Conservación y restauración de los bosques de tejo en Europa

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LIFE baccata

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O proxecto LIFE BACCATA (LIFE15 NAT/ES/000790), executado entre 2016 e 2021, foi cofinanciado ao 75% pola Comisión Europea, e posibilitou a mellora do estado de conservación do hábitat 9580* (Bosques mediterráneos de Taxus baccata) en 15 lugares da Rede Natura 2000 da Cordillera Cantábrica repartidos entre Galicia, Castilla y León, e País Vasco. Esta publicación, prevista no Plan After-LIFE BACCATA elaborado durante a execución do proxecto, é unha das actuacións que se desenvolven tras a súa finalización, asegurando a continuidade e a difusión da aprendizaxe e o coñecemento xerado. Os contidos desta publicación reflexan únicamente a opinión dos autores, non sendo responsable a Comisión Europea do uso que poida facerse da información que conten.

Conservación y restauración de los bosques de tejo en Europa

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Prólogo

El empleo de las plantas por el ser humano (alimento, vestidos, medicinal, etc.) es una de las actividades que ha dejado registros históricos más antiguos. Uno de los de mayor antigüedad proviene del siglo VIII a. C. en Mesopotamia, donde Marduk-Apal-Iddina II, Rey de Babilonia (722 a.C.-710 a.C., 703 a.C. – 702 a.C.), relaciona en una tablilla asiria un listado de más de 60 nombres (en acadio) de plantas cultivadas en los jardines Reales. Siglos después, el filósofo Aristóteles [384-322 a. C.] realizaba en el siglo IV a. C. un compendio de escritos en los que formulaba una clasificación específica de las plantas basada en su forma, período de vida y hábitat.

La presencia del tejo en la literatura es casi tan antigua como las primeras aportaciones escritas a la botánica. Y sería precisamente también en la Grecia clásica, cuando un discípulo del propio Aristóteles, Teofrasto de Ereso [372-287 a. C.], realizaba la primera mención al tejo en la escritura histórica, en su obra *La historia de las plantas* (*De historia plantarum* en latín, *Περὶ φυτικῶν ἱστοριῶν α'-θ'* en griego). Teofrasto hace repetidas referencias al tejo (que en la Grecia clásica se denominaba *mílos* o *milax)*, describiendo diversos aspectos de la especie como porte, foliación, ecología, floración, crecimiento y morfología, así como el carácter venenoso de sus semillas y hojas, empleadas para impregnar las puntas de flecha o para emponzoñar las bebidas que se servían en recipientes elaborados con la madera de este árbol, propiedad tóxica de la que derivaría el vocablo τοξικόν (toxikon), término procedente de τοξόν (*toxón*) que significa 'arco', indicando así la antigüedad de su tradicional uso para la elaboración de arcos y flechas venenosas. A partir de este término, Plinio el Viejo [23-79 d. C.], en su obra *Naturalis historia* (Historia Natural), escrita en latín y que fue empleada hasta la Baja Edad Media como modelo de enciclopedia, ya denomina al tejo como *Taxus,* describiéndolo en el apartado relativo a los árboles silvestres, incorporando las primeras referencias sobre la toxicidad de los especímenes Ibéricos, y haciendo un gran hincapié en la propia etimología de la palabra "tóxico".

La información clásica fue posteriormente reordenada por Bahuin en su *Pinax theatri botanici* [1623] y Tournefort en *Institutiones rei herbariae, editio altera* [1719]. Mientras que E. Kaempfer, en *Amoenitatum exoticarum politico-physico-medicarum* [1712], designa al tejo japonés como "*Taxus nucifera*", indicando además su denominación vulgar como "kaja". Linnaeus en *Species Plantarum* [1753], describe dos especies dentro del género *Taxus*, una distribuida en Europa y Canadá, *Taxus baccata,* y la segunda oriental, que siguiendo el trabajo de Kaempfer, designa como *Taxus nucifera.* En fechas posteriores, se describen nuevas especies de *Taxus*, tanto en el Viejo como en el Nuevo Mundo.

En las monografías más modernas del género *Taxus* se ha precisado su distribución pasada y presente, encontrándose en la actualidad representado tanto en Europa, como en el Norte de África, América del Norte y Asia, especialmente en las áreas montañosas de Sumatra, Célebes y Filipinas. Más dispar se muestra su taxonomía, para la que existen propuestas en las que se reconocen un número reducido de especies, algunas de las cuales abarcan un elevado número de subespecies, mientras que otros botánicos, defienden la consideración de más de 25 especies vivas y unas 6-10 especies extintas en la actualidad. La incorporación de nueva información morfológica, bioquímica, genética y evolutiva, determinan que nos encontremos ante un debate botánico no cerrado, especialmente en relación con los taxones asiáticos.

La única especie nativa presente en la actualidad en Europa es *Taxus baccata* L., el tejo europeo o euroasiático. Se trata de un árbol que mantiene una amplia distribución a lo largo de los territorios centro y sur de Europa. Hacia el N alcanza la porción meridional de la Península Escandinava y de Finlandia, mientras que por el S se distribuye desde la Península Ibérica a la Península Balcánica, estando además presente en numerosas islas y archipiélagos, Irlanda, Gran Bretaña, Açores, Madeira, Baleares, Córcega, Cerdeña y Sicilia, y ausente en Canarias. Además, cuenta con presencias más reducidas en el W de Asia (N de Irán) y el Norte de África. Su valencia ecológica le permite crecer bajo climas de tipo mediterráneo, atlántico, continental y boreal, sobre sustratos con desarrollo edáfico muy variable (paredes rocosas, canchales, suelos desde esqueléticos hasta profundos) y con condiciones nutricionales que comprenden desde la oligotrofia hasta la basicidad. En relación con la altitud, es posible encontrarlo desde el nivel del mar hasta los 2.200 m de altitud, aunque en la Península Ibérica raramente sobrepasa los 2.000 m.

El tejo es, una especie vegetal con gran arraigo en diferentes culturas del ámbito europeo, como consecuencia de las propiedades toxicas para los humanos (salvo la envuelta carnosa rojiza que envuelve su semilla) y ganado doméstico (caballos), su gran longevidad y la durabilidad y resistencia a la descomposición de su madera, habiéndosele atribuido propiedades mágicas y protectoras a los entornos en los que se plantaba frente a fenómenos atmosféricos (rayos, temporales de viento). Este significado cultural ancestral, justifica que se trate de una especie frecuente en huertos y patios de viviendas agrícolas de muchas áreas europeas, teniendo una presencia relevante entre las especies arbóreas plantadas en los cementerios y las proximidades de las capillas e iglesias. Algunos de estos individuos se consideran ejemplares monumentales que superan los doscientos o trescientos años de vida cuyo origen hay que relacionarlo con extracciones de las formaciones nativas próximas o, en algunos casos, en mercados locales.

Actualmente, el tejo forma parte de manera espontánea de una gran variedad de biocenosis arbóreas de carácter natural o seminatural en Europa, pero son muy escasos los lugares en los que llega a ser la especie dominante y formar tejedas. Los tejos y las tejedas tienen un papel relevante en el mantenimiento de la biodiversidad de diversos territorios, puesto que las hojas y frutos del tejo son aprovechados por muchas especies de fauna, y su densa copa y follaje proporcionan abrigo y refugio a un gran número de aves y mamíferos en la época invernal. Estas circunstancias, unidas a su fragmentada distribución geográfica y a las presiones y amenazas que se ciernen sobre las tejedas, justifican su consideración como formaciones de gran singularidad y elevado interés para la conservación de la biodiversidad en Europa.

A este respecto, la Directiva Hábitat (DC 92/43/CEE) incluye dentro del Anexo I un total de 246 tipos de hábitats de interés comunitario, de los que 71 son considerados como prioritarios. Los hábitats de bosques representan 82 tipos de hábitats de interés comunitario, de los que 28 tipos son considerados como hábitats prioritarios. En la denominación de cuatro de estos tipos de hábitats se hace referencia expresa al tejo o a sus formaciones: Nat-2000 9120 Hayedos acidófilos atlánticos con sotobosque de *Ilex* y a veces de *Taxus*, 9210* Hayedos de los Apeninos con *Taxus* e *Ilex*, 91J0* Bosques de las Islas Británicas con *Taxus baccata* y 9580* Bosques mediterráneos de *Taxus baccata*. De ellos, el primero y el último han sido reconocidos en la Península Ibérica en las Listas de referencia de hábitats de la Región Biogeográfica Atlántica y Mediterránea relativas a España y Portugal.

Con respecto al tipo 9580*, se ha destacado el papel del tejo y las tejedas en el mantenimiento de la biodiversidad y el patrimonio natural en el ámbito ibérico, resolviendo que los bosques ibéricos de tejo son representaciones del tipo de este hábitat prioritario. La calificación de este tipo hábitat 9580* en términos biogeográficos (‘Bosques mediterráneos de *Taxus baccata’*), no excluye la posibilidad de encontrar el mismo tipo de hábitat en la región Atlántica española. Al contrario, las representaciones atlánticas de este tipo de hábitat, situadas en el Norte de la Península Ibérica, poseen un gran valor científico y de conservación de la biodiversidad y el patrimonio natural, ya que se encuentran a menudo aisladas y muy fragmentadas e influenciadas por actividades humanas, lo cual motiva una situación de alta vulnerabilidad y fragilidad.

En este escenario, entre los años 2016 y 2021, se ejecutó el proyecto LIFE15 NAT/ES/000790 “Conservando y restaurando los bosques de tejo (9580*) de la Cordillera Cantábrica” (LIFE BACCATA), que ha promovido la mejora del estado de conservación del hábitat 9580* en la Red Natura 2000 de la Cordillera Cantábrica (Norte de la Península Ibérica), gracias al esfuerzo de sus beneficiarios: el IBADER (Universidade de Santiago de Compostela), la Junta de Castilla y León, la Fundación CESEFOR, la Fundación HAZI y la empresa pública TRAGSA. Cada uno de los socios ha desarrollado acciones de mejora del estado de conservación de los bosques de tejo dentro de su ámbito territorial de actuación, superando los objetivos planteados al comienzo

del proyecto, lo cual ha permitido que el partenariado del mismo se encuentre altamente satisfecho de los resultados alcanzados.

