出國報告（出國類別：其他-出席國際研討會議）

參與 2024 年國際有害生物風險研究群組會議「害蟲風險評估：迎接新技術，瞭解植物有害生物在全球快速變化中的社會經濟影響」

服務機關：農業部動植物防疫檢疫署

姓名職稱：植物檢疫組 寧方俞技正、基隆分署 呂柏寬技士

派赴國家：西班牙

出國期間：**113** 年 **9** 月 **15** 至 **9** 月 **22** 日

報告日期：**113** 年 **12** 月 **13** 日

提要表

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<tr><td>相關專案：</td><td>無</td></tr>
<tr><td>計畫名稱：</td><td>113 年科發基金人才培育與研發成果推廣計畫-「2024 年國際有害生物風險研究群組會議(International Pest Risk Research Group, IPRRG)」（計畫編號：NSTC 113-3111-Y-061-001）</td></tr>
<tr><td>報告名稱：</td><td>參與 2024 年國際有害生物風險研究群組會議「害蟲風險評估：迎接新技術，瞭解植物有害生物在全球快速變化中的社會經濟影響」</td></tr>
<tr><td>計畫主辦機關：</td><td>農業部動植物防疫檢疫署</td></tr>
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<tr><th>姓名</th><th>服務機關</th><th>服務單位</th><th>職稱</th><th>官職等</th><th>E-MAIL 信箱</th></tr>
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<tr><td>呂柏寬</td><td>農業部動植物防疫檢疫署</td><td>基隆分署花蓮檢疫站</td><td>技士</td><td>七職等</td><td>klpkl@klaphia.gov.tw</td></tr>
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<tr><td>前往地區：</td><td>西班牙</td></tr>
<tr><td>參訪機關：</td><td>西班牙國家研究院及馬拉加大學</td></tr>
<tr><td>出國類別：</td><td>其他：出席國際研討會議</td></tr>
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<tr><td>關鍵詞：</td><td>國際有害生物風險評估研究群（IPRRG）、有害生物風險分析（PRA）、前瞻性掃描（Horizon Scanning）、地球觀測（Earth Observation）</td></tr>
<tr><td>報告書頁數：</td><td>31 頁（不含附件）</td></tr>
<tr><td>報告內容摘要：</td><td>第 18 屆國際有害生物風險評估研究群年度會議 （2024 Annual Meeting of the International Pest Risk Research Group, IPRRG）於 113 年 9 月 17 日至 20 日由西班牙國家研究委員會（Spanish National Research Council, CSIC)亞熱帶與地中海園藝研究所（The Institute of Subtropical and Mediterranean Horticulture, IHSM)及馬拉加大學（University of Malaga, UMA) 共同舉辦。防檢署由植物檢疫組寧技正方俞與基隆分署花蓮檢疫站呂技士柏寬（風險分析小組成員）赴西班牙馬拉加參加，並配合會議主題以「氣候因子對檢疫有害生物潛在分布風險評估之方法學比較：以臺灣現行作業方式與 MaxEnt 模型預測方式為例」為題進行英語口頭簡報，探討以最大熵值法（MaxEnt）之機器學習技術建立物種分布模型（Species Distribution Model, SDM）與我國現行定性分析法進行分析結果與效益之比較，會議期間另與昆士蘭大學 Dr. Kriticos、瓦赫寧恩大學 Prof. Werf、英國環境、食品暨鄉村事務部（DEFRA）研究人員 Allen 及愛爾蘭農業、食品和海洋部（DAFM）農業督導員 McGeea 等專家學者交流 GBIF 資料與生態棲位模型應用之經驗。英國、愛爾蘭、加拿大與 CABI 代表分享前瞻性掃描評估（Horizon Scanning）的作法及風險登記的概念，並運用自組織映射圖網路分析方法進行風險排序，可較一般風險分析提早進行風險管制作為。德國、荷蘭及</td></tr>
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	歐洲食品安全局代表則分享有害生物發生初期的調查策略，有害生物取樣調查工具與相關系統開發。CABI 及 Assimila 團隊介紹了地球觀測技術之研究趨勢與進展，並以小型工作坊的方式邀集與會人員腦力激盪地球觀測（Earth Observation）技術於有害生物風險分析作業的可能應用方式與情境。IPRRG 會議於有害生物入侵風險模型建構和風險圖譜研究扮演領航角色，並與各國政府植物保護組織關係密切，建議未來持續投入出國經費派員參與，持續汲取有害生物風險評估、監測與管理措施之新興技術工具與經驗，提供未來防檢疫綜合管理措施與政策之參考。
電子全文檔：	
附件檔：	
限閱與否：	否

摘要

第 18 屆國際有害生物風險評估研究群年度會議（2024 Annual Meeting of the International Pest Risk Research Group, IPRRG）於 113 年 9 月 17 日至 20 日由西班牙國家研究委員會（Spanish National Research Council, CSIC)亞熱帶與地中海園藝研究所（The Institute of Subtropical and Mediterranean Horticulture, IHSM)及馬拉加大學（University of Malaga, UMA) 共同舉辦。防檢署由植物檢疫組寧技正方俞與基隆分署花蓮檢疫站呂技士柏寬（風險分析小組成員）赴西班牙馬拉加參加，並配合會議主題以「氣候因子對檢疫有害生物潛在分布風險評估之方法學比較：以臺灣現行作業方式與 MaxEnt 模型預測方式為例」為題進行英語口頭簡報，探討以最大熵值法（MaxEnt）之機器學習技術建立物種分布模型（Species Distribution Model, SDM）與我國現行定性分析法進行分析結果與效益之比較，會議期間另與昆士蘭大學 Dr. Kriticos、瓦赫寧恩大學 Prof. Werf、英國環境、食品暨鄉村事務部（DEFRA）研究人員 Allen 及愛爾蘭農業、食品和海洋部（DAFM）農業督導員 McGeea 等專家學者交流 GBIF 資料與生態棲位模型應用之經驗。英國、愛爾蘭、加拿大與 CABI 代表分享前瞻性掃描評估的作法及風險登記的概念，並運用自組織映射圖網路分析方法進行風險排序，可較一般風險分析提早進行風險管制作為。德國、荷蘭及歐洲食品安全局代表則分享有害生物發生初期的調查策略，有害生物取樣調查工具與相關系統開發。CABI 及 Assimila 團隊介紹了地球觀測技術之研究趨勢與進展，並以小型工作坊的方式邀集與會人員腦力激盪地球觀測技術於有害生物風險分析作業的可能應用方式與情境。IPRRG 會議於有害生物入侵風險模型建構和風險圖譜研究扮演領航角色，並與各國政府植物保護組織關係密切，建議未來持續投入出國經費派員參與，持續汲取有害生物風險評估、監測與管理措施之新興技術工具與經驗，提供未來防檢疫綜合管理措施與政策之參考。

