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- ▶ A previous survey conducted in 1978-1980 found that the range and distribution of the pine marten had undergone a major reduction, that they were absent from areas where they were historically present and that the population was concentrated in the mid-west of Ireland.
- ▶ The National Pine Marten Survey of Ireland 2005 repeated a random selection of 55 x 10 km² National Grid Squares originally surveyed.
- ▶ Transect surveys based on scats, with DNA testing to verify scat identity, assessed the current distribution of pine martens.
- ▶ The increase in the distribution of pine martens occurred mainly from core population areas. This increase is probably the result of reduced persecution, increased afforestation that has increased the habitat available to pine martens and its connectivity, and also through deliberate reintroductions.
- ▶ There are, however, relatively large regions of Ireland where pine martens still appear to be absent and data are lacking from other regions on their distribution.

National Pine Marten Survey of Ireland 2005

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Introduction

The pine marten (*Martes martes*), also known as the tree cat (Cat Crainn) or marten cat, is an indigenous member of Ireland's depauperate mammalian fauna. It is a medium-sized carnivore typically inhabiting forested or scrub habitats throughout their range, although in Ireland they can also be found in relatively open habitats such as limestone pavement. They are solitary, inhabiting a defined home range that can range in size from 1.5 to 32.9 km² depending on the availability of contiguous habitat, food resources, sex (male home ranges are larger than females) and season (Zalewski *et al.* 1995, Bright and Smithson 1997). In Ireland, data from Dromore Forest (Co Clare) suggest that ranges can be as small as 13 ha (0.13 km²) (Warner and O'Sullivan 1982). Within home ranges pine martens can travel several kilometres during activity bouts such as foraging, mostly at night (Zalewski 2000). Breeding typically takes place during July or August after which delayed implantation occurs for approximately 6 months. After a gestation period of approximately 30 days the kittens are born in March or April in a den that can be located in tree cavities, roots or rock outcrops. Litters usually range from 1 to 3 in number and reach maturity within 12 months. In terms of diet, the species is considered to be omnivorous.



The pine marten,
Martes martes

PHOTO: Mike Brown

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Prior to the mid 1970s the only data on pine marten distribution in Ireland came from anecdotal observations based on incidental sightings (King 1952, Deane 1952, Moriarty 1961), returns from taxidermists (Stendall 1946) and trapping records (Stendall 1947, Rutledge 1948, Rogers 1959). The most comprehensive data available on the status of pine martens in Ireland came from a study conducted by O’Sullivan (1983) which investigated the distribution of pine martens in 428 x 10 km² National Grid Squares selected throughout the Republic of Ireland. The study did not include Northern Ireland, but a questionnaire survey during the early 1990s suggested that the species was mainly confined to Co Fermanagh and parts of Co Tyrone (Hughes 1993).

In total, 97 x 10 km² or just over 22% of 10 km² National Grid Squares surveyed were found to be positive for pine martens (O’Sullivan 1983). It was concluded that pine martens mainly occurred in the mid-western region, Slieve Bloom mountain range and three outlying areas: the Boyne river valley, Portlaw and a mountain range in the south west. Important points concerning the distribution of pine martens in the Republic of Ireland were emphasised:

- i) Their range and distribution had undergone a major reduction.
- ii) Pine martens were absent from regions where historical records indicated they were formerly present.
- iii) The population was concentrated in woodland areas in the mid western region of the country and this constituted a stronghold for the species.

The major reduction in the species range was attributed to the continual loss and fragmentation of established woodland habitat and predator control programmes which involved the use of poison baits and traps.

The status of pine martens in Ireland is similar to that documented in the Britain where they are considered functionally extinct in England and Wales due to historical persecution and habitat loss, and are only recently recovering in parts of Scotland where a substantial conservation programme for the species has been initiated (Bright and Harris 1994).

Since O’Sullivan (1983) there has been no repeat of the survey and little systematic investigation into the current distribution and status of pine martens in Ireland. Data from

confirmed road kills suggest the population may be increasing in certain areas such as the southeast (Smiddy and Berridge 2002) but these were insufficient to conclude a general increase throughout the country or reliably determine the status of pine martens in Ireland on a national scale.