De forma paralela, el proyecto LIFE BACCATA ha desarrollado una ambiciosa estrategia de difusión y *networking* que ha permitido transferir y replicar las lecciones aprendidas por el mismo, e integrar la visión y conocimientos de otros proyectos o iniciativas, tanto dentro de las CCAA involucradas en las acciones de restauración, como en el resto de España e incluso del territorio europeo. El potencial de la información intercambiada ha sido tan elevado, y el impacto de la misma tan notable, que los socios de LIFE BACCATA han estimado necesario dar un paso adelante, y realizar un compendio de conocimientos, experiencias y mejores prácticas acerca del tejo y las tejedas, tanto a nivel español como europeo.

De este modo, una vez finalizado LIFE BACCATA, durante su fase *After*-LIFE se ha planteado la edición de la presente publicación, de carácter científico-técnico y divulgativo, centrada en los distintos aspectos relacionados con el tejo *(Taxus baccata),* el hábitat prioritario 9580* Bosques mediterráneos de *Taxus baccata* u otros tipos de formaciones vegetales o hábitats (8240*, 9120, 9180*, 91J0*, 9210, 9380) en los que el tejo tenga un papel relevante, así como otros aspectos relacionados con el tejo y su hábitat (ecología, demografía, genética, regenerado, etnografía, toponimia, jardinería, etc.) que los autores han considerado relevantes para su publicación y divulgación.

En esta publicación, se han recopilado textos temáticos de carácter técnico, científico o divulgativo, dando cabida tanto a trabajos que provienen de tesis doctorales, trabajos fin de grado/máster, revisiones, recensiones, notas corológicas, trabajos empíricos (de campo o laboratorio), comunicaciones cortas, etc. En consecuencia, la obra que ahora publica el IBADER, a través de su serie Monografías del IBADER, viene a servir como fuente de continuación de las jornadas internacionales del tejo celebradas en España entre los años 2007 y 2014, y contribuir a incrementar el conocimiento e información generados por los proyectos TAXUS (LIFE11 NAT/ES/000711) y LIFE TAXUS (LIFE12 NAT/PT/000950) entre los años 2014 y 2017.

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Taxus baccata woods in Ireland: ecology, conservation status and necessary conservation measures

Abstract *Taxus baccata woods of the British Isles is a priority habitat under Annex I of the EU Habitats Directive (with the habitat code H91J0*). Ireland is now the only EU Member State in which H91J0* occurs and so has a special responsibility for its conservation. Its distribution in Ireland is highly restricted, with only six sites present nationally. These are located in the south and west of Ireland and most are associated with limestone geology. The ecology and condition of H91J0* in the Irish context are relatively well studied. Monitoring data, as required under Article 17 of the Habitats Directive, are available for all six sites. The most recent national conservation status assessment found that the status of H91J0* in Ireland is Unfavourable – Bad. The overall trend in conservation status is stable. The main pressures affecting H91J0* are invasive non-native species, overgrazing (primarily by deer), and Ash Dieback disease. In this paper, we review the current state of knowledge of H91J0* in Ireland and discuss the conservation measures which are needed to bring the habitat into Favourable status.*

Keywords *applied ecology, conservation status assessment, conservation measures, woodland ecology, Yew woodland*

Introduction

Taxus baccata L. (Yew) is one of only three coniferous species native to Ireland. It is slow-growing and its lifespan can exceed 1000 years (Thomas & Polwart 2003). It has been widely planted in demesnes, gardens and churchyards but is rare in semi-natural habitats. During a national survey of native woodlands, *T. baccata* accounted for only 0.2% of measured trees (Perrin et al. 2008). Individuals can be found occasionally in the understorey of semi-natural woodland on well-drained mineral soils over limestone or sometimes on podzols over sandstone (Devaney et al. 2015, Perrin et al. 2006). Waterlogged conditions are avoided. In karstic areas, particularly in the Burren in western Ireland, scattered *T. baccata* plants can be found growing as a pioneer shrub on open limestone pavement, often heavily browsed by livestock or feral goats (*Capra hircus*). Very rarely, *T. baccata* may become the canopy dominant within woodlands on outcropping limestone. In Britain, *T. baccata* woods have been noted as developing from a *Crataegus monogyna* or *Juniperus communis* scrub sere, with the thorny plants providing protection to juvenile *T. baccata* plants from browsing animals (Watt 1926). In Ireland, *T. baccata* woods may also develop from a *T. baccata-Corylus avellana* scrub woodland sere (Perrin et al. 2006). *T. baccata* is highly shade-tolerant (Perrin & Mitchell 2013) but studies have shown that it regenerates poorly under its own canopy. Regeneration may be more successful in canopy gaps, woodland edges, and adjacent areas with shrubby cover (Devaney et al. 2014, Perrin et al. 2006, Watt 1926).

Taxus baccata woods of the British Isles (henceforth denoted as H91J0*) is a priority habitat under Annex I of the EU Habitats Directive (92/43/EEC). Ireland is now the only EU Member State in which H91J0* occurs and so has a special responsibility for its conservation. Its distribution in

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Ireland is highly restricted, with only six sites known nationally (Table 1, Figure 1). These are located in the south and west of Ireland and most are associated with limestone geology.

Under Article 17(1) of the Habitats Directive, Member States are required to report on the implementation of the measures taken under the Habitats Directive. The most recent Article 17 report assessed the national conservation status of H91J0* in Ireland as Unfavourable – Bad. The overall trend in conservation status is stable (NPWS 2019a). At site level, the conservation status of H91J0* has been assessed as Favourable at one site and as Unfavourable – Bad at five sites (Table 1).

Under Article 6(1) of the Habitats Directive, Member States are required to establish the conservation measures necessary to maintain or restore the Favourable conservation status of the habitats and species for which Special Areas of Conservation (SACs) are designated. In the Irish context, it is therefore necessary to establish site-specific conservation measures for H91J0* within the five SACs for which this habitat is a qualifying interest (Table 1).

Conservation measures must correspond to the particular ecological requirements of the habitat and specifically address the pressures which are identified as affecting H91J0* within each of these SACs. Furthermore, the current area of H91J0* present in Ireland is not considered adequate to ensure the long-term survival of the habitat. To reach the Favourable Reference Area, it is necessary to expand existing H91J0* and create new H91J0* where appropriate. However, this is limited by the availability of suitable limestone substrates and furthermore by grazing pressure (Cross & Lynn 2013). Expansion of H91J0* can also potentially conflict with conservation objectives for other habitats, e.g. H8240* Limestone pavement.

In this paper, we summarise the results of the most recent conservation status assessment of H91J0* on a site-by-site basis (adapted from Daly et al. in press), provide a new assessment of the conservation measures implemented to date, and discuss the conservation measures which are necessary to bring the habitat into Favourable status.

Site Descriptions

The following site descriptions are largely based on those of Cross & Lynn (2013). All six sites are located within SACs (Table 1). Article 17 monitoring data are available from each site (Cross & Lynn 2013, Daly et al. in press).

Reenadinna

The largest and most intensively studied area of H91J0* in Ireland comprises 63.0 ha (NPWS 2019a) and is centred on Reenadinna Wood (Figure 2a). It is located on the Muckross Peninsula, between Lough Leane and Muckross Lake, in Killarney National Park. The National Park is also part of the UNESCO-designated Kerry Biosphere Reserve. The woodland occurs on limestone pavement and limestone outcrops and is a complex of fairly pure *T. baccata* stands, *T. baccata* and *C. avellana* stands and *T. baccata* and *Fraxinus excelsior* stands. The canopy is dense and even-aged. The shrub layer of *C. avellana* and *Ilex aquifolium* is poorly developed and the herb layer is sparse and species-poor. Herbs, shrubs and tree regeneration are largely confined to edges and canopy gaps. Where grazing has been excluded, *I. aquifolium* and *Rubus fruticosus* agg. have developed a relatively good cover. There is a carpet of pleurocarpous mosses. Invasive non-native species including *Rhododendron ponticum*, *Clematis vitalba* and *Cotoneaster* spp. are present (Cross & Lynn 2013) and another, *Luma apiculata*, was recorded at Reenadinna for the first time in 2021 (Hamilton et al. in press).