目次

一、前言

國際有害生物風險研究群組（International Pest Risk Research Group, IPRRG）於 2007 年首次成立，當時名為國際有害生物風險繪圖工作小組（International Pest Risk Mapping Workgroup），是一個由科學研究人員和有害生物風險從業人員組成的專門小組，共同目標為：「透過嚴謹且創新的研究開發更有效率的害蟲風險建模與風險圖譜」，該研究群透過定期舉開國際性會議，發表、討論和測試風險研究相關的各種新技術及工具，引領風險模型建構與圖譜研究之發展與趨勢。

歷年 IPRRG 主辦單位多為會員國之國家植物保護機構、研究單位及相關學校系所，會員多為前揭機構之農業部門、植物保護部門或研究技術人員，例如美國農業部（USDA）、澳大利亞聯邦科學及產業研究組織（CSIRO）、歐洲食品安全局（EFSA）及地中海歐洲植物保護組織（EPPO）等。2018 年曾於臺灣召開 IPRRG 第 12 屆年會，討論主題聚焦於亞洲的新貿易伙伴關係和基礎設施迅速擴張將對全球農產品貿易產生巨大的影響，探討中國一帶一路政策可能因重建及連接中亞、歐洲與其他地區貿易路線而帶來全新且不同的入侵風險。2019 年本署亦曾派員前往波蘭參與第 13 屆年會，發表有關我國因應秋行軍蟲（*Spodoptera frugiperda*）入侵之風險管理措施與經驗。本屆年會由西班牙國家研究委員會（Spanish National Research Council, CSIC）亞熱帶與地中海園藝研究所（The Institute of Subtropical and Mediterranean Horticulture, IHSM）及馬拉加大學（University of Malaga, UMA）共同舉辦，由防檢署植物檢疫組寧技正方俞及基隆分署花蓮檢疫站呂技士柏寬與會（圖一），藉由本次有害生物研究群年度會議，了解世界各國對於有害生物風險研究的投入與進展，從中學習風險分析的新技術工具，並汲取各國如何應用新興工具於防檢疫管理之經驗，有助於我國植物防檢疫風險分析研究方向之調整。

英國、愛爾蘭、加拿大與國際應用生物科學中心（CABI）與會人員分享了執行前瞻性掃描的作法，並提到了風險登記的概念，及如何應用自組織映射圖網路分析方法進行風險排序，希望以前瞻性評估找到各國尚未入侵且具有高風險之有

害生物，而能提早因應準備。荷蘭、德國及歐洲食品安全局與會人員則分享有害生物發生初期的調查策略，有害生物取樣調查工具與相關系統開發，並說明有害生物發生預測模型應隨氣候變遷及風險因子變化滾動式調整以符合實務需求。CABI 及 Assimila 團隊介紹了地球觀測技術的應用案例，藉由該年會拋磚引玉，邀請與會研究人員應用該技術投入有害生物之相關研究，並分享如何利用地球觀測技術資料進行有害生物防治時機之建模。

我國非國際植物保護公約（International Plant Protect Convention, IPPC）會員，自 91 年正式加入世界貿易組織（World Trade Organization, WTO）後積極參與國際植物有害生物風險分析與風險管理相關研討會、研習營及雙邊交流，先後派員赴美國及澳大利亞研習有害生物及農產品風險評估之作業方式、風險管理措施之決策過程與風險溝通機制，並制定植物風險評估作業手冊，因應植物產品（貨品）首次輸入、國際疫情及新興有害生物於邊境攔截等因素啟動風險分析，針對特定國家、植物種類、植物部位及有害生物，委由相關領域專家或防檢署風險分析小組進行深入分析。

鑒於有害生物風險分析、預警監測、傳播途徑預測與風險管理已成為各國農產品輸入評估之重要流程，相關國際重大有害生物疫情資料偵蒐整合、有害生物鑑定技術開發、有害生物分佈模型圖譜（Mapping）建構、不確定性分析及氣候變遷影響等知識及技術應用日新月異，我國亟待引入新風險評估工具，以瞭解重大有害生物發生時可能造成之經濟損害，強化我國邊境有害生物風險管理措施，以提升管理效能與國際接軌。藉由參加 IPRRG 年度會議可了解各國在有害生物風險評估上的進展與推進情形，並分享我國於風險分析方法上的突破，透過這些研究討論，促進研究、產業和政策領域之間能有更強有力的合作，互相分享創新策略和最佳實踐應用作為，為永續發展奠定基礎，確保各地區在面對全球變化時，能採取積極主動的生物風險管理方法。

二、行程及紀要

日期	地點	行程紀要
9 月 15 日	臺灣桃園-香港	搭乘長榮航空 BR857 前往香港國際機場
9 月 16 日	香港-德國法蘭克福-西班牙馬拉加	搭乘漢莎航空 LH797 前往法蘭克福機場轉機 LH1148 抵達西班牙馬拉加
9 月 17 日	馬拉加拉馬約拉實驗站	2024 年第 18 屆 IPRRG 會議於地中海與亞熱帶園藝研究所“La Mayora”工作站召開，計有歐洲食品安全局（EFSA）、國際應用生物科學中心（CABI）、西班牙國家研究委員會、地中海植物保護組織（EPPO）等機構，英國、荷蘭、加拿大、西班牙、德國及澳大利亞等國與會。 1. 英國環境、食品暨鄉村事務部介紹該國使用進行前瞻性評估的作法 2. 荷蘭瓦赫寧恩大學介紹以歷史紀錄建立生成式模型預測有害生物可能的立足地點。 3. CABI 分享自組織映射圖網路分析法（SOM）於害蟲風險評估的實用性。 4. 加拿大食品檢驗局以多層前瞻性掃描建立木材蛀蟲風險優先名單。 5. EPPO 修訂管制害蟲資訊並介紹資料庫平臺之使用。
9 月 18 日	馬拉加拉馬約拉實驗站	1. 防檢署發表以 MaxEnt 模型分析導入定性風險分析案例比較。 2. 西班牙高等科學研究委員會評估果園的植食性蟎類多樣性及驗證 DNA 條碼技術檢測有效性。 3. EFSA 介紹害蟲調查工具優化系統。 4. 德國聯邦食品暨農業部分享油菜菌核病田間流行病學風險預測模型之優化。 5. CABI 分享如何辨別國內農作物最具破壞性害蟲的兩個研究案例。 6. 愛爾蘭農業、食品和海洋部介紹國

