Appendix B

Review of the hosts of *Agrilus planipennis* listed in Great Britain legislation

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Background

Currently, Great Britain regulates *Agrilus planipennis*, emerald ash borer ("EAB") (Insecta, Coleoptera, Buprestidae), within the Implementing Regulation (EU) 2019/2072[1] ("the Phytosanitary Conditions Regulation") as retained and made operable in GB. EAB is a Quarantine Pest ("QP") in Annex 2, with associated special requirements which apply to the import of plants and wood of specified hosts in Annex 7. The EU has similar requirements, but the list of hosts to which the special requirements apply to is starting to diverge. This document examines the evidence for the hosts currently listed in GB and the EU and considers whether the current GB host lists should be updated, and if so, what changes are appropriate.

Summary of recommendations

Add *Chionanthus virginicus* to the GB regulation for Annex 7 hosts requiring special measures for EAB, for both plants and wood. Natural infestation of this host is seen in North America, and EAB is able to complete its development to adult on this plant, though it is a less suitable host than many North American *Fraxinus* species.

Remove *Juglans ailantifolia, J. mandshurica* and *Pterocarya rhoifolia* from the GB regulation for Annex 7 measures for EAB, for both plants and wood. Papers written over the last ten years or so regard these host records as unreliable, and recommend that, at a minimum, they require review. As EAB is an Annex 2 QP, action would be taken on findings of EAB associated with any plant, including these three species, irrespective of their inclusion or exclusion from the Annex 7 host list for special requirements.

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[1] Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019

Maintain *Ulmus davidiana*, but keep under review. While the historical literature for this as a host is regarded as unreliable, recent host testing suggests some *Ulmus* cultivars allow some larval development in freshly cut wood. This evidence would not be enough to newly list *U. davidiana* as a host. However, given it is already listed, it is proposed to maintain the EAB Annex 7 measures on *U. davidiana*, but to keep an active watch for any new information and review this listing in response.

Current hosts in plant health regulations

Hosts with Annex 7 (GB) or Annex VII requirements (EU)

Great Britain current list

- *Fraxinus* L.
- *Juglans ailantifolia* Carrière
- *Juglans mandshurica* Maximowicz
- *Ulmus davidiana* Planchon
- *Pterocarya rhoifolia* Siebold & Zuccarini

European Union current list

Recent deletions indicated in red.

- *Chionanthus virginicus* L.
- *Fraxinus* L.
- ~~*Juglans ailantifolia* Carr.~~
- ~~*Juglans mandshurica* Maxim~~
- ~~*Ulmus davidiana* Planc~~
- ~~*Pterocarya rhoifolia* Siebold & Zucc~~

Technical justification: summary of evidence for each host

The EU commission's reference for their changes is the EFSA survey card (latest version updated 2023), but that contains some other references within it. This document examines the evidence in the papers cited in EFSA's survey card, supplemented by a Web of Science all databases search using the key words "*Agrilus planipennis*" and each of the non-*Fraxinus* host genera included in both sets of plant health regulation. The results were filtered by manually selecting relevant papers based on the abstracts and locating full text where possible. The Japanese journal site JStage was also searched for "*Agrilus planipennis*" with relevant host genera, or even just *Agrilus* plus a host genus. Where no relevant scientific papers could be found, targeted internet searches for grey literature were carried out. Papers which deal only with adult maturation feeding on various plants were not included.

Chionanthus virginicus (recommend adding to GB Annex 7)