Site	Special Area of Conservation	Qualifying interest	County	Ownership	Conservation status
Reenadinna	Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC 000365	Yes	Kerry	NPWS	Unfavourable - Bad
Garryland	Coole-Garryland Complex SAC 000252	Yes	Galway	NPWS	Unfavourable - Bad
Cahir Woods	Lower River Suir SAC 002137	Yes	Tipperary	Coillte	Unfavourable - Bad
Curraghchase	Curraghchase Wood SAC 000174	Yes	Limerick	Coillte	Unfavourable - Bad
Cornalack	Lough Derg North-east Shore SAC 002241	Yes	Tipperary	Private	Favourable
Kylagowan	Pollnaknockaun Wood Nature Reserve SAC 000319	No	Galway	Coillte	Unfavourable - Bad

Table 1.- Designation status (under the EU Habitats Directive), location, ownership and conservation status of H91J0* sites in Ireland (Fig. 1)

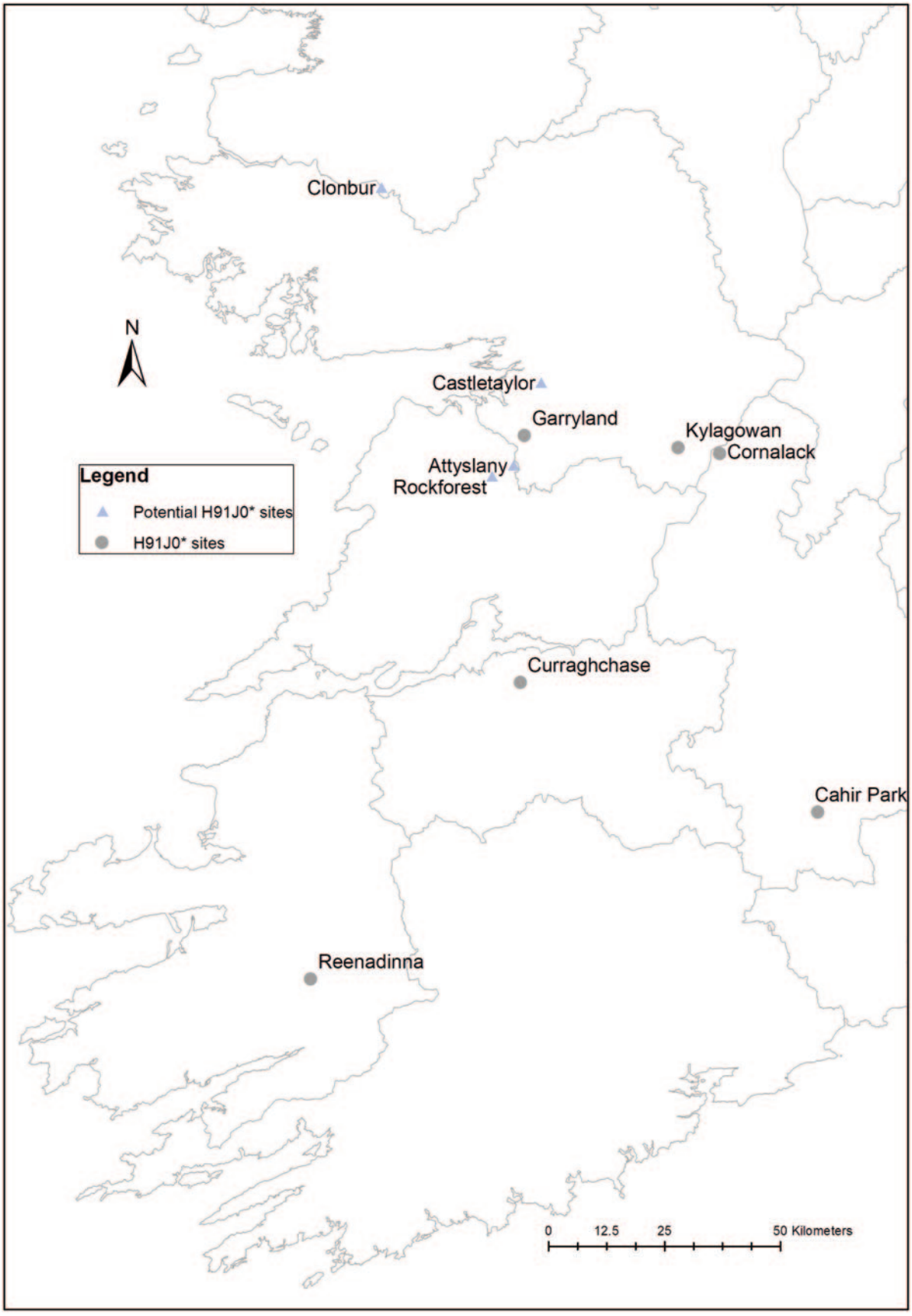

Figure 1.- Map of the south and west of Ireland, showing the location of H91J0* sites (Table 1) and potential H91J0* sites referenced in the text

The rare plants *Botrychium lunaria* and *Neottia nidus-avis* (Hamilton et al. in press, Hodd 1997) are present within Reenadinna Wood; the former is classified as 'Near Threatened' on the Irish Red List of Vascular Plants (Wyse Jackson et al. 2016). Some rare spider species have also been found, including *Agyneta subtilis, Diaea dorsata* and *Hyptiotes paradoxus* (Nolan 2019, Fuller et al. 2014).

Reenadinna Wood is one of Ireland's few known Ancient Woodlands, i.e., it is believed to have remained continuously wooded since at least 1660 (Perrin & Daly 2010). A high spatial-resolution palaeoecological study of the long-term dynamics of Reenadinna Wood found that the *Taxus*-dominated woodland developed 3000-5000 years ago from a stand dominated by *Pinus, Quercus, Ulmus* and *Corylus.* It underwent periods of disturbance due to patch cultivation and site occupancy (Mitchell 1990a).

Also in Killarney National Park, Monks Wood is a 6.0 ha stand of H91J0*, located *c.* 0.5 km east of Reenadinna. It is situated on limestone outcrops, which are part of the same series found at Reenadinna. Monks Wood is more modified in nature. It is largely dominated by *T. baccata* but the non-native invasive *Fagus sylvatica* is also abundant. Other invasive non-native species present include various conifers and the shrubs *Prunus laurocerasus* and *Hypericum calycinum*.

A small stand (0.8 ha) of H91J0* has been mapped at Dundag Point (NPWS 2019a), *c.* 0.5 km south-east of Reenadinna. Vegetation data are not available from this stand and its conservation status has not been assessed to date. In total, 69.8 ha of H91J0* has been mapped within Killarney National Park (NPWS 2019a). Small unmapped patches of H91J0* are also present on limestone outcrops south and east of the Arboretum, near Cailín Bán Rock (K. Freeman, pers. comm.) and on Cow Island (J. Roche, pers. obs.).

Garryland

Three small stands of H91J0* are present on limestone outcrops at Garryland (Figure 2b), comprising 3.2 ha in total (NPWS 2019a). They occur within a large area of mixed broadleaved woodland, which the National Survey of Native Woodlands (Perrin et al. 2008) ranked as joint first nationally in terms of its conservation assessment score. The woodland is part of the state-owned Coole-Garryland Nature Reserve. The canopy averages *c*. 13 m in height. It is dominated by *T. baccata* with some *F. excelsior*, *Quercus robur* and the invasive non-native *F. sylvatica*. Both the shrub and herb layers are very poorly developed but the bryophyte layer is well developed. A small amount of *T. baccata* regeneration is present. *T. baccata* is also scattered through the surrounding broadleaved woodland (Cross & Lynn 2013) and on the more open limestone pavement habitat, where it occurs with *J. communis*, *C. monogyna* and *Prunus spinosa* (R. Stephens, unpublished data). It also occurs on limestone outcrops with an open canopy, in association with *Pinus sylvestris, J. communis, Q. robur* and *C. avellana* (E. Mooney, pers. comm.).

Cahir Park

At Cahir Park, a narrow 1.4 ha stand of *T. baccata* woodland occurs along the steep western flank of a limestone knoll (Figure 2c). It is located within modified woodland in a former demesne. The canopy of *T. baccata* is *c.* 15 m tall, with small amounts of *F. excelsior* present. *I. aquifolium*, *C. avellana* and *Sambucus nigra* form a thin shrub layer. Under deep shade, the field layer is poorly developed and consists largely of *Hedera helix sensu lato*. Patches of *R. fruticosus* agg. are present where there is lateral light from the margins. The bryophyte layer is poorly developed. The woodland contains numerous non-native tree species, as well as the invasive shrubs *P. laurocerasus* and *Prunus lusitanica*.

Curraghchase

A mixed 3.3 ha stand of H91J0* is present on the top and sides of a limestone ridge at Curraghchase (Figure 2d). It is located within a large area of broadleaved and mixed woodland, which was ranked joint first nationally in terms of its conservation assessment score (Perrin et al. 2008). The canopy averages 15-18 m. It is dominated by *T. baccata* with large *F. sylvatica* emergents and occasional *Q. robur*. There is good regeneration of *T. baccata* in light gaps, most of the young plants having developed from layering of low-hanging branches. A thin shrub layer is formed by *F. excelsior*, *C. avellana*, *I. aquifolium*, *P. laurocerasus* and *Ulmus* sp. Under deep shade, the field layer is poorly developed and consists largely of *H. helix sensu lato*. *R. fruticosus* agg. is abundant in light gaps.

Cornalack

A 2.4 ha stand of H91J0* occurs on shattered limestone pavement at Cornalack (Figure 2e). It is located on the shore of Lough Derg and is partly within a small, long-abandoned quarry. The canopy reaches 8-12 m in height. *F. excelsior* is constant within the canopy. *I. aquifolium* dominates the understorey, with some *Sorbus aucuparia* and occasional *Rhamnus cathartica* and *Euonymus europaeus. H. helix sensu lato* dominates the ground flora. Bryophyte cover is high, varying from 50 to 80%. Unusually, *T. baccata* regeneration is abundant within an adjacent *J. communis* formation (Annex I habitat H5130), where it appears that *T. baccata* is gradually shading out and replacing *J. communis*. Dynamic interfaces between H91J0* and *J. communis* scrub represent an important successional stage in the development of H91J0* in Britain (Watt 1926) but this is the only known example in Ireland at present.

Kylagowan

On acidic soil at Kylagowan, *T. baccata* dominates the sub-canopy and shrub layer of an area that would otherwise correspond to Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles (Annex I habitat H91A0). This site is considered anomalous (Cross & Lynn 2013) and H91J0* is not a qualifying interest of the SAC. This site is not given further consideration here but must continue to be monitored.

Results and Discussion

To establish site-specific conservation measures that correspond to the particular ecological requirements of H91J0*, we examine the negative and positive pressures affecting H91J0* and analyse the structure and functions assessment results, focusing on the criteria under which the habitat has failed the assessment. The most recent conservation status assessment results for H91J0* are derived from Daly et al. (in press).

The total mapped area of H91J0* in Ireland is 83.0 ha (NPWS 2019a). The most recent Article 17 monitoring survey of all six sites (Daly et al. in press) covered 27.1 ha (32.7% of H91J0* nationally). At five sites, 100% of H91J0* was surveyed. A 14.0 ha sample of H91J0* was surveyed at Reenadinna (20.1% of H91J0* in Killarney National Park). No anthropogenic habitat loss of H91J0* was recorded so the habitat area of all sites was assessed as Favourable (i.e. stable or increasing).