		家害蟲監測計畫及植物有害生物風險登記。 7. Assimila 介紹地球觀測技術之應用。
9 月 19 日	馬拉加拉馬約拉實驗站	參訪拉馬約拉實驗站和亞熱帶水果作物的種源資源庫
9 月 20 日	馬拉加拉馬約拉實驗站	1. CABI 利用番茄潛旋蛾族群動態監測優化 IPM 策略。 2. 荷蘭瓦赫寧恩大學比較害蟲爆發時的向內及向外調查策略。 3. 英國氣象局哈德利中心評估氣候變遷下的甘藍甲蟲 IPM 策略。 4. CABI 討論估算作物產量損失因素的方法。 5. 歐洲聯盟執行委員會介紹歐洲評估檢疫害蟲的過程。 6. CABI 利用地球觀測數據來建置咖啡果小蠹的預測模型與防治策略。
9 月 21 日	馬拉加-德國	搭乘漢莎航空 LH1149 前往法蘭克福機場轉機 LH796 前往香港
9 月 22 日	香港-臺灣桃園	抵達香港後搭乘長榮航空 BR856 前往桃園國際機場

三、會議概況

近年來，氣候變遷、全球化貿易等因素導致植物有害生物的傳播速度加快，對全球農業生產造成嚴重威脅。本次會議聚焦於「害蟲風險評估：迎接新技術，瞭解植物有害生物在全球快速變化中的社會經濟影響」，旨在透過學術界、產業界和政府部門的共同努力，探討如何利用新興技術，更準確地評估有害生物風險，並制定有效的管理策略，以保障全球糧食安全。本次與會講者來自英國、荷蘭、西班牙、義大利、德國、愛爾蘭、瑞典、加拿大及臺灣等 9 個國家之政府機關、跨政府組織、非營利組織、大專院校、企業研究機構及民間公司等，講者之研究背景包含資料科學、電腦演算法、應用生態模型、生物統計學、地理資訊學（GIS）、生物地理學、入侵生態學、植物病原菌流行病學、昆蟲學、植物保護、植物有害生物風險評估、食品及動植物安全、生物經濟及氣候學等，共計 34 位與會者（圖二），屬於主題專一之小型研討會。

本會議內容含括有害生物風險模型的創新、植物有害生物對社會經濟的影響、因應氣候變遷有害生物風險評估之調整、政策與決策支援工具、利害關係人參與之有害生物管理、成功的有害生物管理案例研究、植物健康的新威脅、有害生物監測的數位創新、有害生物監測之全球網絡等 9 大主題，透過研究人員、產業專業人士和政策制定者口頭報告、海報展示與工作坊，交流分享創新策略和最佳實踐應用作為，促進更強有力的合作，為永續發展奠定基礎，建立一個更全面、更具彈性的有害生物風險管理方法，會議摘要如附件 1，筆者另依應用情境歸納相關議題，分為有害生物入侵前風險管理、國內防治管理與全球尺度的應用科技等三個面向，摘述如下：

（一）有害生物入侵前風險管理-植物有害生物前瞻性掃描（Plant Pest Horizon Scanning）及風險分析（Plant Pest Risk Analysis）

植物有害生物對國家之農業生產、環境生態及經濟發展均可能造成嚴重威脅，為有效預防和控制外來植物有害生物入侵國內，各國植物保護監管組織均有相關

風險監測工作，透過及早採取管理措施，減少害蟲入侵的可能性，為防治工作贏得寶貴的時間，減少害蟲對農作物的危害，進而保護生物多樣性，減緩外來害蟲對本地生態系統的入侵、破壞和永續發展，各國常用之兩種風險監測方法為植物有害生物前瞻性掃描（Horizon Scanning）及植物有害生物風險分析（Plant Pest Risk Analysis）。

植物有害生物風險分析關注的時程較靠近時事，通常是針對特定進口植物產品或貿易活動進行潛在威脅之風險評估，我國動植物防疫檢疫署（以下簡稱防檢署）主責針對特定植物有害生物，評估其入侵某一地區的可能性、潛在危害程度，並據此制定相應的檢疫管理措施，現行以國外申請輸入之植物及植物產品（貨品）輸入至國內為途徑啟動的植物有害生物風險分析工作為主。而在進行植物有害生物風險分析前，歐盟及加拿大等國家另還有另一層面的風險監測作業，也就是植物有害生物前瞻性掃描，前瞻性掃描的關注層面較為長遠，針對未來數年甚至數十年進行預測，同時考慮氣候變遷、全球貿易及生物技術發展等因素，識別和評估未來可能對農業和生態系統造成威脅的新興或重新出現的植物有害生物。

植物有害生物前瞻性掃描考慮氣候變化、全球貿易、生物技術、社會及經濟等因素，有系統地識別和評估特定環境下（農業、林業及環境）新興或再發生之植物有害生物潛在威脅與機會，達到提前發現潛在威脅及預防之目的，過程包含（1）廣泛且大量蒐集（掃描）各種潛在威脅項目並製作有害生物清冊、（2）透過工作坊及風險評估縮短清單及（3）達成最終共識。部分國家會將該有害生物清冊彙整建檔，也就是植物有害生物風險登記（Plant Pest Risk Register），是一個用來系統性管理外來植物害蟲入侵風險的工具，它就像是個「黑名單」，列出所有可能對某一地區的農業、生態環境造成威脅的植物害蟲。在前瞻性掃描下產生的有害生物清冊遠遠大於風險分析產生的清冊表單，有助於為植物有害生物風險分析及其他目的排定有害物種之優先順序，而如何濃縮精萃該表單則是風險分析研究的課題。

英國環境、食品暨鄉村事務部（Department for Environment, Food and Rural Affairs, DEFRA）的科學家 Duncan Allen 分享該國前瞻性掃描及風險評估的做法（圖三）可分為四個階段：

1. 早期偵測：搜尋各種資訊來源，聚焦於已知或可能的新興有害生物，主要資訊來源包含：
   （1） 現有科學文獻：團隊訂閱了 107 本科學期刊。
   （2） 相關媒體網站：如華盛頓郵報及社群媒體（Facebook）。
   （3） 公民科學社群：如 iNaturalist 登載之新紀錄物種。
2. 風險排序：相關有害生物種類列於英國植物健康風險登記表 （*UK Plant Health Risk Register*），初步快速篩選低風險有害生物，專注於較高風險的威脅，作為風險評估及應變處理之排序。
3. 風險評估：依據有害生物之氣候適應性、寄主範圍、潛在經濟損害等因素進行評估，計算風險分數用以決定風險管理等級，風險較高的害蟲會建議較嚴格之管理措施。
4. 風險決策：每月與政策幕僚及其他相關利益者開會，討論這些風險評估的結果，並決定是否進一步採取行動或繼續觀察。