Chionathus virginicus (white fringetree) was added to the EU regulation in December 2021 (Commission Implementing Regulation (EU) 2021/2285[2]). From the literature searches, the first report of white fringetree as a host of EAB was by Cipollini (2015). Trees in three locations in Ohio showed typical buprestid D shaped exit holes, and upon removal of the bark, extensive larval galleries. Live larvae were extracted from some trees, and were morphologically consistent with EAB. Later, a dead adult male trapped near a pupal gallery was also consistent with EAB (including the genitalia) (Cipollini, 2015). These trees had been naturally infested, and all the evidence suggested that the host was suitable for complete development of EAB from egg to adult. Olson & Rieske (2019) confirmed *C. virginicus* as a host through lab experiments placing colony-reared eggs on cut branches of different hosts (i.e., no-choice experiments). Over the six weeks the experiment ran, EAB on the *C. virginicus* wood showed lower percentage survival, less phloem consumed and a smaller head capsule width in the surviving larvae, compared to the two *Fraxinus* species tested, but the larvae did grow and develop (Olson & Rieske, 2019). A number of other papers confirm various aspects of *C. virginicus* as a host of EAB in North America, including more reports of adult emergence from naturally infested trees: Cipollni & Rigsby (2015); Thiemann *et al.* (2016); Peterson & Cipollini (2017); Rutledge & Arango-Velez (2017); Peterson & Cipollini (2022).

In summary, it is recommended that *Chionanthus virginicus* is added as a host to the GB regulation for Annex 7 measures. Natural infestation of this host is seen in North America, and the beetle is able to complete its development to adult on this plant.

Fraxinus (recommend no changes)

Multiple species of *Fraxinus* (ash) are proven hosts of EAB. There is no evidence to suggest that any changes to this genus level host listing is required (or desirable) and GB and the EU remain aligned.

Juglans ailantifolia, J. mandshurica and *Pterocarya rhoifolia* (recommend removal from GB Annex 7)

All mention of these three host species appears ultimately to trace back to a single source (sometimes a second website, no longer available, is also referenced). Various papers mention these hosts in Japan as part of the background in the introduction and/or discussion, and all cite a checklist of Japanese Buprestidae[3] for this information. In general, checklists are invaluable sources of overall information

[2] Implementing regulation - 2021/2285 - EN - EUR-Lex
[3] Akiyama, K., and S. Ohmomo. 1997. A checklist of the Japanese Buprestidae. Gekkan-Mushi, Supplement 1. 67 pp. – document could not be located in the time available

and usually carefully researched. However, the sheer number of species included in such documents means that not every piece of data included can be carefully checked and traced back to an original, primary, source. Therefore, for crucial host records, it is best practice that additional verification is required for checklist data.

Taxonomic changes in *Agrilus planipennis* further complicate the story. As species are synonymised with *A. planipennis*, the host records are reassigned. See the introduction and first paragraph of the discussion in Anulewicz *et al.* (2008); or Orlova-Bienkowskaja & Volkovitsh (2018)'s section on Japanese records for a more comprehensive discussion around this point.

EPPO Global Database regards these three species as doubtful hosts, stating that the checklist reference requires verification. The Expert Working Group who wrote the 2013 EPPO Pest Risk Analysis had personal communications suggesting none of these species were verified hosts. The CABI datasheet lists two of these species as hosts, but provides no citation for the source for any of the records. Orlova-Bienkowskaja & Volkovitsh (2018) comments that there is no evidence as to whether these historical non-*Fraxinus* hosts were based on larval rearing records, or merely that adults were collected from these species.

Broadening the search to grey literature and other sources on the internet, three different search engines were tried: Google, Startpage and DuckDuckGo. For each search engine, specialist search operators were used[4] to restrict the searches to webpages hosted in Japan, along with "*Agrilus planipennis*" and each host genus in question. It was assumed that any semi-reliable information would contain pest and host name in Latin font, even if the rest of the text was in Japanese and therefore searches using Japanese names for either pest or host were not attempted. Results were either irrelevant, or appeared to be summaries, copies and excerpts of the EU plant health regulations. It should be noted not every last link was followed, and automatic translation was used for the Japanese text.

In summary, it is recommended that the three host species *Juglans ailantifolia, J. mandshurica* and *Pterocarya rhoifolia* are removed from the GB regulation for Annex 7 measures. The evidence for these as hosts appears to all trace back to a single source, and several authors recommend that the data from this source requires review. As an Annex 2 QP, action would be taken on any findings of EAB on any host, including these three species, irrespective of the Annex 7 host list for special requirements.