At national level, the area of H91J0* is assessed as Unfavourable – Bad because it is more than 10% below the Favourable Reference Area (132 ha). This reflects the need to increase the area of H91J0*. The Favourable Reference Range is based on the Favourable Reference Area. There is no evidence of loss of range of H91J0* in Ireland since the Habitats Directive came into force. However, range has been assessed as Unfavourable – Bad because it is more than 10% below the Favourable Reference Range (NPWS 2019a), reflecting the need to expand the range of H91J0* into additional areas.

Reenadinna

Conservation status

Two successive Article 17 monitoring reports (Cross & Lynn 2013, Daly et al. in press) have assessed the overall conservation status of H91J0* at Reenadinna as Unfavourable – Bad. The overall Conservation Objective for H91J0* within the Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment SAC is to restore the habitat to Favourable conservation status (NPWS 2017a).

The most recent report (Daly et al. in press) assessed the structure and functions (i.e. condition) of H91J0* at Reenadinna as Unfavourable – Bad. The site failed the assessment due to inadequate cover of the native shrub layer, inadequate cover and height of the native dwarf shrub and field layers, excessive grazing, and the absence of saplings of *T. baccata* and other native tree species from the monitoring plots (Figure 2a). Negative (i.e. non-native) trees and shrubs were recorded as being present, though their cover was not so high as to fail the structure and functions assessment. The negative pressures affecting H91J0* were overgrazing by deer and, to a lesser degree, invasive non-native species (Table 2), both of which impact woodland structure and regeneration potential.

Conservation measures implemented to date

The invasive non-native shrub *Rhododendron ponticum* was introduced to the Killarney area in the 19th century and became highly invasive in woodlands (Cross 1981), necessitating a *Rhododendron* control programme in Killarney National Park. This was initiated in the 1960s and is ongoing. Significant areas of infestation have been removed from Reenadinna following intensive control work (Cahalane 2018, Higgins 2008, Perrin et al. 2008). *R. ponticum* is now relatively sparse within Reenadinna.

H91J0* at Reenadinna has been subject to chronically high levels of grazing and browsing by native red deer (*Cervus elaphus*) and non-native invasive sika deer (*Cervus nippon*). The latter was introduced to the Killarney area in the 19th century. Numerous studies have reported the excessive impact of deer grazing at Reenadinna and have recommended that grazing levels be reduced (e.g. Perrin et al. 2006, 2011, Cross & Lynn 2013, Newman et al. 2014a, Fuller et al. 2014, Daly et al. in press, Hamilton et al. in press).

Deer grazing levels in Killarney National Park have fluctuated in response to the level of deer management effort, which itself fluctuated according to available resources and varying management priorities over time. Newman et al. (2014a) found a clear trend over time of increasing numbers and diversity of saplings of native tree species in Reenadinna and Camillan oakwood, both of which are located on the Muckross Peninsula and within the same Deer Management Unit. This area was subjected to regular and relatively intensive deer culling from 1991 to 2011. However, staffing and resource constraints following the post-2008 Irish economic downturn resulted in a reduction in deer culling effort. The most recent round of Article 17 monitoring, conducted in 2018, reported a high intensity of grazing by deer throughout H91J0* (Daly et al. in press). *T. baccata* is highly susceptible to browsing and bark stripping (Thomas & Polwart 2003). No *T. baccata* saplings have been recorded within long-term monitoring plots at Reenadinna by surveys conducted between 1996 and 2021 (Hamilton et al. in press). Indeed, in 2018, Daly et al. (in press) found no saplings of any species within the

Site	Pressure	Effect	Intensity	% Habitat affected	Description
Reenadinna	Grazing in forests/ woodland	Negative	High	100	Deer grazing is preventing regeneration. Deer are present within the deer fenced area.
	Invasive non-native species	Negative	Low	3	Mature *Acer pseudoplatanus* and *Fagus sylvatica* present in small numbers within the wood. Regeneration of these species has been noted. *Clematis vitalba* and *Cotoneaster* sp. are also present.
Garryland	Invasive non-native species	Negative	High	75	*Fagus sylvatica* trees and regeneration are present throughout most of the woodland. *Acer pseudoplatanus*, *Abies alba* and *Carpinus betulus* are occasionally present.
	Introduction of disease (microbial pathogens)	Negative	Low	3	Ash Dieback disease is present.
Cahir Park	Invasive non-native species	Negative	Medium	20	*Prunus laurocerasus* and *Prunus lusitanica* shrubs present. Regeneration of *Acer pseudoplatanus*, *Acer campestre* and *Fagus sylvatica*.
	Introduction of disease (microbial pathogens)	Negative	Low	0.5	Ash Dieback disease is present.
	Forest replanting (native trees)	Positive	Low	0	*Taxus baccata* planted in the adjacent stand as part of a LIFE Project.
Curraghchase	Invasive non-native species	Negative	High	100	Mainly *Fagus sylvatica* with some *Acer pseudoplatanus* and *Prunus laurocerasus*.
	Forest replanting (native trees)	Positive	Low	0	*Taxus baccata* planted in the adjacent stand as part of a LIFE Project.
	Use of biocides, hormones and chemicals (forestry)	Positive	Low	0.5	Spraying of *Prunus laurocerasus* regrowth with herbicide has been carried out relatively recently.
Cornalack	Invasive non-native species	Negative	Low	5	*Acer pseudoplatanus* and *Populus* × *canescens* seedlings present. *Clematis vitalba* and *Cotoneaster* sp. also observed.

Table 2.- Results of negative and positive pressures assessment (Daly et al. in press) for monitoring sites within SACs where H91J0* is a qualifying interest

monitoring plots. The shrub layer is absent from much of the H91J0* area (J. Roche, pers. obs. 2020). Ultimately, there has been no effective large-scale recruitment to the adult tree population on the Muckross Peninsula since at least the 1950s, as evidenced by recent monitoring of H91J0* and H91A0 (Daly et al. in press, Hamilton et al. in press) and tree-ring analysis from H91A0 (O'Sullivan & Kelly 2006).

As part of the People's Millennium Forests project, a national woodland conservation programme, two large exclosures were erected at Reenadinna in 2001 to control grazing by deer (Cross & Lynn 2013) but these have not remained deer-proof. The design and large size of the exclosures created several issues, including the following: (i) the long fence perimeter was difficult to monitor regularly enough to prevent deer ingress; (ii) when deer found a single access point, the entire exclosure (>20 ha) was compromised; and (iii) it was difficult to locate and safely cull deer within the exclosure. These issues were compounded by staffing and funding shortages. In 2018, Daly et al. (in press) found that deer were present within the exclosure, increasing the grazing intensity therein compared to the adjacent unfenced H91J0*. We must conclude that these large exclosures were an unsuccessful conservation measure. Large-scale, permanent fencing of woodlands is not considered good practice due to its detrimental impact on ground flora diversity (Newman et al. 2014b, c). The complete exclusion of grazing causes a shift from vegetation characterised by woodland specialist to woodland generalist species (Perrin et al. 2011).

In recent years, deer culling effort within Killarney National Park has intensified. This has been focused on the ecologically important woodlands of the Muckross Peninsula, including Reenadinna, where deer densities were reduced by an estimated 15% from 2018 to 2020 (D. O'Keeffe, pers. comm.). The programmes of Article 17 monitoring (Daly et al. in press) and long-term monitoring of permanent plots (Hamilton et al. in press), which are in place in five and six woodlands in Killarney National Park respectively, will enable the assessment of changes in natural regeneration over time in response to deer culling.

In terms of statutory conservation measures, this site is designated under the Bourn Vincent Memorial Park Act, 1932. It is state-owned and managed by the National Parks and Wildlife Service (NPWS).

Necessary conservation measures

Deer management and natural regeneration

The reinstatement of the natural process of tree regeneration is a fundamental prerequisite for the long-term survival of H91J0* at Reenadinna, as well as other ecologically important woodland habitats in Killarney National Park.

Research conducted within H91A0 Old sessile oak woods in three Irish National Parks (including from the Muckross Peninsula, in the same Deer Management Unit as Reenadinna) indicates that low grazing levels need to be maintained through culling and herbivore management. The practice of large-scale, long-term fencing of woodlands, which may result in the loss of ground flora diversity after 12 years, should be discontinued. Short-term fencing, intended to increase tree regeneration or maintain biodiversity, can be considered as a management option (Newman et al. 2014b, c).

A consistent, sustained programme of deer management is needed to progressively reduce deer numbers to levels which are compatible with sustained natural regeneration of trees. Rather than working to pre-defined quantitative targets for reductions in deer numbers, the level of grazing impact within a given area (Deer Management Unit) can instead be used as a benchmark (after Rao 2017). Monitoring programmes are already in place in Reenadinna to provide data on tree regeneration levels (Daly et al. in press, Hamilton et al. in press). Deer numbers need to be progressively reduced by means of culling until, at the very least, an adequate level of tree regeneration is reached to ensure the survival of the woodland canopy. Given the fecundity of the deer population and the absence of natural apex predators in Ireland, ongoing culling will then be needed, at lower intensity, to maintain deer densities at this level and ensure an appropriate grazing regime.

Until an appropriate grazing regime is achieved, there remains a need for smaller-scale, temporary fencing, given the urgency of the need to secure regeneration. It is proposed to pilot an innovative temporary fencing technique within H91J0* at Reenadinna. Durable, moveable, reusable metal fencing panels can be used to construct small exclosures where canopy gaps occur. Unlike fencing with posts, this method does not damage the limestone pavement substrate. These exclosures can be dispersed throughout H91J0*. Exclosure size and shape can vary according to the size and terrain of individual canopy gaps. Where hollows occur in the terrain, additional wire fencing can be used below the panels to seal off potential deer creeps. The exclosures are removed once the trees are sufficiently grown to withstand damage by deer, subject to monitoring of tree growth. The ultimate objective of these small, temporary exclosures is to secure pulses of tree regeneration while preventing the reduced species diversity which results from long-term exclusion of grazers.