英國科學家 Duncan Allen 於報告中亦討論了可支援前瞻性掃描的技術例如人工智慧（Artificial Intelligence, AI）的應用，並表示因植物健康領域相對小眾，數據量不足以支撐 AI 運作，整體產出的結果往往無法有效應用。另於會後與筆者分享其嘗試使用網頁爬蟲（web crawler）進行前瞻性掃描之缺點，包含資料錯誤、過時或格式問題，需要進行大量的資料清洗和驗證，耗費大量時間及人力，另因爬取的資料量非常龐大（包含許多垃圾資料），需要設計高效之資料儲存與管理平台，並建議應定期請平台使用者提供操作回饋意見，藉由系統工程修正資料問題，達到前瞻性掃描與資訊應用之目的。

愛爾蘭農業、食品和海洋部（Department of Agriculture, Food and the Marine, DAFM）農業監察員 Conor Francis McGeea 分享該單位於 2021 年成立植物有害風險小組（The Irish pest risk analysis unit, PRAU），其任務之一為評估歐洲聯盟委員會實施規範（EU）2019/2072 所列歐盟檢疫植物有害生物對愛爾蘭生物安全構成的風險，並於國內對歐盟檢疫害蟲進行為期 7 年的監測，或證明愛爾蘭氣候不適合該有害生物的生物學特性，或愛爾蘭沒有種植寄主植物。風險小組耗時三年完成風險登記表，包含 429 種植物有害生物及其相對應之風險分級排序、危害狀、寄主植物、傳播媒介、氣候適應性及風險摘要等訊息（圖四），其中在氣候適應性因子係利用全球生物多樣性資訊（Global Biodiversity Information Facility, GBIF）及物種分布模型（Species Distribution Model, SDM）進行分析，以確認有害生物於愛爾蘭完成生命史的能力，另分析已知寄主植物識別高風險種類，提高國內監測調查的頻率。該計畫最終目標為（1）提供風險登記表予相關植物保護部門提高監測調查頻率；（2）將風險登記表設計為一個公開的數據庫；（3）編撰相關有害生物之診斷鑑定手冊，供第一線防檢疫人員進行相關監測活動時參考，近期一研究開發線上害蟲風險分析模型 （Online Pest Risk Analysis Modelling, OPRAM），可協助植物有害生物風險評估，並為氣候變遷下的監測提供資訊（圖五）。

加拿大食品檢驗局（Canadian Food Inspection Agency, CFIA）研究人員 Joseph R. Stinziano 提到防止有害生物入侵，對於國家的經濟回報率為 100 倍，而當物種於國內建立族群，則需進行緊急撲滅，回報率僅 25%，如第一時間未能完全撲滅而持續投入時間與管理成本，至投入的經費遠大於作物實際上的經濟價值，則回報率為 0%（甚至負值），顯見前瞻性掃描的重要性（也就是發現尚未正式留意的威脅）。以加拿大林業為例，因木材產製品為其重要經濟支柱，CFIA 對木材蛀蟲（Wood-boring beetles）以定量分析方式進行多層次前瞻性掃描（Multi-layered Horizon Scan）與快速風險評估，從 10,824 種有觀察紀錄的物種名單中，透過適生性、自組織映射圖網路分析法（Self-Organizing Map, SOM）分數（圖六）、特有種、

有害生物狀態、寄主利用性及貿易量等風險指標進行快速分析，並同樣利用 GBIF 資料進行物種-氣候適宜性模型，另整合加拿大國家森林數據庫計算森林影響性，計算整體風險分數，產生了 9 到 13 個物種的短名單，達到 99.9%的目標減少效率。這份短名單與 CFIA 現有檢疫有害生物清單做比較發現，此種快速風險評估的方法可有效識別潛在的管制害蟲，並代表加拿大現行的風險評估程序已成功識別出 22%到 46%的高風險木材蛀蟲。而此種快速分析的主要限制在於物種發生紀錄的取得、氣候因子與物種存在與否的關聯性、可用於快速風險評估的資料及可用的電腦運算能力等。

國際應用生物科學中心（CAB International, CABI）分別於 2018 年及 2019 年推出前瞻性掃描工具（Horizon Scanning Tool, HST）（圖七）和有害生物風險分析工具（Pest Risk Analysis Tool, PRAT）（圖八），隨後根據用戶需求進行多次改進，提升了設計、可用性和技術內容，經 CABI 評估顯示，這兩種工具為支持生物安全領域有害生物風險決策的重要資源。

前瞻性掃描工具（網址：https://www.cabi.org/HorizonScanningTool）可用於幫助用戶快速識別潛在的入侵物種威脅，篩選“來源地區”並根據特定標準決定有害生物風險評估之物種優先順序，例如：哪些個別有害生物之入侵風險最急需進行風險分析；哪些有害生物之入侵途徑可能會隨商品 X 從 Y 國家運抵；哪些有害生物已經在鄰近國家出現，需要監控或應變計畫。以非洲迦納地區為例，前瞻性掃描工具可自動比對 CABI 資料庫，篩選已有完整生物資料表且在其他地方有入侵紀錄之物種，產出可能自非洲其他地區入侵迦納之 270 種植物有害生物清單（又稱風險登記表）。CABI 透過專家工作小組刪除有害生物清單中較不重要之物種，同時依據迦納公告之檢疫有害生物清單加入尚未入侵非洲之高風險物種，最後經由專家共識篩選出 110 種節肢動物、60 種病原菌及線蟲進行有害生物風險評估。風險評估完成後風險登記表仍需定期檢視，確認風險動態。CABI 目前參與歐洲植物檢疫研究協調組織（European Phytosanitary Research Coordination, EUPHRESCO）計畫，利用氣候模型開發定量之前瞻性掃描工具，以辨識氣候變遷下可能成為植物有害生物之物種。

CABI 開發之有害生物風險分析工具（Pest Risk Analysis Tool, PRAT）（網頁：https://www.cabi.org/PRA-Tool/signin?returnUrl=%2FPRA-Tool%2F）則基於植物產品之進口申請，協助生成害蟲清單並生成風險分析報告，提供相關輸入檢查或其他植物檢疫措施之建議。

