibly as early as 1881, and certainly by 1886. The earliest outbreak in New South Wales seems to have occurred at Mudgee in 1890 from either horse fodder or as a 'garden escape'. It now occurs in all States. Herbarium records suggest that its range was still increasing in the 1980s. Today it is still abundant in some localities, particularly in south-eastern Australia. For example, in 1986, 200 000ha of the Tablelands of New South Wales were heavily infested with the wort.**

The pattern of spread of St. John's wort has consisted of increasing numbers of isolated occurrences from which expansion has occurred until they coalesced. Spread rate was most rapid, perhaps through the accidental movement of seed associated with the movement of stock and their fodder, as well as through 'garden escapes' following deliberate plantings for horticultural use.

Initially an agricultural problem, it is now more of a problem along roadsides and easements and in non-agricultural land, generally. Low levels of disturbance, such as mowing-burning-scarifying increased populations whereas frequent, intensive disturbance such as repeated ploughing used in tobacco cultivation, eliminated it. Population explosions could well be attributed to a changed disturbance regime in a locality, and/or seed longevity. That seeds may lie dormant in the soil for many decades underscores the ability of the species to 'return' to a site after a prolonged absence (such as under pine plantations) and to some extent independent of the cause of that absence.

Introduction

For over a century St. John's wort, *Hypericum perforatum* L (family Clusiaceae), has been a problem plant in Australia. In 1883, a writer to the 'Alpine Observer' (Hortus 1883) exhorted the Bright (Victoria) Shire Council to control the 'noxious ugly plant' growing so luxuriously about the racecourse, a plant which had been identified by the Victorian Department of Agriculture as the 'ordinary St. John's wort of Britain' (Martin 1883). Various methods of control were suggested. Over 100 years later, in 1986, 'St. John's Wort is still one of the most troublesome tableland weeds' heavily infesting more that 200 000 hectares in New South Wales (Freebairn 1986).

The seriousness of the problem that St. John's wort posed in 1928 (and today) to farmers is illustrated by the comments of a manger of the Manus Estate, Tumbarumba, New South Wales (NSW):

> 'Two hundred and forty merino sheep were drafted into a paddock where there was an infestation of about 50% St. John's wort, the rest being grass. At the end of two months, forty of the sheep died. Others were blind, and some had the skin of the face and shins peeled off, leaving raw flesh. All of the sheep had shed the whole of their wool, and went mad at the slightest touch of water' (Tillyard 1928).

Problems due to wort include loss of pasturage, photosensitization, abortion and loss of milk production (Campbell and Delfosse 1984). Tainting of cow's milk is a problem in dairying areas (Muenscher 1951).

St. John's wort has had a long and mostly unwelcome presence in Australia despite persistent attempts at its control. A review of the history of its introduction and spread was undertaken to understand why this is so. Two localities receive special attention. Bright, in north-eastern Victoria, has been given as the first site of St. John's wort in Australia outside of Botanic Gardens and, together with the second locality of Tumbarumba, was the site of the first entomological research into the control of the plant. Manus, near Tumbarumba in south-eastern NSW, was the site of extensive experiments on agronomic and chemical methods of control by the NSW Department of Agriculture and the Council for the Scientific and Industrial Research (CSIR), now CSIRO Australia.

The aim of this brief review is to provide an historical context for the more technical research on the biology of the plant and methods of control. We have cited newspapers, letters, and internal papers, not because of any confirmable veracity they may have, but rather because of the lack of information on certain topics in the scientific literature, and the historical perspective which these documents provide.

Establishment of St. John's wort in Australia

Determining when and where *H. perforatum* first grew in Australia is difficult. French (1905) noted that 'an old lady introduced the seeds from Germany for medicinal purposes' in about 1880 and grew the plants in her garden in Bright, Victoria (Figure 1). The plant subsequently spread to the Bright racecourse and received the name 'racecourse weed'. It is likely that the following (Anon. 1880) refers to St. John's wort: 'The engineer was instructed to employ labour to destroy thistles in the streets of Bright **and the plant growing near the racecourse**' (our emphasis). The occurrence at Bright is particularly significant in being the origin of the wort outbreak in Australia, but it was not the first importation to Victoria. Baron Ferdinand von Mueller, the Director of the Melbourne Botanic Gardens, refers to it as being in cultivation at the Gardens in 1858 (Mueller 1858).