Gap creation and control of invasive non-native species

The regeneration of *T. baccata* is controlled by a complex interplay of factors. It has been well documented that *T. baccata* regenerates poorly beneath its own canopy. In long-term monitoring exclosures at Reenadinna, no *T. baccata* saplings were recorded over a 32-year period, which indicates that grazing is not the only factor affecting regeneration (Perrin et al. 2006). In temperate forests, the maintenance of *T. baccata* populations seems to depend mainly on selective canopy opening to reduce light competition (Linares 2013). Perrin & Mitchell (2013) concluded that, beneath denser canopies, gap dynamics play an important role in facilitating successful regeneration of *T. baccata*. As the canopy at Reenadinna is relatively dense, it is proposed to create canopy gaps to facilitate natural regeneration. The canopy can be maintained and gaps can be opened up by the removal of non-native species (Cross & Collins 2017).

Mature *Acer pseudoplatanus* and *F. sylvatica* are scattered through H91J0* at Reenadinna. They are occasional in frequency but are regenerating (Daly et al. in press). Long-term monitoring indicates that *F. sylvatica* regeneration at Reenadinna is accelerating (Hamilton et al. in press). In Ireland, unlike many other Member States, these species are non-native and invasive. *F. sylvatica* casts heavy shade. It has been suggested that this may reduce competition from other more vigorous species while still allowing regeneration of *T. baccata* (Cross & Lynn 2013) and that some *F. sylvatica* can be retained in H91J0* with monitoring and control of regeneration (Cross & Collins 2017). However, the retention of *F. sylvatica* is ultimately not compatible with the conservation objective to restore H91J0* to Favourable status. The regeneration and excessive cover of invasive non-native species (>10%) and various associated effects on woodland structure can preclude the possibility of reaching Favourable status, because if a H91J0* monitoring plot fails three or more out

of eleven structure and functions assessment criteria (Daly et al. in press), the plot fails the structure and functions assessment. Retained non-native invasive trees pose a continuing threat of reinvasion, as well as creating an ongoing need to manage their regeneration, an inefficient use of much-needed resources. Instead, the focus at Reenadinna must be on restoring a native woodland canopy.

It is proposed that the scattered mature *A. pseudoplatanus* and *F. sylvatica* be ringbarked, where safe to do so. This will reduce the cover and regeneration of non-native species, provide deadwood habitat, and create canopy gaps, which can be fenced as described above to promote the regeneration of native trees. *A. pseudoplatanus* and *F. sylvatica* regeneration can be manually removed using non-chemical methods.

T. baccata can exploit canopy gaps in the absence of grazing (Mitchell 1990b). However, Devaney et al. (2014, 2018) found that conspecific negative density dependence is also a factor in *T. baccata* regeneration. Low levels of *T. baccata* regeneration below mature *T. baccata* canopies are often attributed to low light availability but may also be at least partly related to phytotoxic substances produced by *T. baccata* itself. The proposed measures address the need for deer management and gap creation. However, it is not yet clear how well the conditions created would facilitate *T. baccata* regeneration. Conspecific negative density dependence may still inhibit *T. baccata* regeneration to some degree.

The goal is therefore the re-establishment of natural regeneration of native tree species. This in itself would be an improvement in the structure and functions of the woodland and, in the longer term, may create conditions where *T. baccata* can regenerate among or under native broadleaved species. Continued monitoring is needed to record and assess the response of *T. baccata* to these measures.

Following removal work, *R. ponticum* is now relatively sparse within Reenadinna but ongoing maintenance is required. Other non-native invasive shrub species present include *C. vitalba*, *Cotoneaster* spp. and *L. apiculata*. The programme of invasive species control must be extended to include these species, with methods specific to their ecology being adopted.

Monitoring data are not available for Monks Wood but invasive non-native species are a pressure affecting this stand. These include non-native conifers, *F. sylvatica,* and the non-native shrubs *P. laurocerasus* and *H. calycinum*. Tracks, which are popular with walkers, run around and through the stand and so the site is subject to recreational pressure. The programme of invasive species control needs to be extended to this area to remove the invasive non-native shrubs. A gradual transformation of the modified H91J0* to uneven-aged native woodland is required (Cross & Collins 2017), following Close to Nature/Continuous Cover Forestry (CCF) principles (Sanchez 2017) where possible.

Habitat expansion

Devaney et al. (2014) recommended that, to conserve existing populations of *T. baccata*, management should focus on regeneration around their edges. At Reenadinna, however, the scope for H91J0* to colonise new areas is limited by the availability of suitable limestone pavement or limestone outcrop substrates. A small stand of non-native conifer species is located on limestone at the western end of Reenadinna. This can potentially be felled, temporarily fenced and managed for the development of thorny scrub, which is an early successional stage in the development of H91J0* (Watt 1926).

Outlook

The measures outlined above, all else being equal, and if fully implemented, are expected to shift the structure and functions of H91J0* at Reenadinna from Unfavourable – Bad to Favourable status. If an appropriate grazing regime is achieved and maintained and invasive non-native species are maintained at their current low levels, the future prospects of the habitat are expected to shift from Unfavourable – Inadequate to Favourable status. This would result in the overall conservation assessment of H91J0* being assessed as Favourable, which is critically important given that Reenadinna is by far the largest area of H91J0* in Ireland and the EU.

Garryland

Conservation status

The most recent Article 17 monitoring report (Daly et al. in press) assessed the overall conservation status of H91J0* at Garryland as Unfavourable – Bad and so the Conservation Objective for H91J0* within the Coole-Garryland Complex SAC is to restore the habitat to Favourable conservation status (NPWS 2021).

The negative pressures affecting the habitat were invasive non-native species and, to a lesser degree, Ash Dieback disease (Table 2). The structure and functions of H91J0* at Garryland were assessed in the most recent Article 17 monitoring report (Daly et al. in press) as Unfavourable – Bad, due to the regeneration and excessive cover of negative (i.e. non-native) species, inadequate cover of the native shrub layer, inadequate cover and height of the native dwarf shrub and field layers, and the absence of *T. baccata* saplings from the monitoring plots (Figure 2b).

The mortality of at least 84 *T. baccata* trees was recorded at Garryland (R. Stephens, unpublished data) due to the flooding of an adjacent Annex I priority habitat (H3180*

Figure 2a.- H91J0* at Reenadinna is heavily grazed. The field and shrub layers are lacking

Figure 2b.- H91J0* at Garryland with natural regeneration of *Ilex aquifolium*. Non-native *Fagus sylvatica* is abundant in this area

Turloughs). This was deemed to be a natural process and was therefore assessed as a neutral pressure (Daly et al. in press). Recurrence of flooding presents a threat to H91J0* but this impact is not considered preventable.

Conservation measures implemented to date

Within the Coole-Garryland Complex SAC, the removal of mature *F. sylvatica* has been trialled on a small scale. Following the removal of individual *F. sylvatica* trees and the

resultant increase in light levels, the foliage of juvenile *T. baccata* beneath was observed to undergo a "bleaching" effect, which was marked but temporary (E. Mooney, pers. comm.). Perrin & Mitchell (2013) recorded a similar response in an *ex situ* experiment. When *T. baccata* juveniles, grown under heavy shade for the first two growing seasons, were exposed to full light in the third growing season, a rapid bleaching effect was observed on the foliage. However, no mortality of *T. baccata* was observed as a result.

In terms of statutory conservation measures, this site is legally protected under Statutory Instrument No. 379/1983 – Nature Reserve (Coole-Garryland) Establishment Order, 1983. It is state-owned and managed by NPWS.

Necessary conservation measures

Adaptation to Ash Dieback disease (ADB)

ADB, caused by the invasive fungal pathogen *Hymenoscyphus fraxineus*, is now fully established and has been identified from all counties in Ireland. In the longterm, significant mortality of *F. excelsior* is expected. Eradication of the disease is not considered feasible (COFORD 2020) and policy has shifted to adaptation. *F. excelsior* is a typical component of H91J0* in the Irish context. In woodlands with a significant cover of *F. excelsior* it will be important to ensure sufficient levels of natural regeneration of native trees to replace lost *F. excelsior*. The necessary measures will depend on site-specific pressures, particularly grazing and invasive non-native species, which are discussed below.

Control of invasive non-native species

Invasive non-native tree species are a significant pressure affecting H91J0* at Garryland. The long-term management objective at Garryland must be the restoration of a native woodland canopy, on a timescale which is appropriate to site-specific conditions.

H91J0* at Garryland exhibits limited natural regeneration, mainly *I. aquifolium* and very little *T. baccata*, despite grazing being within acceptable limits. In areas of H91J0* where the *T. baccata* canopy is dense and *F. excelsior* and non-native trees are scattered, the focus must be on removal of non-native trees to create canopy gaps, thereby promoting natural regeneration and the development of the field and shrub layers. This can be done by ringbarking, where safe to do so.

In areas containing higher proportions of *F. excelsior* and non-native trees, the impacts of ADB on the canopy present a dilemma. The regeneration and excessive cover of invasive non-native species (>10%) and associated effects on woodland structure can preclude the possibility of reaching Favourable status (Daly et al. in press). Non-native species must be controlled to prevent them from replacing lost *F. excelsior*. However, the rate of canopy opening due to ADB is unpredictable. Sudden exposure to full light appears to have negative, if temporary, physiological effects on juvenile *T. baccata* (Perrin & Mitchell 2013). Excessive opening of the canopy may also affect the woodland microclimate and vegetation structure and should be avoided. A gradual transformation of H91J0* and the surrounding woodland to native woodland is needed (Cross & Collins 2017), following Close to Nature/CCF principles (Sanchez 2017) where possible. The most invasive species must be prioritised for removal, in this case *F. sylvatica.* Regeneration of invasive non-native trees can be removed by non-chemical means to favour native species.