[4] Example of search logic: "agrilus planipennis" pterocarya site:jp

Ulmus davidiana (recommend retention in GB Annex 7 but keep under review)

Most of the discussion on lack of reliable data on EAB host association for the three previous species (*J. ailantifolia, J. mandshurica* and *Pterocarya rhoifolia*) also applies to *U. davidiana*. However, this tree is discussed separately due to a 2022 paper reporting results from field experiments by Miller & McMahan.

Formal host testing of *U. davidiana* and other elm species and commercial cultivars was carried out by Miller & McMahan (2022). Only the larval studies on elm are summarised here, though this formed only one part of the study. Cut branches of elms were attached to branches of EAB-infested *F. pensylvanica* trees in the USA, i.e., allowing natural infestation via adult host selection and egg laying. In the first year of the study, "larvae did not establish or construct any galleries when feeding on the Asian elms *U. szechuanica, U. macrocarpa,* and *U. davidiana*" (Miller & McMahan, 2022). However, it must be noted that only 1/24 *F. americana* control branches were infested, suggesting that conditions were not ideal for the beetles to use any experimental cut branches: cut *Fraxinus* should have been attractive to EAB and infestation rates would have been expected to be higher.

The second year of Miller & McMahan's (2022) study used branches of four commercial elm cultivars: 'Accolade', 'Triumph', 'Danada Charm' and 'Commendation'. See box below for an attempt at providing details of which parent species were used to breed these cultivars. Larvae established on all four cultivars, but consumed less of the available phloem than larvae in the ash controls (less than 1% on the elms, compared to 2% on the ash control). Further details are not provided in the paper. While larval feeding was less on *Ulmus*, lab experiments on the proven host *C. virginicus* (discussed earlier in this document) also demonstrated lower amounts of phloem consumed over the course of similar cut-branch, time-limited bioassays (Olson & Rieske, 2019), and *C. virginica* does allow development to adult. Therefore, a judgement cannot be made on *Ulmus* suitability based purely on the quantity of phloem consumed in a time-limited experiment. Another factor to consider is that recently cut wood is more attractive to EAB than growing plants, and so research using fresh cut sections of wood of any species will over-estimate the suitability of living trees as a host.

Ulmus cultivars tested by Miller & McMahan (2022)

Only the commercial cultivar names are included in the paper. As far as can be determined from internet searches, the species used to breed the cultivars mentioned are as follows, though sources do vary slightly in the exact details given:

'Accolade' is from *U. japonica* and *U. wilsoniana*

'Triumph' is from 'Vanguard' (*U. pumila* x *U. japonica*) and 'Accolade'

‘Danada Charm’ was from open pollination of *U. davidiana* var. *japonica* and ‘Accolade’

‘Commendation’ is from *U. davidiana* var. *japonica* and a hybrid elm (*U. pumila* × *U. minor*)

https://landscapeplants.oregonstate.edu/plants/ulmus-accolade
https://landscapeplants.oregonstate.edu/node/2117
https://plantsnouveau.com/plants/trees/ulmus-danada-charm
https://plantsnouveau.com/solutions/streets-parkways/ulmus-commendation

Miller & McMahan’s paper does suggest that adult EAB choose to oviposit on cut branches of *Ulmus* spp., and some larval development does take place. The authors come to the conclusion (in the discussion) that “Asian and hybrids of Asian and European *Ulmus* taxa do not appear to be suitable hosts for EAB larvae” but based on the results reported in the paper it is unclear what data is behind this statement.

In summary, historical information suggests that the host records of *U. davidiana* are as unreliable as those of the two *Juglans* species and *P. rhoifolia*. One recently published paper does suggest limited larval feeding on *Ulmus* cultivars including those with *U. davidiana* in their parentage, but the paper is lacking in details.

The research by Miller & McMahan would not be sufficient evidence to justify new regulation for any species of *Ulmus*. However, given that *U. davidiana* is already in the GB plant health regulation, the new evidence was considered sufficient to maintain the Annex 7 listing for special measures for now, on a precautionary basis. As more evidence becomes available, the host listing of *U. davidiana* for EAB can be revisited.