During 2005 a repeat survey of 55 of the original 97 x 10 km² squares was undertaken to assess the current status and distribution of pine martens in Ireland. The field-based survey, carried out from August to September 2005, relied mainly on scat identification to determine presence or absence, with validation of results using DNA testing procedures.

Field survey

The basis for the National Pine Marten Survey 2005 was a random selection of 29 x 10 km² National Grid squares that were previously negative for pine marten and 26 x 10 km² National Grids squares that were previously positive for pine marten. The 55 squares surveyed during 2005 were located in the east, southeast, southwest, mid-west, Slieve Blooms, mid-west and west (Figure 1).

Positive and negative grid squares were identified with reference to O’Sullivan (1983). Within each selected 10 km² National Grid Square, 4 x 1.5 km transects were surveyed. Using OS maps, GIS-based forest inventory maps provided by Coillte, and visual assessment, suitable areas to survey for pine martens within each square were identified. The location of survey transects was stratified according to the availability of suitable woodland habitat such that larger



A typical pine marten scat.

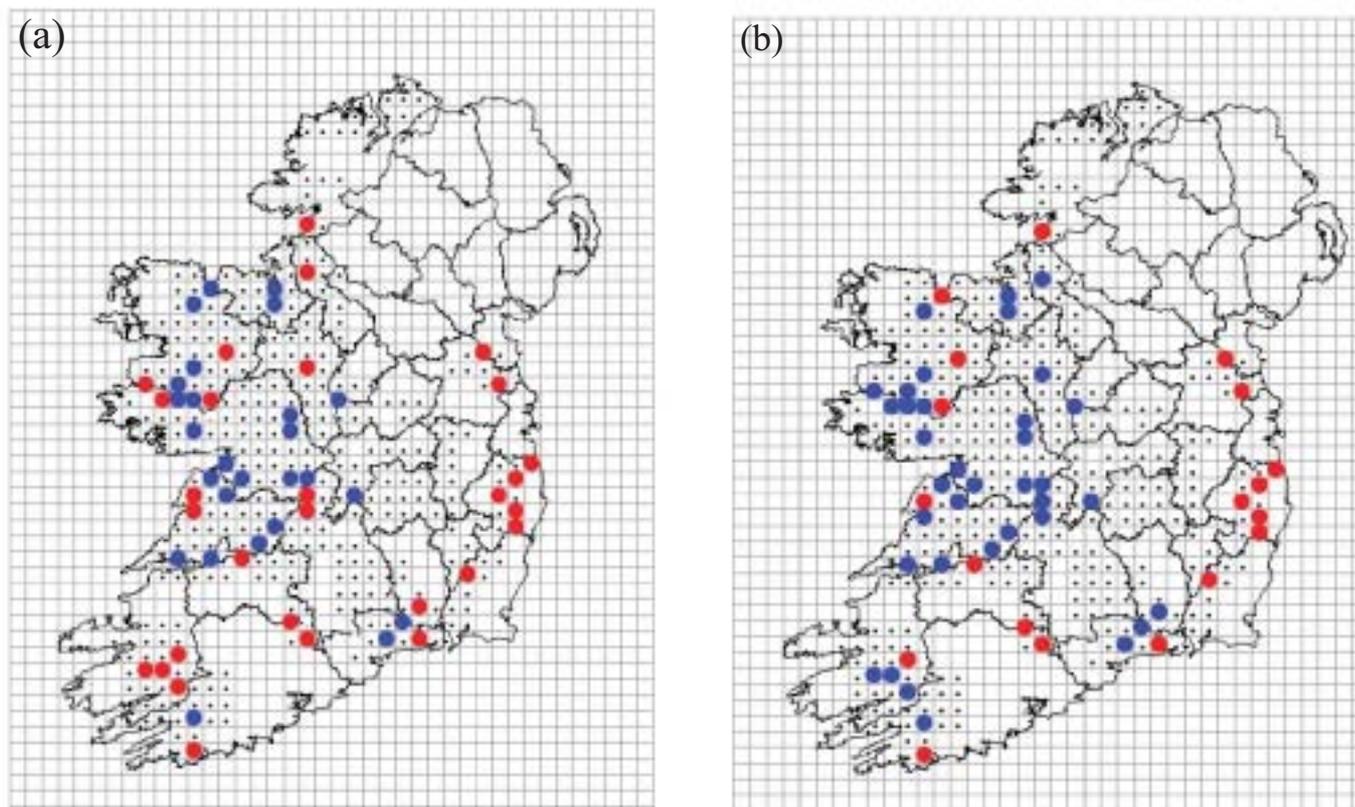


Figure 1. Map of Ireland with 10 km² National Grid overlay, indicating the location of survey squares completed in the National Pine Marten Survey 2005 and their status (occurrence indicated by blue dots, non-occurrence indicated by red dots) according to O'Sullivan (1983) (a) and their status as determined by the National Pine Marten Survey of Ireland 2005 (b). Also indicated are the locations of the remaining 10 km² National Grid survey squares (total n = 428; indicated by black dots) completed by O'Sullivan (1983). In total, 55 x 10 km² National Grid Squares were surveyed.

blocks of contiguous habitat were given preference during surveys. Transects were also located in a variety of habitat types such as plantation forest, semi-natural forest and scrub. Where possible, survey transects were located on little used forest trails or paths that were not heavily used or frequented by people and/or vehicles. However, in some circumstances such transects were not available within a particular 10 km² square. In such instances animal trails (badger or deer) or paved minor roads that were adjacent to inaccessible forests, scrub, hedgerows or tree-lines were used.

The total number of transects undertaken 195 (frequency distribution of transects by 10 km² square: minimum 1; mean 3; maximum 5). The mean transect length was 1.5 km (random selection of 20 transects measured using GIS: minimum 0.5 km, maximum 4.5 km). Thus, in total 292.3 km of transects were completed during the National Pine Marten Survey of Ireland 2005, with an