There is no evidence that the Melbourne planting became the source of a naturalized population in the manner of the Bright planting. It is also unlikely that the first South Australian outbreak was made from Victoria. A specimen was collected in 1881 (Adelaide Herbarium sheet AD 95651005) from Coromandel Valley near Adelaide (P. Kloot personal communication 1986) where a species, probably *H. perforatum*, was reported as a weed in 1901 (Anon. 1901) under the name *H. canariense*. Summers (1904) asserted that *H. perforatum* was first noticed in Coromandel Valley in about 1886.

Hypericum perforatum was grown early in the Adelaide Botanical Gardens (Francis 1859) under the name *H. calycinum* L. (P. Kloot personal communication 1986). Cultivation in a botanical garden implies a recommendation for horticultural use and, indeed, an herbaceous perennial *Hypericum*, 0.6–1.2 m tall with yellow flowers was recommended for planting in home gardens as early as the 1870s (Heyne 1871, 1877, 1881).

St. John's wort was either deliberately introduced into Eaglevale Station, in Gippsland, Victoria, or accidentally introduced and protected because of the beauty of its flowers (Tillyard 1928). The plant was similarly introduced to the area of Tumbarumba, NSW, (Tillyard 1928). The outbreak at Mudgee, NSW, began either as a garden escape (Currie 1929) or from imported fodder (Roe 1940). Maiden (1901) recorded St. John's wort from Mudgee before 1901 while a correspondent from the NSW Department of Agriculture to CSIR Division of Entomology (February 1940) noted that: 'The infestation is a very old one, and according to local history dates back to about 1890'.

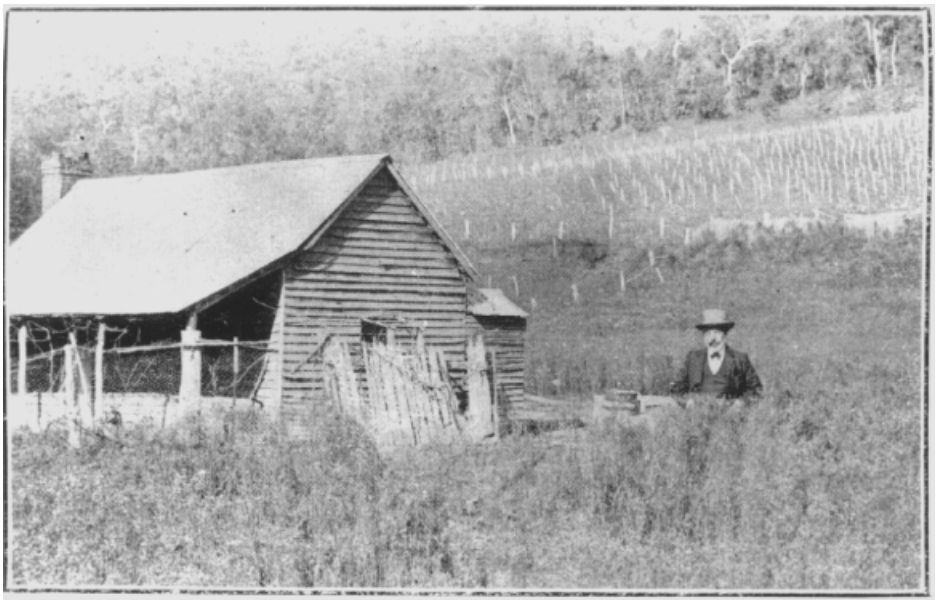

Figure 1. The house of the 'old lady' at Bright from which St. John's wort was thought to have spread in the 1880s (from French 1905). Reproduced with permission.