Other plants not in legislation

Following the establishment of EAB in North America, a great deal of research has been carried out on the potential host range, both in the lab and in field experiments. Papers which cover larval development in hosts not mentioned so far are summarised here. None of the trees covered below have been shown to be both chosen by EAB for oviposition in the field, and allow full development from egg to adult. However, some do seem to have demonstrated their suitability for at least some larval development, at least on cut branches. It is recommended that a watching brief should be kept on those plants in particular to monitor for developments, especially reports of natural field infestations. Table 1 (next page) summarises key points. More detailed text on each host follows, summarising the key points from each paper.

Table 1. Summary of other plants tested as potential EAB hosts by various authors. Experiments were carried out under a range of protocols and results are not directly comparable. For further details and sources, see text summaries of each paper that follows this table. For full details, always check the original papers. Plants of most concern are shaded in green.

Tree species tested	Experimental set up		Type of wood tested	Larval development	Summary, recommendation
Carya ovata	Laboratory	No choice	Cut branches	No evidence of galleries	No evidence this species allows development
	Field	Choice	Cut branches	Eggs laid, no galleries	
Celtis occidentalis	Laboratory	No choice	Cut branches	Larvae died in first instar	No evidence this species allows development
	Field	Choice	Cut branches	Eggs laid, no galleries	
Chionanthus retusus	Field	Choice	Mature growing trees	No evidence of wild infestation	No evidence this species allows development or is chosen as a host
	Laboratory	No choice	Cut branches	Larvae died in first instar	
***Forestiera acuminata, Ligustrum amurense, L. lucidum, L. sinense* (results reported together as "privet")**	Laboratory	No choice	Cut branches	Some larvae reached third instar at end of experiment	Monitor any further research into which of these species might be suitable, and if any allow development to adult
Juglans nigra	Laboratory	No choice	Cut branches	Larvae died in first instar	No evidence this species allows development
	Field	Choice	Cut branches	Larvae died in first instar	
Olea europaea* subsp. *europaea	**Laboratory**	**No choice**	**Cut branches**	**Adults emerged**	**No evidence of adults choosing to lay eggs on this host or natural infestations. Monitor situation carefully for new developments**
	Laboratory	**No choice**	**Young growing trees**	**Fourth instar larvae**	
Osmanthus americanus	Field	Choice	Mature growing trees	No evidence of wild infestation	Monitor any further research into whether this species allows development to adult
	Laboratory	No choice	Cut branches	Some larvae reached second instar at end of experiment	
Syringa reticulata	Laboratory	No choice	Cut branches	No evidence of galleries	No evidence this species allows development
	Field	Choice	Young growing trees	Larvae died in first instar	
Ulmus americana	Laboratory	No choice	Cut branches	Larvae died in first instar	No evidence this species allows development
	Field	Choice	Cut branches	Eggs laid, no galleries	

Cipollini *et al.* (2017) carried out lab experiments on ***Olea europaea* subsp. *europaea* (olive)** as a host of EAB larvae. Sections of wood from a single tree were used for no-choice bioassays using eggs from captive colonies. During the experiment, selected logs had their bark removed at regular intervals to monitor larval development, and the final intact logs were monitored longer term for adult emergence. A limited number of adults emerged from the logs remaining intact at the end of the experiment (Cipollini *et al.,* 2017). Peterson & Cipollini (2020) developed this work with further lab experiments on olives from multiple trees (and two different cultivars) using culture-sourced eggs, i.e. no-choice experiments. Cut branches and live trees (girdled, previously damaged and healthy) were used. Larval survival was lower in olives compared to ash in cut branches, and data suggest that the two olive cultivars tested seemed to be vary in suitability for EAB. In growing trees, galleries were established in the olives, but no live larvae were found when the trees were debarked at the end of the experiment, not even in the girdled trees. The authors note that the young trees with relatively narrow stems used in the experiments may have been a confounding factor, and that older trees may be more susceptible to EAB (Peterson & Cipollini, 2020). Peterson & Cipollini (2020) (citing Cipollini & Peterson (2018)) note in their discussion that in a previous experiment, a fourth instar larva was recovered from a healthy growing olive tree so some development in growing olives would seem to be possible. No reports could be located of EAB adults choosing to lay eggs on olives, or of any natural infestations of olives in the wider environment.