average total transect length completed per 10 km² National Grid survey square of 5.3 km. The majority of transects were located on either vehicle tracks or walking forest trails (n = 152; 77.9%), with the remainder being located on animal paths (n = 34, 17.5%) or paved minor roads (n = 9, 4.6%) (Figure 2). The type of transect used depended on their local availability within survey squares. In terms of the habitat encountered whilst on transects, the most frequent was conifer plantation (n = 92, 47.2%), then mixed forest (n = 53, 27.2%) with broadleaf and scrub habitats accounting for n = 33, 16.9% and n = 17, 8.7%, respectively.

Transects were walked slowly and searched for distinctive pine marten droppings (also known as scats) or direct sightings. In addition, if any prominent features were located near transects where pine martens have a tendency to deposit scats, such as tree stumps, dead logs or stones, then they were also searched. Any scats found were placed in a zip-lock bag and labelled according to the number of

the 10 km² National Grid Square, the transect number (labelled 1 to 4) and the number of scats (as necessary), where if more than one scat was found on a particular transect they were numbered sequentially. Scats were then placed within a padded envelope and sent for storage and subsequent DNA analysis to Waterford Institute of Technology.

DNA analysis

For DNA analysis, approximately 0.2 g of scat material was transferred to 1 ml S.T.A.R.® buffer (Stool Transport and Recovery buffer, Roche) in a 2 ml microfuge tube. The tube was vortexed for 15 seconds and then left to stand for at least 60 minutes, 100 µl chloroform was added to the sample, mixed by vortexing and centrifuged at 6000 x g for 1 minute, 200 µl of the supernatant was transferred to a sterile microcentrifuge tube for DNA isolation. DNA was isolated using the High Pure PCR Template purification kit (Roche) used according to the manufacturer's instructions. Primers (PM-FOR 5'-CACCAGGCCTCGAGAAACCAT-3' and PM-REV (5'-GGCCCGGAGAAG-3') and probes for real-time PCR were designed using Primer Express 2 software (Applied Biosystems). The sequences used were fox (AJ585358) and pine marten (AJ585357) d-loop sequences (Statham *et al.* 2005). Primers were selected based on T_m, product size, predicted T_m of amplicon and the ability of the primer set to amplify both fox and pine marten. The primers designed were conserved in all available fox and pine marten sequences. TaqMan® MGB probes were labelled with 6-FAM (fox 5'-TCCTGGCTCGAAGTAT-3') and VIC (pine marten 5'-CCCTTGCCCGATGTG-3').