The above evidence suggests that multiple entry and establishment have occurred. The following contemporary evidence confirms it:

i. morphological and physiological studies of variation in St. John's wort populations in Australia are consistent with multiple entry and establishment (Campbell 1985),
ii. plants grown from seed imported from Germany and being cultivated for medicinal use were discovered in southern NSW in 1985 (P. Gorham NSW Department of Agriculture personal communication 1986).

Distribution

There has been no systematic study of the spread of St. John's wort in Australia. Our information comes from numbers of observers using various methods. We have supplemented the data of Campbell and Delfosse (1984) on areas of infested country and numbers of shires infested to varying degrees in Victoria and NSW, with further data, e.g. from Jose and Carter (1926) for areas affected in Victoria and from government Gazettes of Victoria and NSW for details of numbers of shires for which St. John's wort was declared to be a problem plant. In addition, we report information derived from a collation of herbarium records of Federal and State herbaria: districts represented by 1:250 000 map sheets in which St. John's wort has been collected and mapped cumulatively by decade (Figure 2). Note that a single collection of a small infestation can occur as a large shaded area on the map: thus, it should not be inferred from the maps that the species is to be found throughout the shaded area. Indeed, populations in Western Australia, South Australia, Tasmania and Queensland are small (Campbell and Delfosse 1984).

The herbarium records suggest a steady rate of spread from 1890 to 1940 after which spread continued at a slower rate until the present. The numbers of shires recording St. John's wort as an actual or potential problem showed a relatively slow rate of initial spread followed by a rapid increase. While 35 shires in NSW had declared St. John's wort noxious to 1921, there were 76 shires in which the plant was thus declared in 1977 (Campbell 1977).

Neither the herbarium data nor those for the numbers of declared shires can show that the plant has possibly been lost from some areas while expanding in others. Shepherd (1983) revealed an ebb and flow to the presence of the plant in various inspection districts of Victoria.

Areas of Victoria in which St. John's wort occurs have been recorded sporadically throughout its history. French (1904) reported that 67% of infested land was privately owned (2283 ha) while in 1916 this figure was only 15% but in absolute terms was a much larger area (11 340 ha). By 1948–50, by far the greater part of the occurrence of the species was on timbered land and dredgings (Clark 1953), presumably public land. Similarly, Shepherd (1983)—30 years later—reported that 7% of infested land was agricultural (12 250 ha)