CABI 資料科學家 Libertad Sánchez-Presa 同樣介紹了組織映射圖網路分析法（SOM），可將前瞻性掃描產生的冗長且難以管理的有害生物風險登記表，透過 SOM 識別害蟲物種組合並篩選具有入侵特定地理區域潛力的物種，建立有害生物的風險排序，解決政府部門資源有限無法處理所有風險的問題，未來將會把 SOM 風險排序分數新增於前瞻性掃描工具中，持續優化前瞻性評估系統。

（二）國內防治管理-有害生物監測與管理（Pest Monitoring and Management）

荷蘭瓦赫寧恩大學（Wageningen University）教授 Wopke van der Werf 係生態模型及統計專家，本次探討有害生物首次建立（爆發）的地點及分析這些地點的特徵，有助於將管理注意力轉移至風險最高的區域，從而更有效率地分配資源。過去的研究分析結果顯示，受人類活動密度較多的區域，較有可能出現新的外來有害生物，尤其城市最有可能是第一個發現的地點，如過度依賴人類的觀察紀錄，可能產生樣本偏差並得到錯誤的結論。本研究利用生成模型（Generative Model）從過去的首次發生記錄地點，預測可能建立族群的潛在區域，並以（1）實際有發生紀錄的科學報導及（2）可能有發生紀錄的報導（如 GBIF）等不同觀測值來源建立生成模型，並比較兩者所產生的預測結果。

瓦赫寧恩大學博士候選人 Hongyu Sun 探討新興有害生物於首次發現時，如何從首次發現的地點擴大進行發生範圍調查，其分別討論向內（inward）及向外（outward）策略，使用以個體為基礎的預測模型比較兩種不同策略的調查效率，若在足夠確認感染範圍前緣下，劃定大範圍向內調查策略樣本採集數較少，所以

人力使用率較高整體效率高，但若對該有害生物的生物學、擴散速率及入侵時間不易掌握下，仍偏向使用向外調查策略，提供了研究或政府決策時調查方式的建議。

歐洲食品安全局（European Food Safety Authority, EFSA）Tomasz Kaluski 博士向與會者說明 EFSA 接受歐盟的委託，正在為歐盟成員國建立一個以統計學原理及風險為基礎的檢疫有害生物調查操作指引系統（Risk-based Pest Survey Tool, RiPEST）（圖九），各成員國在有害生物監測上須進行不定期調查，過去多只能於單一時間調查單一物種，規劃和執行十分耗時耗力。該系統整合約 300 種有害生物調查方式，使用者設定目標有害生物種類、調查（檢測）方法、寄主植物、植物部位及目標地理區域（如都市、森林及農業生產區等）等參數，該系統工具包即可自動依據有害生物族群結構及族群量，計算統計信賴區間及可能的流行率（prevalence），直接提供田間調查者取樣之建議，可於單一時間、相同寄主、多種目標有害生物下，規劃最少取樣量及最低田間採集頻率建議。

西班牙高等科學研究委員會（CSIC）亞熱帶與地中海園藝研究所（IHSM）研究人員 Eduardo de la Peña Alonso 則探討了因為國內的消費者對檬果及釋迦等熱帶水果需求量大增，自國外引入前揭水果繁殖用組織或植株至西班牙當地種植的數量也大幅增加，進而造成外來有害生物的入侵。除了基本的邊境植物檢疫，該部門針對自國外引入植物品種的苗圃啟動了有害生物監測計畫，並以馬氏網（Malaise Trap）進行非特定標的田間取樣，以調查同一果園中宏觀的昆蟲群落，並使用 DNA 條碼進行物種鑑定，為這些果園訂下 DNA 條碼的背景值，以藉此了解果園內的節肢動物多樣性，並說明外來有害生物的形態鑑定對於該國專家學者的不易，DNA 條碼應是未來有害生物監測的新趨勢。

德國聯邦食品暨農業部朱利葉斯·庫恩研究所（Julius Kühn Institute）研究員 Anto R Dominic 長期致力於植物病害田間流行病學與發生預測模型之研究，以油菜菌核病（*Sclerotinia sclerotiorum*）為例，該研究所過去針對該病害長期累積氣象

因子、病害發生與植物生長紀錄等數據，建立可供農民登錄現地位置，即可預測菌核病發生並提供防治建議的決策支援系統（Decision Support Systems, DSS），稱為 Sclerotinia risk forecasting model（SkleroPro）（圖十）。然近年因氣候變遷使預測準確率下降，該研究所旋即啟動模型精進計畫，除原有氣象因子及植株生長數據外，另以每日溫度和光週期為基礎的物候模型來模擬油菜花的花期，並蒐集可誘導菌核（sclerotia）產生子囊盤（apothecia）及釋出子囊孢子（ascospores）的環境因子數據，將其匯入原有預測模型進行優化，大幅提升預測準確率至 78%，協助農民更精準、及時地進行殺菌劑處理，減少不必要的藥劑使用與產量損失。

（三）全球尺度的應用科技-地球觀測技術（Earth Observation）

地球觀測技術是指利用衛星、飛機或無人機等平台搭載各種遙測感測器，對地球表面進行遠距離、非接觸式觀測以獲取地表資訊的技術（圖十一），其獲取資料的方式及原理包括：

1. 電磁波輻射：地球表面上的物體都會吸收、反射或輻射電磁波。遙感測器通過接收這些電磁波，分析其強度、波長等特性，以推斷地表物體的性質。
2. 影像獲取：感測器將接收到的電磁波信號轉換為數字影像，這些影像包含了地表物體的空間分布、光譜特性等資訊。
3. 資訊提取，透過影像處理、分類、分析等技術，從影像中提取出所需的資訊，如土地利用類型、植被覆蓋度、水體變化等。

常用的遙測感測器類型包括：

1. 光學感測器：可接收可見光（400-700 nm）、近紅外光（780-2500 nm）、短波紅外光（900-2500 nm）等波段的電磁波，主要用於地表覆蓋、植被及水體等方面的觀測。
2. 微波感測器：可接收微波波段（1mm-1 m）的電磁波，具有穿透雲層的能力，主要用於地表濕度、土壤水分及冰雪覆蓋等方面的觀測。

3. 熱紅外感測器：可接收熱紅外光（780 nm-1 mm）波段的電磁波，用於測量地表溫度，可應用於火山監測、森林火災監測等。

地球觀測技術的應用範圍非常廣泛，涵蓋了多個領域（圖十二），例如：

1. 資源探勘：尋找礦產、石油、天然氣等資源。
2. 環境監測：監測空氣品質、水質、土壤污染、森林砍伐、荒漠化等環境問題。
3. 災害監測：監測地震、火山、洪水、颱風等自然災害，以及城市災害等。
4. 農業作物生長狀況監測：估算產量、病蟲害監測等。
5. 城市規劃與城市發展監測：土地利用規劃、交通流量分析等。
6. 氣象預報：雲圖分析、海溫監測等。