Statistical analysis

The principal data collected during the National Pine Marten Survey of Ireland 2005 was repeated binomial data (i.e. presence or absence). To test for significant changes in the number of positive and negative 10 km² National Grid Squares between O'Sullivan (1983) and the National Pine Marten Survey of Ireland 2005, a McNemar Test was used (Sokal and Rolf 1995) incorporating a correction for continuity. Changes in distribution (i.e. where one or more previously negative squares was found to be positive or vice versa) were assessed visually and described by geographic region (i.e. southeast and southwest).

Survey results

In total 243 scats were found during surveys. Only a single direct sighting of a pine marten was recorded. In 14 x 10 km² National Grid survey squares no scats were found. In the remainder of survey squares an average of 5.9 scats were recorded per 10 km² National Grid Square (min 1; max 17). The total number of scats that underwent DNA testing was 60, of which 40 were positive for pine marten. Positive pine marten scats were obtained from 36 x 10 km² National Grid survey squares resulting in 65.4% of survey squares completed being positive (Table 1; Figure 1). 19 x 10 km² National Grid survey squares (or 34.6%) were negative for pine martens during the National Pine Marten Survey of Ireland 2005 (Table 1; Figure 1). Compared to the previous study this represented an increase in positive squares of 18.1%. This was a statistically significant difference. In comparison to O'Sullivan (1983), 11 x 10 km² National Grid Squares changed from negative to positive, whereas

Table 1. Summary of the number of positive and negative 10 km² National Grid squares surveyed during the National Pine Marten Survey of Ireland 2005, with reference to their previous status during 1978-80 (O'Sullivan 1983). Figures in parentheses are percentages. Differences are statistically significant (McNemar Test; $\chi^2 = 5.8$; d.f. =1; $p < 0.05$)

Year	No. of Positive 10 km ² National Grid squares	No. of Negative 10 km ² National Grid squares
1978-1980	26 (47.3%)	29 (52.7%)
2005	36 (65.4%)	19 (34.6%)



Vehicle trail transect type



Walking forest trail transect type



Animal path transect type



Paved road transect type

Figure 2. Examples of transect types undertaken during the National Pine Marten Survey of Ireland 2005. In terms of proportions, the most commonly used transect type was vehicle tracks or forest trails (77.9%), with animals paths and paved minor roads accounting for 17.5% and 4.6%, respectively.

only 1 x 10 km² National Grid Square changed from positive to negative during the National Pine Marten Survey of Ireland 2005 (Figure 1).

The distribution of pine martens in Ireland has increased in the southwest (3 x 10 km² National Grid squares), southeast (1 x 10 km² National Grid Squares), Slieve Bloom mountain range (2 x 10 km² National Grid Squares), mid-west and west (3 x 10 km² National Grid Squares) and in Sligo/Leitrim (1 x 10 km² National Grid Square). It has decreased in north Mayo (1 x 10 km² National Grid Square).

No positive records were found in the east of the country, while survey squares in North Cork/Limerick border remained negative for pine marten.

Pine marten scats were verified from 27 separate Coillte properties that were mainly dominated by conifer high forest and ranged in size from 14.2 to 516.7 ha. The remainder of pine marten scats were verified from the Burren, National Nature Reserves and on private property such as estates and, in one instance, an outdoor pursuit centre.

The survey design of the current study focused on implementing a standardised methodology with consistency in survey effort and transect sampling procedures that could be readily repeated. The methodology had a validation component in 2 x 10 km² National Grid Squares where pine martens were known to exist and proved to be effective in determining presence within relatively short time periods (≤ 25 mins.) and transect lengths (< 1 km). The fact that the survey also detected pine martens in Coillte properties where pine martens are known to exist, such as Cong Forest, and also where they have been reintroduced (Killarney National Park) increases the confidence in the methodology of detecting pine martens during the National Pine Marten Survey of Ireland 2005. According to Balharry *et al.* (1996) completing 3 km of survey transects within core pine marten range where resident, breeding adults occur gives a 97.8% probability of finding at least one scat and confirming presence. Given that on average 5.3 km of transects were traversed in each 10 km² National Grid Square completed during the National Pine Marten Survey of Ireland 2005 it is highly likely that if resident pine martens were present they would have been detected.