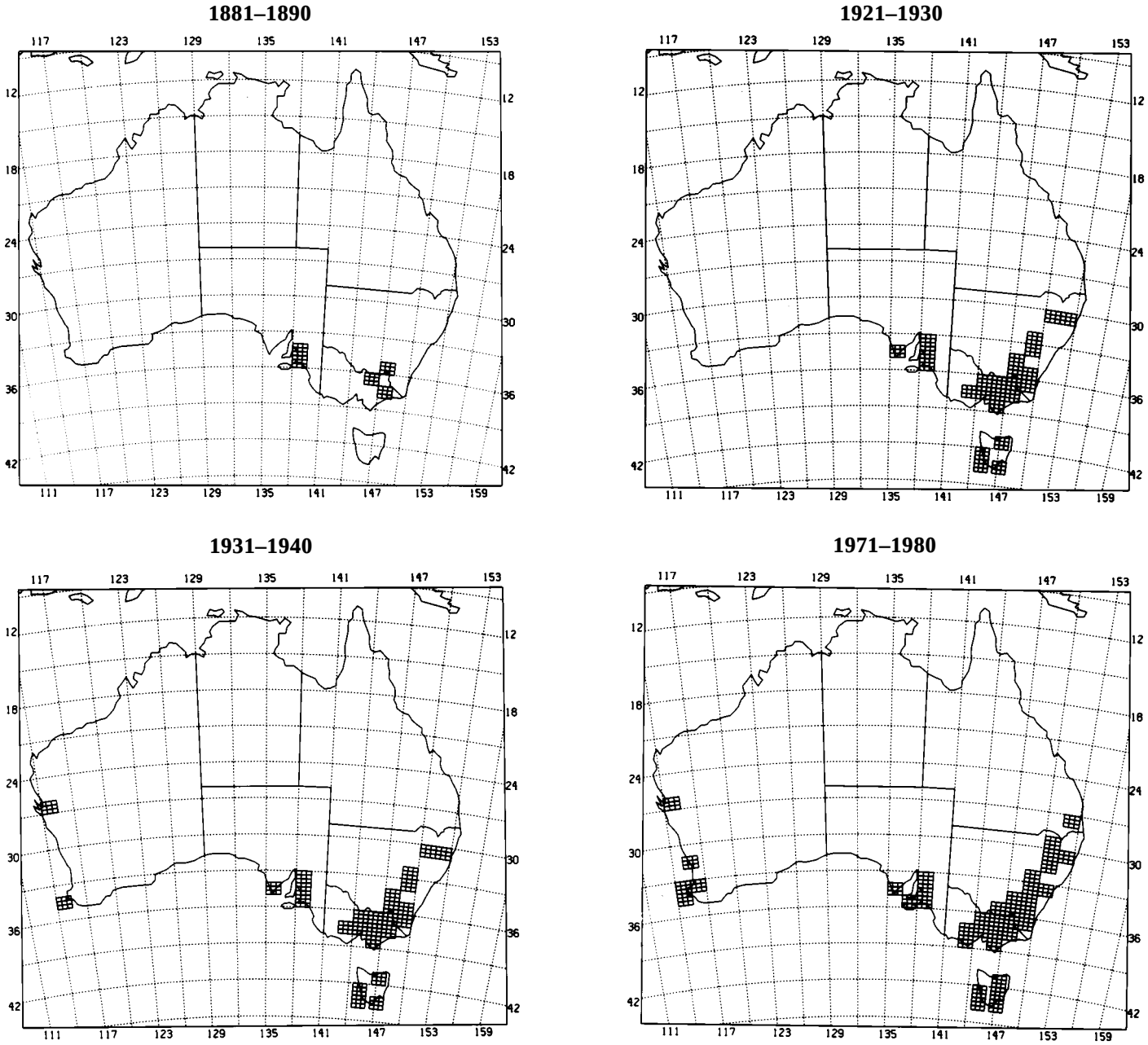

Figure 2. Maps of the cumulative spread of *Hypericum perforatum* in Australia as determined from herbarium specimens.

while 83% was in unsown native forests. If we can equate privately owned with agricultural, above, there was only a slight net increase in agricultural land affected by St. John's wort from 1916 to 1983 in Victoria (11 000–12 000 ha).

Methods of spread

The pattern of spread of St. John's wort has consisted of increasing numbers of isolated occurrences from which expansion has occurred until, at times, they coalesced. The detailed maps of early distributions show the discontinuous nature of the distribution (French 1905) as do the coarse-grained maps from herbarium records (Figure 2). In north-eastern Victoria, the map in French (1905)—probably prepared by Davey (1921)—shows the major area of occurrence to be linear along the Ovens Valley, but there were also isolated occurrences around Wangaratta, Rutherglen, Tallangatta and Omeo, for example.

The outbreak in north-eastern Victoria, beginning at Bright about 1880, had spread in a more-or-less continuous fashion to Everton—about 50 km away—by 1905 (French 1905). Thus the average linear rate of spread was approximately 2 km a year. What method(s) of spread could account for this rate?

Vegetative spread is too slow to account for the major features of distribution but can be important locally (Clark 1953). The expansion of a single plant by its rhizomes over a period of five years until it became 'a densely infested patch of weed about 100 square feet in extent' was measured (Tillyard 1928). Assuming a circular infestation, the linear rate of spread implied by these figures is approximately 30 cm per year which is about four orders of magnitude too slow.