Outlook

The measures outlined above, all else being equal, and if fully implemented, are expected to shift the structure and functions of H91J0* at Garryland from Unfavourable – Bad to Favourable status. However, change to the canopy would be gradual in areas with high cover of non-native species. The future prospects of H91J0* will remain Unfavourable – Inadequate as long as a significant presence of non-native species remains but, ultimately, Favourable status is considered achievable in the long-term.

Cahir Park

Conservation status

The most recent Article 17 monitoring report (Daly et al. in press) assessed the overall conservation status of H91J0* at Cahir Park as Unfavourable – Bad. The Conservation Objective for H91J0* within the Lower River Suir SAC is to restore the habitat to Favourable conservation status (NPWS 2017b).

The structure and functions of H91J0* were assessed by Daly et al. (in press) as Unfavourable – Bad, due primarily to the regeneration and excessive cover of negative (i.e. non-native) species and a lack of tree size class diversity and saplings of *T. baccata*. The negative pressures recorded as affecting H91J0* at Cahir Park were invasive non-native species and, to a lesser degree, ADB (Table 2).

Conservation measures implemented to date

Cahir Park was a project site of the LIFE Project "Restoring Priority Woodland Habitats in Ireland" (LIFE05 NAT/IRL/000182 RPWHI 2006-2009), undertaken by Coillte, the state-owned forestry company. The 9.0 ha project area incorporated H91J0* and adjacent woodland. Actions undertaken across the project area included felling non-native broadleaves to recycle *in situ*, removal of invasive non-native shrubs (dense patches of *P. laurocerasus*, occasional *R. ponticum,* and *H. calycinum* which dominated the field layer in places), removal of regeneration of non-native broadleaved trees and invasive shrubs, planting of 3500 *T. baccata* of local provenance, vegetation

management, repair of 900 m of boundary wall and fencing, fencing maintenance, and animal trespass control (Coillte 2010). As part of this project, an area of modified woodland on flatter terrain on top of the knoll, above the area of H91J0*, was felled. This area supports deeper soils and *T. baccata* was planted there (Cross & Lynn 2013).

Permanent quadrats were monitored from 2006-2009. Following the removal of dense *F. sylvatica* and *H. calycinum*, one quadrat exhibited the emergence of *C. monogyna* and *F. excelsior* seedlings, but also regeneration of the invasive non-natives *A. pseudoplatanus*, *H. calycinum* and *P. laurocerasus*. In the other quadrats monitored in 2009, the ground flora remained sparse as removal of *P. laurocerasus* had only been conducted in 2008 (Coillte 2010).

As part of the After-LIFE Conservation Plan, subsequent monitoring found that the planted *T. baccata* appeared to be growing very well at Cahir Park and vegetation management measures were ongoing (Fuller 2015). The planted *T. baccata* are now well established (J. Fuller, pers. comm.) and this measure was assessed as a positive pressure (Daly et al. in press, Table 2).

Efforts to control *P. laurocerasus* and *P. lusitanica* have been ongoing since the LIFE Project (J. Fuller, pers. comm.). Fuller (2015) found that occasional young *P. laurocerasus* was scattered throughout the site. Non-native tree species were still present and regenerating. In 2018, Daly et al. (in press) recorded *Acer campestre, Acer platanoides, A. pseudoplatanus, Castanea sativa, F. sylvatica, Larix* sp., *Quercus ilex, Tilia cordata* and *Ulmus procera,* with all except *Larix* sp. and *Q. ilex* regenerating. The level of natural regeneration of native trees was relatively high (Figure 2c).

In terms of statutory conservation measures, the designation process for the Lower River Suir SAC is underway. Cahir Park is a state-owned property. The site is managed primarily for biodiversity and is included in the Coillte BIOForest Project, through which management plans combining silviculture and ecology have been developed for biodiversity areas (J. Fuller, pers. comm.).

Necessary conservation measures

Control of invasive non-native species

The RPWHI LIFE Project and ongoing maintenance has involved substantial work to remove non-native invasive shrubs from the project area (Coillte 2010). Maintenance work to control regrowth must continue, with the aim of eradicating invasive non-native shrubs from H91J0* and the surrounding woodland to create a buffer to prevent reinvasion.

Although the LIFE Project involved some removal of non-native trees (Coillte 2010), they were a major component of the canopy and many were retained (Fuller 2015). The restoration of a native woodland canopy in H91J0* at Cahir Park would be challenging, given the modified nature of the existing habitat. The site is not considered suitable for a CCF thinning intervention due to its high level of recreational use and difficulty for machine access, as well as stability issues. The topography and over-mature canopy make the area of H91J0* at this site prone to windthrow if large trees were removed. Ringbarking would raise safety concerns due to the high level of recreational use throughout the site. The long-term management objective of Coillte at Cahir Park is therefore to maintain the canopy and gradually diversify its structure and species composition through tending, a low-intensity thinning intervention, where possible (J. Fuller, pers. comm.). H91J0* at Cahir Park exhibits relatively high levels of natural regeneration of native trees. These can be favoured by the removal of non-native tree regeneration by non-chemical means. *U. procera* regeneration is locally abundant and appears to be very invasive in this case. Areas where it occurs must be prioritised for removal of non-native regeneration.

Management of planted *T. baccata*

Vegetation management measures to favour planted *T. baccata* should continue as needed. As recommended by Fuller (2015), manual removal of competing vegetation is sufficient for this purpose and herbicide use should be minimised.

Adaptation to Ash Dieback disease (ADB)

As the cover of *F. excelsior* within H91J0* at Cahir Park is relatively low, the impacts of ADB are expected to be less severe. The measures above, which aim to manage non-native tree regeneration and promote native tree regeneration, can contribute to adaptation to ADB at this site.

Outlook

The measures outlined above, all else being equal, and if fully implemented, are expected to shift the structure and functions of H91J0* at Cahir Park from Unfavourable – Bad to Unfavourable – Inadequate status but the achievement of Favourable status will remain challenging. The lack of size class diversity of *T. baccata* trees can only be resolved with time. Change to the canopy will be slow due to the existing cover of non-native species and the long timeframe of the proposed intervention. The future prospects of the habitat will remain Unfavourable – Inadequate for many years due to the ongoing presence of non-native trees. In the interim, a more realistic objective for H91J0* at Cahir Park is to improve sufficiently to reach an overall conservation status of Unfavourable – Inadequate.

Figure 2c.- H91J0* on a steep slope at Cahir Park with high levels of natural regeneration

Figure 2d.- H91J0* at Curraghchase with a poorly-developed field layer under dense shade. *Fagus sylvatica* is visible downslope

Curraghchase

Conservation status

Two successive Article 17 monitoring reports (Cross & Lynn 2013, Daly et al. in press) have assessed the overall conservation status of H91J0* at Curraghchase as Unfavourable – Bad and so the overall Conservation Objective for H91J0* within the Curraghchase Woods SAC is to restore the habitat to Favourable conservation status (NPWS 2018).

The most recent report (Daly et al. in press) assessed the structure and functions of H91J0* at Curraghchase as being Unfavourable – Bad. The site failed the assessment primarily due to excessive cover and regeneration of negative (i.e. non-native) species and an inadequate proportion of *T. baccata* in the canopy (Figure 2d). The only negative pressure recorded as affecting H91J0* was invasive non-native species (Table 2).

Conservation measures implemented to date

Curraghchase was another project site of the RPWHI LIFE Project (2006-2009) undertaken by Coillte. The 6.9 ha project area incorporated H91J0* and adjacent woodland. Actions undertaken across the project area included felling of non-native broadleaves (mainly *F. sylvatica*) and scattered young conifers to recycle *in situ*, removal of invasive non-native shrubs (mainly dense *P. laurocerasus*), removal of regeneration of non-native broadleaves and invasive shrubs, planting of 4000 *T. baccata* of local provenance and vegetation management. Following consultation with statutory bodies, it was decided in 2008 to retain some non-native trees: an avenue lined by *Chamaecyparis lawsoniana* trees as a cultural feature and some *F. sylvatica* due to concern that lesser horseshoe bat (*Rhinolophus hipposideros*), another qualifying interest of the Curraghchase Woods SAC, may be roosting in the surrounding area. It was also suggested that birds perching on old *F. sylvatica* trees contributed to seed dispersal and natural regeneration of *T. baccata* (Coillte 2010).

Permanent quadrats were monitored from 2006 to 2009. *P. laurocerasus* was removed in 2007 but, due to the retention of non-native *C. lawsoniana* and *F. sylvatica*, no change in canopy cover occurred within the quadrats. Overall, no change was observed except the re-emergence of *P. laurocerasus.* No *T. baccata* had been planted within the quadrats (Coillte 2010).

Since the LIFE Project, Coillte has undertaken control of *P. laurocerasus* and tending of *T. baccata*, and this continues on an annual basis. In 2015, monitoring found that the planted *T. baccata* appeared to be growing very well at Curraghchase. These are now well established (J. Fuller, pers. comm.).

In 2015, regeneration of *F. sylvatica, A. pseudoplatanus* and *P. laurocerasus* was present (Fuller 2015). In 2018, Daly et al. (in press) also recorded *F. sylvatica* and *A. pseudoplatanus,* both of which were regenerating, as well as *P. laurocerasus* and *C. vitalba*. The continued control of *P. laurocerasus* regrowth and the planting of *T. baccata* in adjacent woodland were assessed as positive pressures on H91J0* (Table 2). The level of natural regeneration within H91J0* at Curraghchase is reasonably good, though the shrub layer comprises both native (including *T. baccata*) and non-native (mainly *F. sylvatica*) species (J. Roche, pers. obs. 2020).