地球觀測技術的優點為：

1. 快速觀測：短時間快速獲取大範圍的地表觀測資訊。
2. 重複觀測：可定期重複獲取同一區域的影像，長期監測地表變化的動態過程。
3. 非接觸式觀測：無需實地勘察，減少人物力成本。

而地球觀測技術的缺點在於巨量的影像數據需要高效的數據處理和分析技術；雲層遮擋及大氣中的水氣可影響影像的質量，限制了觀測的時效性；地表覆蓋類型多樣且複雜，增加了影像解譯的難度。

地球觀測技術在作物病蟲害及營養管理的應用範圍可區分為：

1. 早期病蟲害偵測：當植物感染病害時，其光譜反射率會發生變化，透過計算植被指數的變化，可以早期發現病蟲害的發生。一些病蟲害會引起植物局部溫度升高，利用熱紅外影像可以檢測出這些熱異常區域。
2. 病害擴散監測：
   A. 時序影像分析，透過分析不同時期的衛星影像，可以監測病害的擴散速度和範圍。

B. 異常區域劃分：利用影像分類技術，將病害區域與健康區域進行劃分，並估算病害的發生面積。

C. 病蟲害種類鑑定：高光譜影像可以獲取地物非常詳細的光譜資訊，透過光譜特徵的分析，可以初步判斷病蟲害的種類。

3. 施藥與施肥精準化：根據遙測影像分析結果，可確定不同區域的施肥量，實現變量施肥；利用無人機搭載的高精度噴灑系統，可以對病蟲害發生區域進行精準噴灑，提高防治效果，減少農藥濫用。

4. 實現多源數據融合：將遙測影像與氣象數據、土壤數據等多源數據進行融合，為建模提供了新的可能性 （圖十三）；配合人工智慧深度學習應用，提高病蟲害自動識別和分類的準確性；結合無人機技術，進一步提高空間分辨率和時間分辨率，提高用於監測因氣候變遷而加劇的農作物害蟲傳播的資料集的品質，為精準農業提供更強有力的支持。

CABI 在英國研究與創新總署 （UK Research & Innovation, UKRI）的資助下，於原有病蟲害的蒐集觀測數據、有害生物監測數據、生長積溫及生物學資訊基礎，使用 EO 數據包括灌溉系統、受保護的農業結構（如溫室）和氣候冠層條件，來改進有害生物預測模型中使用的數據層，以預測害蟲可能立足的地理位置，此模型亦為團隊重點計畫「有害生物風險資訊系統建置」（The Pest Risk Information Service, PRISE）之工作項目（圖十四、十五）。CABI 以肯亞主要番茄栽培區重要害蟲-番茄潛旋蛾（*Phthorimaea absoluta*）發生預測模型為例，研究發現距地面兩公尺溫度為重要模型驅動參數，且依賴成蟲捕捉器的資料可能會建議錯誤的防治時機，應將幼蟲族群量的偵查納入害蟲管理方案中，透過及早預測番茄潛旋蛾危害時機，提供農友防治短訊，相較於慣行農業栽培區，無需增加施藥次數及可增加產量及收入，顯示良好的預測模型可有效防治重要害蟲。該團隊目前正在進行咖啡果小蠹（Coffee Berry Borer, CBB）之研究，因咖啡為多年生植物，不似番茄可蒐集較為準確的植物生長積溫數據，目前透過分析溫度、濕度和作物生長指數

等環境因素，開發了一套可預測 CBB 出現的穩健系統，模型的重要參數為降雨量及溫度相關數值，先模擬植株發育狀況，預測大量開花的時機據以推測結果時機，可更精確地掌握防治措施的時機，團隊下一步將於哥倫比亞咖啡產區進行模型輸出驗證，同時蒐集 CBB 在果實內部發育的數據，評估生物防治用藥使用之最佳時機。因應國內番茄潛旋蛾疫情，番茄於臺灣的栽培模式並非露天大規模栽植，而是以精緻的溫網室進行栽作，筆者向 CABI 研究者表示我國番茄多種植於設施內，詢問 EO 數據否適合應用於設施農業（圖十六），研究人員表示仍可進行，但須透過各設施內另加裝之觀測器，如溫溼度紀錄器進行資料轉換始能整合應用。

我國由防檢署植物檢疫組寧技正方俞及基隆分署花蓮檢疫站呂技士柏寬（風險分析小組成員）共同與會，並與東京都立大學廖博士治榮及植物檢疫組陳技正俊宏合作發表，以「氣候因子對檢疫有害生物潛在分布風險評估之方法學比較：以臺灣現行定性分析法與 MaxEnt 預測模型為例」進行口頭報告（圖十七），（附件 2），針對桃枒蛾（*Anarsia lineatella*）、地中海果實蠅（*Ceratitis capitata*）、蘋果蠹蛾（*Cydia pomonella*）、蘋果癭蠅（*Dasineura mali*）及桃折心蟲（*Grapholita molesta*）等五種檢疫有害生物探討兩種分析方法產生之風險分析結果及其優缺點（圖十八）。定性分析主要評估生物地理區域、寄主分佈和溫度對其發育之影響，缺乏對其他氣候因素和寄主植物相互作用的客觀分析過程。相較之下，MaxEnt 物種分布模型（SDM）以機器學習之原理預測有害生物在台灣的潛在適宜棲息地分佈，配合寄主植物的鄉鎮分佈圖，可提供準確的潛在分佈預測。最後，筆者建議將 SDM 和新的 PRA 工具與定性分析方法整合應用，可更有效地針對影響物種分布模式的複雜因子進行更全面的評估，減少定性方法造成的人為偏差，對於未來我國風險評估流程的優化至關重要。