Following confirmation of *C. virginicus* as a host allowing complete development, the Asian ***Chionanthus retusus* (Chinese fringetree)** and the related North American species ***Osmanthus americanus* (devilwood)** were tested for their suitability as EAB hosts by Cipollni & Rigsby (2015). Trees of each species planted in two arboreta in North America were surveyed for signs of attack. Neither of the two species tested showed any evidence of EAB infestation, with EAB found only in trees of the known host *C. virginicus*. A no-choice laboratory experiment by Cipollni & Rigsby (2015) used fresh cut logs in laboratory bioassays from the two species tested and the known hosts *C. virginicus* and *F. pensylvanica.* Eggs sourced from captive colonies were attached to the logs, and subsequent hatching and larval feeding was assessed for around 40 days. The newly hatched larvae entered the wood of all the species tested. Three larva in the *O. americanus* logs was able to create galleries over 10 cm long, with two of these larvae surviving to the end of the experiment and reaching second instar (compared to the larvae in the proven hosts, which mostly developed to fourth instars over the same time period) (Cipollni & Rigsby, 2015). However, 92% of the *O. americanus* larvae failed to survive to the end of the bioassay. Larvae in the *C. retusus* logs were only able to create galleries a maximum of 2.5 cm before all died (Cipollni & Rigsby, 2015) and therefore this species seems to have very little host potential.

Considering ***Ulmus americana* (American elm)**, Anulewicz *et al.* (2008) carried out destructive sampling on nine elm trees growing within 5 m of severely attacked *Fraxinus pensylvanica*. Four trees had all their bark removed, and five had 50-80% of the bark removed. “There was no evidence that any *A. planipennis* ever fed or attempted to feed on the elms despite the proximity of the heavily infested ash trees” (Anulewicz *et al.*, 2008). Other host testing of *U. americana* logs did not show any larvae developing past the first instar (Anulewicz *et al.,* 2006; 2008).

Anulewicz *et al.* (2006) have tested a variety of tree species in no-choice laboratory experiments, using freshly cut logs of various North American trees: various ash species along with ***Carya ovata* (shagbark hickory), *Celtis occidentalis* (hackberry), *Forestiera acuminata* (swamp privet), *Juglans nigra* (black walnut), *Ligustrum amurense, L. lucidum* (glossy privet), *L. sinense* (Chinese privet), *Syringa reticulata* (Japanese tree lilac)** and ***Ulmus americana* (American elm)**. Of the non-ash hosts, only those classed as “privet” (the authors used this term to lump together the records from *F. acuminata* as well as the *Ligustrum* species) showed any signs of galleries. Some “privet” larvae had reached the third instar, but it was noted that the assays used cut branches which have a limited lifespan. Some attempts at feeding by first instars were made on elm, walnut and hackberry, but these were all unsuccessful and the larvae all died (Anulewicz *et al.*, 2006). Later work by Anulewicz *et al.* (2008) built on the no-choice experiments by testing hosts in the field, using cut logs of plants to be tested. Freshly cut logs from green ash, white ash, American elm, black walnut, hickory and hackberry were mounted individually on posts and, in a second experiment, attached to the trunks of large infested ash trees. A limited number of eggs were laid in the logs of all non-ash species tested, but fully developed galleries were only seen on the ash logs. Some first instar larval feeding attempts were made on the *J. nigra* logs, but the galleries were all short and the larvae died in the first instar (Anulewicz *et al.*, 2008). Additional studies were done on by Anulewicz *et al.* (2008) on a more limited range of young growing trees with the opportunity for natural infestation. A total of three short galleries with dead first instar larvae were detected on *S. reticulata* trees (2/10 trees attacked), over two years of testing.

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This review has been undertaken taking into account the environmental principles laid out in the Environment Act 2021. Of particular relevance are:

- The prevention principle, which means that any policy on action taken, or not taken should aim to prevent environmental harm.
- The precautionary principle, which assists the decision-making process where there is a lack of scientific certainty.