In terms of statutory conservation measures, this SAC is legally protected under Statutory Instrument No. 209/2019 – European Union Habitats (Curraghchase Woods Special Area of Conservation 000174) Regulations 2019. Curraghchase Forest Park is a state-owned property. It is managed primarily for biodiversity and is included in the Coillte BIOForest Project, through which management plans combining silviculture and ecology have been developed for biodiversity areas (J. Fuller, pers. comm.).

Necessary conservation measures

Control of invasive non-native species

The RPWHI LIFE Project involved an intensive effort to remove a dense understorey of *P. laurocerasus* from the project area. The area has since been maintained as largely free of *P. laurocerasus* shrubs but there is an ongoing issue with its regeneration. Maintenance work must continue, with the aim of eradicating *P. laurocerasus* from H91J0* and from the surrounding woodland to create a buffer to prevent reinvasion. The highly invasive non-native climber *C. vitalba*, recorded by Daly et al. (in press), must be eradicated before it spreads further.

The long-term management objective at Curraghchase must be to restore a more native woodland canopy, on a timescale which is appropriate to site-specific conditions. Mature *F. sylvatica* remains a major component of the H91J0* canopy. Non-native tree species are to be phased out in the long term (Fuller 2015) but removal of non-native trees during the LIFE Project was constrained by the issues outlined by Coillte (2010) and is now further constrained by ADB. As monitoring by Daly et al. (in press) has shown, invasive non-native species and associated effects on woodland structure have prevented H91J0* at Curraghchase from reaching Favourable status and this pressure must continue to be addressed. However, excessive opening of the canopy should be avoided. The H91J0* area is not considered suitable for a CCF thinning intervention due to its level of recreational use, as well as stability issues due to the ridge topography and presence of over-mature *F. sylvatica*. Ringbarking would raise safety concerns due to the high level of recreational use

throughout the site. The long-term management objective of Coillte for H91J0* at Curraghchase is therefore to gradually remove non-natives from the canopy and diversify its structure and species composition through tending, a low-intensity thinning intervention, where possible (J. Fuller, pers. comm.). Regeneration of non-native trees can be removed by non-chemical means to favour native species and reduce shading of the field layer.

The above proposal is contingent on a detailed assessment of its potential impacts on *R. hipposideros* at this site. This assessment will clarify whether the proposed removal of non-native trees is appropriate with regard to the site integrity and conservation objectives of the SAC and, if so, how potential impacts on *R. hipposideros* may be avoided or mitigated and how the woodland habitat may be enhanced for bat conservation.

Management of planted *T. baccata*

Vegetation management measures to favour planted *T. baccata* should continue as needed. Manual removal of competing vegetation is sufficient for this purpose and herbicide use should be minimised.

Outlook

The measures outlined above, all else being equal, and if fully implemented, are expected to shift the structure and functions of H91J0* at Curraghchase from Unfavourable – Bad to Unfavourable – Inadequate status relatively quickly. However, change to the canopy will be slow due to the high cover of non-native trees in some areas and the gradual nature of the proposed intervention. The future prospects of the habitat will remain Unfavourable – Inadequate for many years. In the interim, a more realistic objective for H91J0* at Curraghchase is to improve sufficiently to reach an overall conservation status of Unfavourable – Inadequate, with Favourable status as the long-term objective.

Cornalack

Conservation status

Two successive Article 17 monitoring reports (Cross & Lynn 2013, Daly et al. in press) have assessed the overall conservation status of H91J0* at Cornalack as Favourable and so the overall Conservation Objective for H91J0* within the Lough Derg North-east Shore SAC is to maintain the habitat at Favourable conservation status (NPWS 2019b).

Invasive non-native species were the only pressure affecting H91J0* at Cornalack (Table 2). Daly et al. (in press) found that negative species regeneration was present within three of the four monitoring stops surveyed but the structure and functions of H91J0* at Cornalack were assessed as

Figure 2e.- H91J0* at Cornalack has relatively good levels of natural regeneration and non-native species are very scarce

Favourable overall. *A. pseudoplatanus* and *Populus* x *canescens* trees were present and were regenerating, with small numbers of seedlings present. *C. vitalba* and *Cotoneaster microphyllus* were also present. Given its low intensity and the relatively small proportion of the habitat affected, this impact was not considered significant in the assessment of future prospects (Daly et al. in press).

Conservation measures implemented to date

There is no evidence of grazing at Cornalack (Cross & Lynn 2013, Daly et al. in press). This is beneficial given the high susceptibility of *T. baccata* to browsing and bark stripping (Thomas & Polwart 2003). The site is unusual in that *T. baccata* regeneration is abundant within an adjacent *Juniperus communis* formation (H5130) (Cross & Lynn 2013). This natural succession to H91J0* contributed to the Favourable assessment of the future prospects of H91J0* at Cornalack (Daly et al. in press). There is no evidence of other active conservation measures having been implemented on site at Cornalack (Cross & Lynn 2013, Daly et al. in press).

In terms of statutory conservation measures, this site is legally protected under Statutory Instrument No. 74/2018 – European Union Habitats (Lough Derg, North-east Shore Special Area of Conservation 002241) Regulations 2018.

Necessary conservation measures

As Cornalack is privately owned, landowner engagement is needed in the implementation of conservation measures.

Control of invasive non-native species

To maintain the Favourable status of this site, invasive non-native species must be removed to prevent them from becoming a more significant pressure.

Grazing management

The current practice of not grazing the site needs to be maintained so that the process of natural succession to H91J0* continues. This dynamic interface is a very rare feature and must be conserved.

Outlook

These measures, all else being equal, and if implemented, will maintain the overall conservation status of H91J0* at Cornalack as Favourable.

As the only Irish H91J0* site which is currently in Favourable status, it is important to consider the underlying factors. The main pressures affecting H91J0* in Ireland are overgrazing and non-native invasive species. Cornlack appears to be in a relatively natural state (Figure 2e). It is not subject to grazing and currently contains only a small presence of non-native invasive species. The woodland edge is dynamic and H91J0* appears to be expanding. These factors contributed to the Favourable assessments of structure and functions and future prospects of H91J0*.

ADB was not recorded at Cornalack in 2018 (Daly et al. in press) but has since become more prevalent in Ireland. The cover of *F. excelsior* within H91J0* at Cornalack is relatively high (70-85%) so the potential impact of ADB is a concern. H91J0* at Cornalack exhibits relatively good levels of natural regeneration of a diversity of native tree species, increasing its resilience to ADB. The measures above, which aim to manage non-native tree regeneration and promote regeneration of native trees including *T. baccata*, can also contribute to adaptation to ADB.

*Potential sites for H91J0**

The present distribution of *T. baccata* in western Ireland represents the remnants of a previously more widespread population (Mitchell 1990b). Palaeoecological data provide useful insights into the past distribution and dynamics of *T. baccata* woods in Ireland and can help to inform restoration targets. *T. baccata* was formerly an important component of the vegetation of the Burren (Watts 1984). Pollen records indicate that *Taxus* woodland existed temporarily in the Burren, where *Ulmus* underwent a major decline *c.* 3200 BC and then recovered. *Taxus* pollen appeared after the *Ulmus* recovery, expanded rapidly, peaked *c.* 2600 BC, and declined. *Taxus* may be capable of exploiting a major perturbation in the forest, such as the widespread death of *Ulmus* due to disease. It may have expanded in response to the *Ulmus* decline, while the forest was unstable. Once established, grazing would be the main threat to its continuation. Notably, its decline coincides with the first major human occupancy of the area. Watts (1984) suggested that *Taxus* woodland may be the climax vegetation community of much of the Burren but is suppressed by grazing. In the present day, some areas of the Burren appear to be suitable for the development of H91J0*.

An area at Rockforest, Co. Clare was identified as having high levels of natural regeneration of *T. baccata* with potential for the development of H91J0* (E. Mooney, pers. comm.). It is located within the East Burren Complex SAC and the Burren National Park, which is state-owned and managed by NPWS. Clearance of scrub had previously taken place but *T. baccata* was retained. Baseline monitoring of the area was undertaken in March 2021 and browsing damage, probably caused by cattle and goats, was observed on the majority of *T. baccata*. A fenced exclosure of *c.* 0.2 ha was erected in May 2021. A Management Plan for Rockforest is in preparation. Regeneration of *T. baccata* within the exclosure will be monitored every five years to record its potential development towards H91J0* (P. Perrin, unpublished data). Once a closed canopy has formed, the fencing should be removed as long-term exclusion of

grazing can be deleterious to ground flora diversity (Newman et al. 2014b, c, Perrin et al. 2011).

The RPWHI LIFE Project (2006 to 2009), undertaken by Coillte, aimed to expand the area of H91J0* by means of natural regeneration and *T. baccata* planting where necessary. Cuttings were taken from native *T. baccata* trees and propagated. Juvenile *T. baccata* of local provenance were then planted into selected suitable sites. This was conducted at Attyslany, in the Burren, Co. Clare (12.0 ha), Castletaylor, Co. Galway (13.0 ha) and Clonbur, Co. Galway (across an area of 15.8 ha), as well as at Cahir Park (9.0 ha) and Curraghchase (5.9 ha). All of these sites are located within SACs and are owned by Coillte. The first three sites comprise relatively open habitat on limestone pavement, where *T. baccata* cuttings were planted in clusters throughout the project area. The latter two sites comprise high forest where the planting density of *T. baccata* was higher. The total area planted was 55.7 ha. Other measures undertaken to promote natural regeneration of native trees included felling of non-native trees, removal of non-native invasive shrubs, removal of regeneration of non-native invasive trees and shrubs, boundary wall repair/erection of fencing, fence maintenance and animal trespass control. Excluding the existing area of H91J0* at Cahir Park and Curraghchase, this represents 51.0 ha of potential new H91J0* in total (Coillte 2010). These sites are included in the Coillte BIOForest Project, through which management plans have been developed.