各國與會人員對於臺灣嘗試導入該模型預測方法於原有之定性方法表示高度興趣，Kriticos 博士針對 MaxEnt 產生的潛在分布圖部分區域之電腦繪圖未呈現

正常色塊，建議應嘗試確認模型運算的閾值是否需調整，並建議未來亦可比較CLIMEX 生態棲位模型之分析結果；Werf 教授依據荷蘭的研究經驗，建議應謹慎使用 GBIF 的分布資料，因 GBIF 的物種採集位點時有過度集中在人口稠密區域的現象，可能並不是物種自然立足下的棲息區域，分布資料應先進行篩選以免影響模型的訓練結果與可信度，Werf 教授另表示物種分佈模型可提供定量分析結果，確實較專家評分方式客觀且科學，筆者希望撰寫一套 MaxEnt 標準操作流程來擴散技術至風險分析小組的企圖雖然務實，仍建議應由同時具昆蟲學及資料分析應用背景之專家執行，並且嚴謹取得訓練模型之原始數據（以荷蘭為例，一個模型的訓練集通常耗時數年整理資料），始能將物種分布圖的誤差降到最低。愛爾蘭農業部 McGeea 先生同樣使用 GBIF 資料及物種分布模型作為該國風險評估過程的風險分級因子，因此針對我國後續研究是否針對氣候變遷情境進行探討表示高度興趣。整體而言，物種分布模型應用於生物多樣性、保育、環境永續及有害生物入侵等不同情境之風險分析已是世界趨勢，許多執行植物有害生物風險評估作業之先進國家如美國及歐盟等均已普遍使用。

四、心得及建議

（一）善用新興風險分析工具精進有害生物風險評估作業

1. 有害生物風險掃描之概念與應用

本次研究群組年度會議可發現，隨著風險分析運作的機關單位隸屬於全球性組織（如 CABI）、區域性聯合組織（如 EPPO、EFSA 及歐洲聯盟執行委員會）或個別國家（如愛爾蘭農業、食品和海洋部）之管轄範圍及目的不同，其風險掃描與風險分析所投入之經費、人物力及後續對於社會、經濟與環境影響評估的完整度均有其差異。而實際執行風險分析與評估的人員，隨著組織編制或業務委外之規劃亦有其差異，例如政府所屬科研單位（如 DEFRA 的約克生物技術園區）、專案團隊（愛爾蘭害蟲風險分析小組（PRAU））、委由學校專家於植物害蟲風險評估單位擔任害蟲風險分析師（如瑞典農業科學大學）或聘用相關資料與生態科學家（如 CABI）等。與會國家之政府機關除風險分析業務外，另進行前瞻性掃描工作，評估與分析更大範圍的地理目標及有害生物。

防檢署自 111 年起著手建置「植物疫情自動偵蒐及研析系統」（以下簡稱偵蒐系統），其部分功能類似前瞻性掃描過程，該系統可自預設之科學期刊、線上資料庫及網路媒體等資訊來源，從預設之關鍵字自動爬蒐新興疫病蟲害及國際植物有害生物疫情，然自動偵蒐的結果是否即代表具有害生物入侵風險，還需進一步請國內專家學者定期審閱新興疫情（First Report）資料，就高入侵風險潛能之有害生物建議後續之風險預警及行動，相關行政作為勢將增加邊境及國內管理成本，後續應持續投入經費導入自組織映射圖網路分析法（SOM）等 AI 運算，將冗長且難以管理的有害生物清單透過 AI 程式語言識別害蟲入侵風險，建立有害生物的風險排序，解決政府部門資源有限的問題。

筆者觀察各國專家在進行前瞻性掃描作業後，會將一系列的有害生

物清單彙集成各國的有害生物清冊，此過程稱為有害生物風險登記（有害生物黑名單），該名單中的有害生物不一定會成為法規中直接列管的標的，但卻是各國國家植物保護機構不定期了解國際疫情趨勢及可能須風險管理對象之參考指標。因此，未來針對臺灣偵蒐系統的資訊來源是否足夠，疫情研析報告是否客觀，能否在蒐集資訊、研析報告後產生可支援決策的風險登記名單，將決定長期風險管理的方向。

2. CABI 開發之風險掃描與分析工具

前瞻性掃描工具（https://www.cabi.org/HorizonScanningTool）依筆者實際操作，使用者可以臺灣作為分析對象，鎖定不同的國家或經濟體群後（假設為有害生物來源或植物產品輸出國），再以氣候、途徑、棲地、植物寄主、植物部位及影響結果進行過濾篩選後，匯出成一個有害生物清單檔案供風險分析使用，協助各國進行前瞻性掃描。

有害生物風險分析工具（https://www.cabi.org/pra-tool/）依筆者實際操作，可選擇以途徑或有害生物來啟動風險分析。如以有害生物來啟動，則依進入可能性、立足可能性、散佈可能性、傳播可能性及後果依序填入或帶入相關資料，則可產生該有害生物的風險分析報告。而以途徑來展開的風險分析，則與我國風險分析小組辦理的各類輸入貨品風險分析報告類似，選取輸出國、輸入國以及貨品學名與樣態後，則可產生有害生物清單，後續再各別選取害物進行個論，同樣包括進入可能性、立足可能性、散佈可能性、傳播可能性及後果，填寫完後即可產生風險分析報告。該平台產生之有害生物表單可自動將 CABI 資料庫中輸出國及臺灣有害生物進行聯集，可大幅縮減風險分析人員之資料搜尋及整理時間，並有效減少人為比對之遺漏，確保分析工作含括所有應評估之有害生物。

（二）持續應用數據分析與預測模型強化國內有害生物監測與管理

1. 新興有害生物爆發時之疫區匡列與調查

荷蘭瓦赫寧恩大學針對新興有害生物爆發時向內及向外調查的研究可提供政府機關第一時間現地調查及官方防治策略的建議，一個新興有害生物的入侵應於發生初期進行大範圍的調查劃定邊界，雖可能造成大量人物力及資源的消耗，但較能達到不擴散及撲滅的可能，反思許多國家包含臺灣，在新興有害生物爆發時，往往採取追蹤式的調查策略，也就是由試驗研究人員、農民或一般民眾通報始前往調查確認及記錄，澳洲研究人員即有感表示，如同澳洲對於入侵紅火蟻的官方作法，只是在做災難的紀錄而已。未來面對新興有害生物入侵的議題，相關物種發生模型與取樣調查的數據科學，將決定臺灣能否於有限資源下達到最嚴謹的向內或向外調查，框定危害邊界於第一時間有效撲滅。

2. 農作物或森林有害生物之普查與取樣工具

EFSA 為歐盟成員國建立有害生物官方調查採樣建議電子化系統（RiPEST），可於單一時間、相同寄主、多種目標有害生物下，規劃最少取樣量及最低田間採集頻率建議。依據中華民國植物特定疫病蟲害種類及範圍（113 年 10 月 8 日公告修訂），臺灣目前須定期進行官方監測調查之有害生物種類僅 22 種，作物以水稻、番茄、草莓及部份果樹、蔬菜與雜糧作物為主，且單一作物上的調查部位重疊性也不高，是否需投入相關經濟型取樣調查方法的規劃仍有待進一步評估第一線農事調查員之需求，惟電子化的系統介面於操作及後續統計應用一定較為便利，如未來監測項目有大幅增加或啟動相關農作物或森林有害生物普查，確可提供地方政府較為經濟、便利且客觀一致化的取樣建議。