Wind is another possibility as the seeds are very light, about 0.14 mg each (Campbell and Delfosse 1984), and produced at heights above the ground of up to 1.2 (Ewart and Tovey 1909) or 1.4 m (Tillyard 1928). However, numbers of seeds in traps of area 0.21 m^2 (18 × 18") at distances of 3.1, 6.2 and 9.3 m (10, 20 and 30 ft) from the downwind edge of an *H. perforatum* stand were only 148, 27 and 7 respectively (Tisdale *et al.* 1959). While no data were given for the height of the stand or number of seed at the origin, the data show that most seed falls near the parent plants and that maximum dispersal distances by wind are likely to be of the order of only 10 m per year.

The linear distribution of the wort down the Oven's Valley from Bright

suggests that distribution by water occurs. However, the species was distributed upstream for tens of kilometres, as well as downstream, and the seed is not at all buoyant (Davey 1917). It is probable that whole plants, seeds or soil , would have been eroded from river banks and been carried downstream during floods or during the period of extensive mechanical dredging for gold that took place after mining began in 1852 (Robertson 1973).

The sticky capsules of *H. perforatum* break off and may adhere to animals (Davey 1922, Calvert 1932, Parsons 1957, Robertson 1973). From the Ovens Valley cattle were taken up to surrounding subalpine country as early as 1878 (Holth 1980). The animals were driven up during spring (before the summer flowering of the wort) and down again around Easter (when capsules may have been ripe). Cattle travelled substantial distances by foot in this regional migration even moving into NSW (Davey 1919). Horses may have carried capsules to and from the mountains during the autumn muster. Rates of dispersal of 2 km per year in this way are possible but not documented. French (1905) declared that 'hay or other cereal crops …[from wort-infested land, is the means by which] …the seed of the weed has been largely distributed'.

Feral animals, such as rabbits (Davey 1917), foxes and horses, could carry seed in their coats just as domestic animals could. Similarly, native animals could also transport seeds, the maximum dispersal most likely being by dingoes and kangaroos. Birds are unlikely to deliberately pick up the seeds, while harvester ants, which can transport the seed short distances (Tillyard 1928) may also consume it.

There are many other means of transport possible apart from those listed above such as in faeces (Calvert 1932), in soils carried by animals on their feet, in soil on cars, or in soil supporting pine seedlings from invested areas (Parsons 1957). Deliberate movement is also important. People have grown the plant ornamentally, including eminent botanists, without realizing the weedy potential of the species.

Infestations at Manus

Nearly half of the 12 000 ha (30 000 acre) property 'Manus' (Whitworth 1866) of the McMicking family near Tumbarumba, NSW, was chosen in 1916 for closer settlement by soldiers. Inspection then revealed that there was no noxious weed to be seen (NSW Closer Settlement Advisory Board 1916). Within a decade 'The spread of St. John's wort became so serious …that special steps were taken …to check the menace' (NSW Department of Lands 1926). All methods of control, with the possible exception of goat grazing, have since been tried at Manus.

At the time of acquisition in 1916, there were 11 share farmers on Manus, nine of whom contributed milk to the homestead cheese factory (NSW Closer Settlement Advisory Board 1916). The NSW Department of Lands recommended that the acquired 5000 ha (12 560 acres) be subdivided into 35 farms, but by 1920 there were only 26 farms occupied from the available total of 29 (NSW Department of Lands 1920).

Most of the new settlers on the Manus were dairy farmers who, 'particularly during the period 1918 to 1928 …encouraged by high wheat prices, were continually cropping their land with wheat' (Moore and Cashmore 1942). Populations of St. John's wort expanded so much during this period that the cost of control exceeded the value of the land (NSW Department of Lands 1926).

The only quantitative data to help explain this population explosion come from trials by Moore and Cashmore (1942) at Manus. They found that, on plots open to grazing, St. John's wort yielded 270 kg per ha (2.16 cwt per ac) on untreated land, 780 kg per ha (6.23 cwt per ac) on previously ploughed land, and 980 kg per ha (7.81 cwt per ac) on land mown, burnt and scarified. Other intermediate-level disturbances such as those associated with the cutting of timber on the slopes of the Ovens Valley also exacerbated the growth of populations of the wort (Clark 1953) but with intense disturbance—such as oft-repeated ploughing for tobacco farms in the Ovens Valley—the wort could be locally eradicated (Davey 1921).