Permanent quadrats at the three new sites were monitored from 2006 to 2009. At Clonbur, *T. baccata* was planted within quadrats where a conifer plantation had previously been felled. Monitoring showed continued growth of existing plants and seedlings, emergence of *Betula pubescens* and *I. aquifolium*, and slightly increased cover of *R. fruticosus* agg. in response to felling. *T. baccata* was not planted within the monitoring quadrats at Castletaylor. At Attyslany, groups of *T. baccata* were planted in winter 2008/2009 within quadrats where a conifer plantation was felled in winter 2007/2008. Monitoring in 2009 showed little change (Coillte 2010). Subsequent monitoring found that planted *T. baccata* appeared to be growing very well at Attyslany. *T. baccata* was recorded at Clonbur and Castletaylor but appeared to be less abundant. However, dense scrub and a lack of markers to signify planting locations may have resulted in under-recording at the latter sites (Fuller 2015).

The growth of *T. baccata* is slow relative to most other tree species, even under optimal conditions and after eliminating potential competitors (Thomas & Polwart 2003) and the development of H91J0* is correspondingly slow. Ongoing maintenance and long-term monitoring are needed at the above sites with regard to the development of H91J0*.

Conclusions

H91J0* is one of Europe and Ireland's rarest woodland types. Though it is relatively well studied in Ireland, our understanding of its long-term dynamics remains underdeveloped. The development of H91J0* appears to require a convergence of factors including suitable limestone substrate and edaphic conditions, a seed source, low levels of seed predation and browsing, and the presence of nurse scrub (Thomas & Polwart 2003). The area with suitable conditions for the development of H91J0* in Ireland is therefore limited. The areas at Attyslany, Clonbur, Castletaylor and Rockforest have good potential, and must continue to be managed and monitored, but the development of H91J0* will be slow. The creation of H91J0* elsewhere is likely to be challenging. The Favourable Reference Area and Range are targets that can only be reached in the very long term.

It has been hypothesised that *T. baccata* woods are long-lived single generation stands, which move across the landscape by edge regeneration. Regeneration of *T. baccata* under the dense canopy is rare and appears to depend on the development of a shrubby sere in gaps formed by the death of old *T. baccata* trees but primarily around the woodland edge. Failure to regenerate will result in degeneration of the *T. baccata* woodland. If conditions remain suitable, scrub can reform and the cycle of *T. baccata* regeneration can begin again. Otherwise, succession will proceed on another trajectory, with the loss of *T. baccata* (Thomas & Polwart 2003, Watt 1926) and potentially the loss of woodland cover altogether.

To conserve existing H91J0* in Ireland, increased focus is needed on promoting the regeneration of native trees, particularly species of thorny scrub, within canopy gaps and woodland edges. Article 17 monitoring surveys of H91J0* in Ireland have not placed much emphasis on the woodland edge. In future surveys, opportunities for H91J0* habitat expansion around the edge of existing stands must be systematically identified. Where appropriate, management needs to promote dynamic interfaces between H91J0* and adjacent scrub and open habitats, rather than static boundaries.

There is potential to promote *T. baccata* regeneration within existing deciduous woodlands, such as the Killarney oakwoods, by reducing grazing pressure (Perrin et al. 2006). This would contribute to tree species diversity and may contribute to H91J0* development in the long term. However, if these woodlands are not on suitable limestone substrate, they are not expected to develop into H91J0*.

With the exception of Cornalack, H91J0* in Ireland has been strongly influenced by anthropogenic pressures. Release from these pressures, through the implementation of conservation measures, will enable a better understanding

of the characteristics of H91J0* under more natural conditions. However, studies from Britain suggest that mature *T. baccata* woods are characteristically species-poor and sparse in terms of the field and shrub layers and *T. baccata* regeneration (Rodwell 1991). If H91J0* continues to fail the structure and functions assessment in the long term, despite the implementation of measures to address pressures, assessment thresholds may need to be revised accordingly.

The assessment and management of H91J0* must continue to develop and adapt to the findings of monitoring and research, and to changing circumstances. The next round of Article 17 monitoring is due to be completed in 2025. The progression of ADB and the resultant rate of loss of *F. excelsior* will be influential. Close to Nature/CCF management is a developing field in Ireland and it will be important for ecologists and foresters to work closely to explore the potential of these approaches for conservation management of H91J0*, where appropriate.

Consistent, progressive and sustained long-term programmes of invasive species and deer management are needed to achieve the conservation objectives of H91J0* and other woodland types in Ireland. This requires staffing and funding to be committed on a long-term basis. Otherwise, as we have seen, progress is lost when staff and budget cutbacks are periodically made to these programmes, and the substantial time, effort and funding invested is effectively lost with it.

Ireland has a special responsibility for the conservation of this internationally rare, priority habitat. In terms of the restoration of Annex I woodland habitats in Ireland, H91J0* can be considered as "low-hanging fruit". The rollout of necessary conservation measures across the entire national resource of H91J0* is relatively achievable. The total area of the habitat in Ireland is only 83 ha and 99.7% of this is within the SAC network. Though a high proportion of the habitat is in Unfavourable – Bad status, all of this occurs on land owned and managed by the state. The majority of H91J0* in Ireland is located at one site, Reenadinna, which comprises *c.* 75.9% of the national resource. An improvement in its structure and functions will contribute significantly to improving the structure and functions of H91J0* at the national level. Indeed, the implementation of conservation measures at Reenadinna will be essential because the structure and functions of a habitat are assessed as Unfavourable – Bad at the national level if more than 25% of the area is unfavourable as regards its structure and functions (DG Environment 2017), making this a high priority site. Though the achievement of Favourable status of H91J0* is a long-term objective, it can be reached by fully implementing the evidence-based conservation measures proposed. This will also produce tangible improvements in the shorter term by improving the future prospects of the habitat and shifting the overall trend of conservation status from stable to improving.

To secure the long-term viability of H91J0* in Ireland, a coordinated and collaborative effort is needed across all relevant sites and among nature conservation and forestry stakeholders. This paper is intended to provide the scientific background information and initial technical guidance to facilitate that process.

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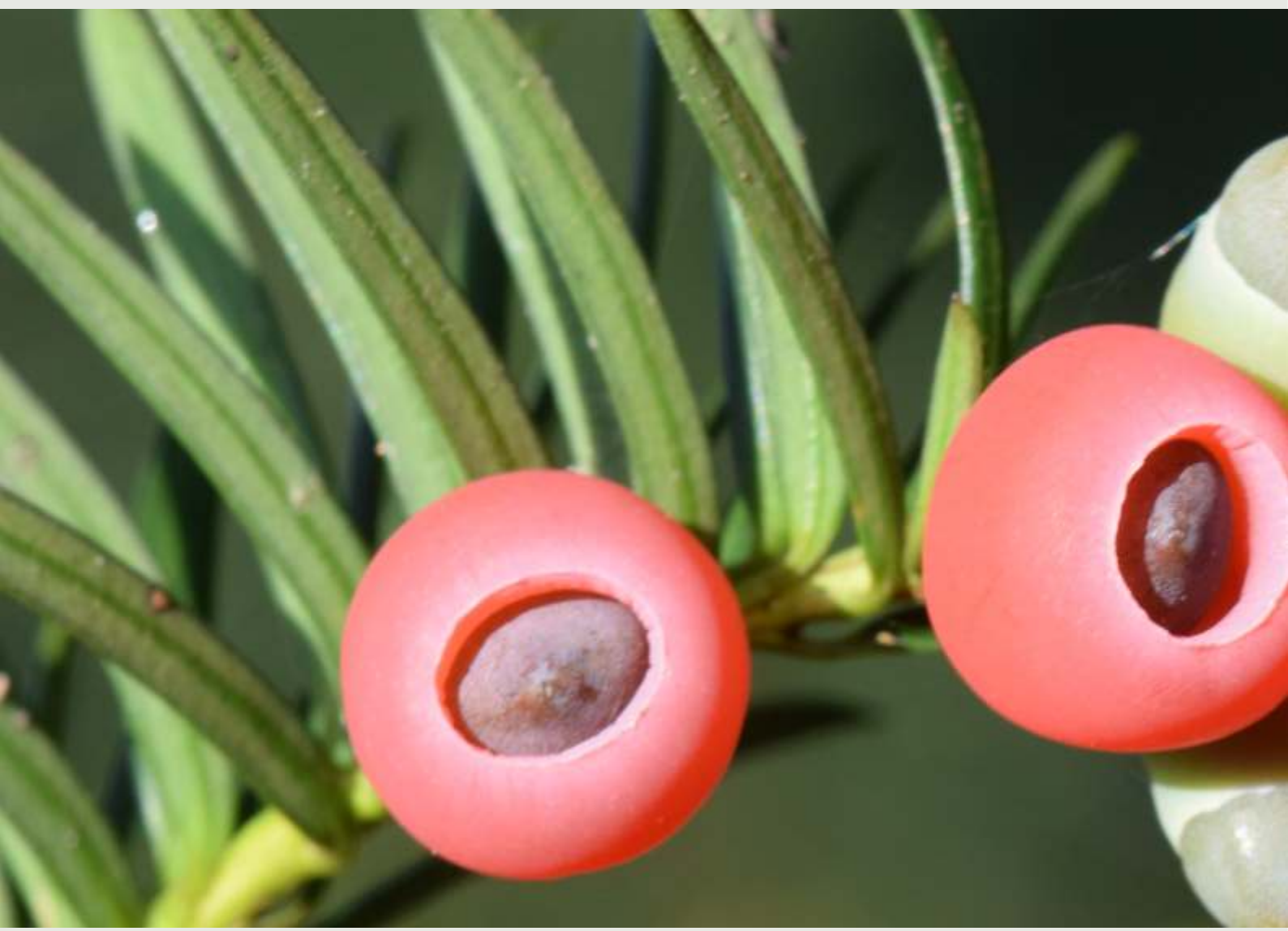

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