Current status of pine marten in Ireland

The results of the National Pine Marten Survey of Ireland 2005 show that there has been a significant increase in the number of positive 10 km² National Grid squares since the O'Sullivan study (1983) and that the distribution of the species is increasing in a number of regions of Ireland. These include the southwest, southeast, Slieve Bloom mountains and parts of the west. This increase is largely occurring from core population areas and represents a natural expansion in the species range. It is likely that the increasing distribution of the species in these regions is due to a number of factors, but principally reduced persecution and increased rates of afforestation in Ireland that has created suitable habitat and increased habitat connectivity for the species to increase its range. Increasing forest cover is now government policy in the Republic of Ireland with an overall aim of 17% forest cover by 2030. Since the mid 1980s the area of Ireland covered by forests has increased from 420,000 ha to almost 700,000 ha in 2005, with an increasing proportion being held in private ownership. Currently, 10% of the land area of the Republic of Ireland is

forested the majority of which is production forest, dominated by conifers such as Sitka spruce.

Apart from natural expansion of the population there have also been deliberate reintroductions of pine martens into areas where they were historically present but became locally extinct. For instance, several pine martens were reintroduced into Killarney National Park from Dromore Forest (Co Clare) over recent history and it appears the population is now increasing steadily and recolonising former habitats around the National Park (P. O'Sullivan personal communication). This probably accounts for the increased distribution of the species in the southwest as determined by the National Pine Marten Survey of Ireland 2005.

Whilst the distribution of pine martens is increasing in several regions of Ireland, there are still some regions where pine martens do not appear to occur, mainly in the east of the country. The National Pine Marten Survey of Ireland 2005 did not survey the northwest of the country which also has an historical absence of pine martens.

It is suggested that absence of pine martens from areas in the east of the country may be due to historical persecution which may have devastated pine marten populations locally, and perhaps even regionally, and that such areas may not currently have pine martens as they are too distant from resident populations in surrounding areas that could provide the opportunity for natural recolonisation. Of course, natural recolonisation is likely to occur of areas where pine martens are currently absent but several factors such as habitat availability and connectivity, dispersal ability and mortality sources will influence how long this may take. In Scotland, Balharry *et al.* (1996) suggested that the population of pine martens doubled from 1200 to 2400 over 12 years whereas in England and Wales relict pine marten populations have been very slow to recover and recolonise former habitats (Macdonald and Baker 2005). It could be argued that a reintroduction, similar to that which occurred in Killarney National Park, could speed up recolonisation in the east of Ireland but reintroductions are complicated and require careful planning.

Evidence of pine martens were found in a variety of habitat types from conifer plantations, to semi-natural woodland, scrub dominated habitats (some of which were relatively open, such as the Burren) and mixed forest.

During the National Pine Marten Survey of Ireland 2005 it was not possible to distinguish between ‘resident’ pine martens that breed and ‘transient’ that typically do not breed. This could be important as resident populations are those that are established in a particular area and breed providing recolonisation opportunities to the surrounding landscape through juvenile dispersal. Transients on the other hand will typically contribute little to the overall status of the population of interest until they become breeders. Variation in scat abundance or density on survey transects has been used to infer resident populations of pine martens (Balharry *et al.* 1996) but there is no empirical evidence supporting the assumption that areas with fewer scats contain only dispersing or non-breeding pine martens (Birks *et al.* 2004).

In conclusion, the National Pine Marten Survey of Ireland 2005 has found that there has been an increase in the distribution of the species in the Republic of Ireland, mainly occurring from core population areas in the mid-west, southeast and southwest. This is probably due to reduced persecution, due to the legal protection afforded the species in the 1970s, increased habitat availability and connectivity provided through increased rates of afforestation and deliberate reintroductions. There are, however, regions of the country particularly in the east where pine martens appear to be still absent and data on their current distribution are lacking from other regions such as the northwest.

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