At Manus, St. John's wort was so bad in 1926 that approximately 1400 ha (3500 acres), or nearly one quarter of the Closer Settlement Area, were handed over to the NSW Forestry Commission for afforestation by conifers. Ewart and Tovey (1909) had suggested afforestation as a solution to the wort problem in the Ovens Valley and *Pinus insignis* Dougl. ex Loud. (=*P. radiata*) was planted there in 1916 (Robertson 1973). As pines over-topped the wort they first suppressed them and later killed them. Fuelbreaks remained infested, however, and any thinning or falling resulted in the reappearance of the wort, presumably from seed stored in the soil over several decades (see Appendix). In wort-infested pine plantations '*Hypericum* is the last to be excluded …and the first to reappear' (Clark 1953). Hence, the wort could be expected to return to pine plantations or farms after several decades should cultivation become less intense, and provided there are seeds lying dormant in the soil.

Initially an agricultural problem, St. John's wort is now more of a problem along roadsides and easements and in non-agricultural land generally. Where it has been successful can be depicted using the framework of disturbance regimes, a regime consisting of particular types, frequencies, intensities and seasons of disturbance. Types of disturbance include fires, fertilizers, cultivation and mowing. Low levels of disturbance, such as mowing-burning-scarifying increased populations whereas frequent, intensive disturbance such as repeated ploughing eliminated it. Population explosions could well be attributed to a changed disturbance regime in a locality, and / or seed longevity. That seeds may lie dormant in the soil for many decades underscores the ability of the species to return to a site after a prolonged absence (such as under pine plantations) and to some extent be independent of the cause of that absence.

Conclusion

Hypericum perforatum has been introduced into Australia a number of times, the first being more than 100 years ago. Like many weeds its history is closely tied to the history of people and their activities.

The long history of St. John's wort in Australia shows that such unwanted species are not easily eliminated or controlled perhaps due to great seed longevity and ability to grow in moderately disturbed sites common across a wide spectrum of developed landscapes from peri-urban through to forestry, agricultural and mining areas.

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Appendix: Assessment of the seed longevity of *Hypericum perforatum*

When a pine plantation reaches stand closure, *H. perforatum* may disappear vegetatively but remain at the locality in the form of seed in the soil. Thinning the stand may enable seed in the soil to produce mature plants in the area once again. We chose an unthinned *Pinus ponderosa* plantation (Block 57) planted in 1937 on the 'Manus' estate near Tumbarumba for an investigation of soil seed. This area was planted to pines because of the dense growth of St. John's wort there in the 1930s (see text). There were a few aetiolated plants of *H. perforatum* under the pines in 1983 but none of these flowered and all died.

Ten soil-core samples of 8 cm^2 surface area and 5 cm deep were taken from under the litter from an area 2 × 1 m between rows of trees or beyond the plantation boundary. The sampling procedure was replicated three times at each site. There were three sites within the plantation and two outside it (one above the plantation edge, one below). All sites were at least 20 m from the plantation edge. Samples within each replicate were combined and then sieved using a 3 mm mesh sieve, the large material being discarded. The finer material was spread on trays of sterile sand in a 20/16°C glasshouse in September 1983. Germination was assessed over a one year period and a few plants were grown to maturity to confirm identity as *H. perforatum*.

Germinants of *Hypericum* were, for replicates combined at each site, 326 and 73 for the upper and lower sites outside the plantation and 350, 387 and 547 for the sites within the plantation. For the plantation sites these figures represent a density of seeds of 1.5–2.3 per cm^2.

Canopy closure of these pines would be expected to take place in 8-10 years from planting (R. Gay, forester, personal communication). If all *Hypericum* had died by this time, then seed longevity of at least 36 years would be expected. If canopy closure took longer for this poorly growing stand—say 20 years—the longevity of seed would still be 26 years.