3. 國內重大有害生物發生預警模型之建置與優化

有害生物的長期監測數據結合氣象因子（溫度、相對溼度、光週期及雨量）及植物生長數據為基礎的物候模型，可建立有害生物發生預測模型。本次自德國油菜菌核病模型案例可知，隨著時間、環境及氣候變遷，模型準確度可能逐漸降低，而以植物病原體及作物之發育數值來修正模型可提高預測精準度。2013 年國立臺灣大學亦曾以病原菌發育觀點結合即時定量 PCR 及孢子收集技術研究稻熱病監測預測模式，然當時之研究結果顯示孢子數量並非顯著因子，而未有更進一步的研究發展。2023 年中興大學歐介皜等人與嘉義大學及全國各試驗改良場所共同發表之 BlastGRU-TW model 與大一代應為最新且已科學研究發表之稻熱病預測模型，然國內植物有害生物戰情平台之稻熱病風險預測儀表板及臺灣水稻疫情整合資訊網有 6 組稻熱病預測模型，且各組模型的預測結果相差甚遠，縣市政府及相關研究人員於不清楚各模型之原理時可能無法選擇適切之模型情境，並做出正確的風險預警與管理。因此後續應持續驗證模型準確性，並隨氣候變遷持續投入相關研究優化模型。

（三）地球觀測技術在植物有害生物管理之應用評估

地球觀測技術在國際上植物病蟲害的監測與防治上扮演著愈來愈重要的角色，但地球觀測技術在植物有害生物管理應用上仍有諸多限制，如雲層遮擋、大氣影響、地表複雜性及農田地表覆蓋類型複雜等，增加了影像解譯的難度。病蟲害種類繁多，不同病蟲害的光譜特徵相似，亦增加了病蟲害鑑定的難度。

CABI 應用地球觀測技術多針對大面積單一農作地區，而臺灣耕地面積狹小且零散，作物種類多樣且地形複雜，地球觀測技術是否具應用潛力仍須進一步了解其解析度與辨識能力，且地球觀測數據需由相關專業技術團隊協助處理大量影像數據資料，國內應用多著重於遙測技術，如國家災害防救科技中心、林業及自

然保育署航測及遙測分署等，建議防檢署可先洽相關單位了解目前國內已有之技術及蒐集之數據種類，再行評估是否可實際應用於農作物有害生物預測。

另筆者向 CABI 研究人員表示地球觀測技術如需應用於設施農業須透過另外加裝之溫溼度紀錄器進行資料轉換，考量我國番茄潛旋蛾主要發生於設施內，若要發展預測模型可能需結合其他觀測設備，且我國番茄設施產區地理位置差異頗大，各溫室模型參數可能需多方設計。另針對國內大面積栽培之主要作物疫病害蟲，如水稻稻熱病、龍眼荔枝椿象及玉米秋行軍蟲等，建議除基礎氣象數據外，可以「多源數據」及「多層次輸入層」的概念，多方蒐集無人機之遙測數據，結合現有參數進行預測模型之研究，並鼓勵植物保護研究人員與資料科學、統計學、地理資訊學、氣象學、遙測影像分析及電腦資訊等相關專家跨領域合作。

（四）結語

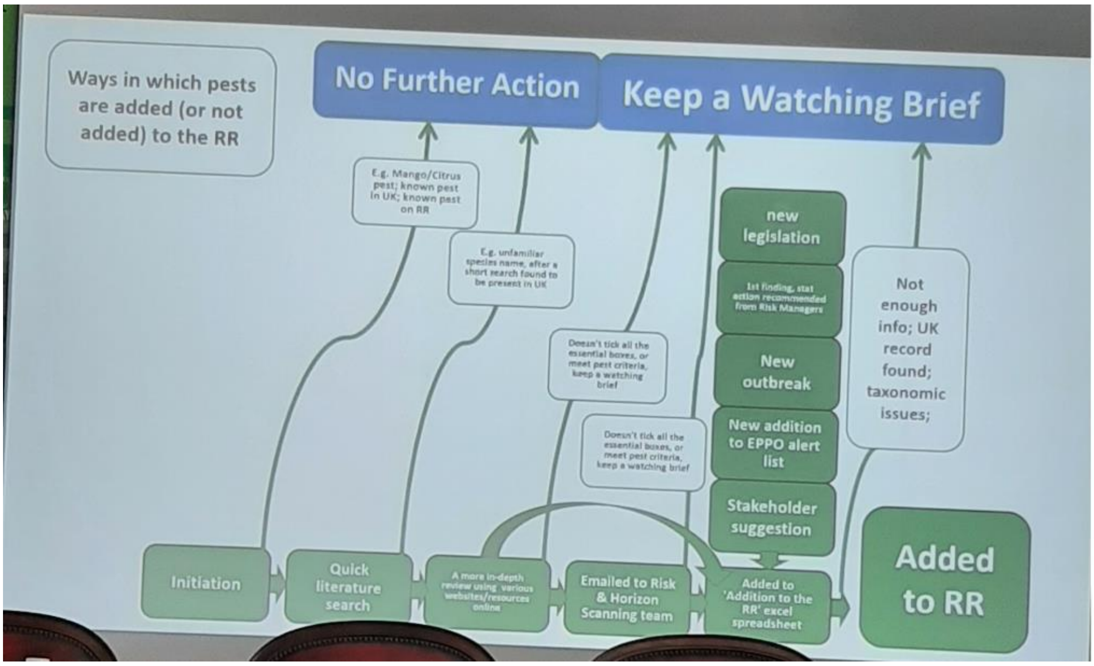
本次前往 IPRRG 年度會議對於我國植物防檢疫作為及管理措施確有諸多啟發，透過該會議無論是在植物有害生物風險分析及病蟲害監測防治上都可看出我國在類似事件的因應對策與其他國家的不同之處，藉由學習他國優點及借鏡缺點是該趟行程的重要收穫。

IPRRG 會議於有害生物入侵風險模型建構和風險圖譜研究扮演領航角色，並與各國政府植物保護組織關係密切，每年 9 月於不同地點舉開，各國成員分享 PRA 研究進展、PRA 新工具與新方法的應用，並舉辦工作坊促進研究人員、產業專業人士和政府機關之行政人員間腦力激盪與交流，建議未來持續投入出國經費派員參與，持續汲取有害生物風險評估、監測與管理措施之新興技術工具與經驗，與國外相關團體之專家交流合作，提供未來防檢疫綜合管理措施與政策之參考。

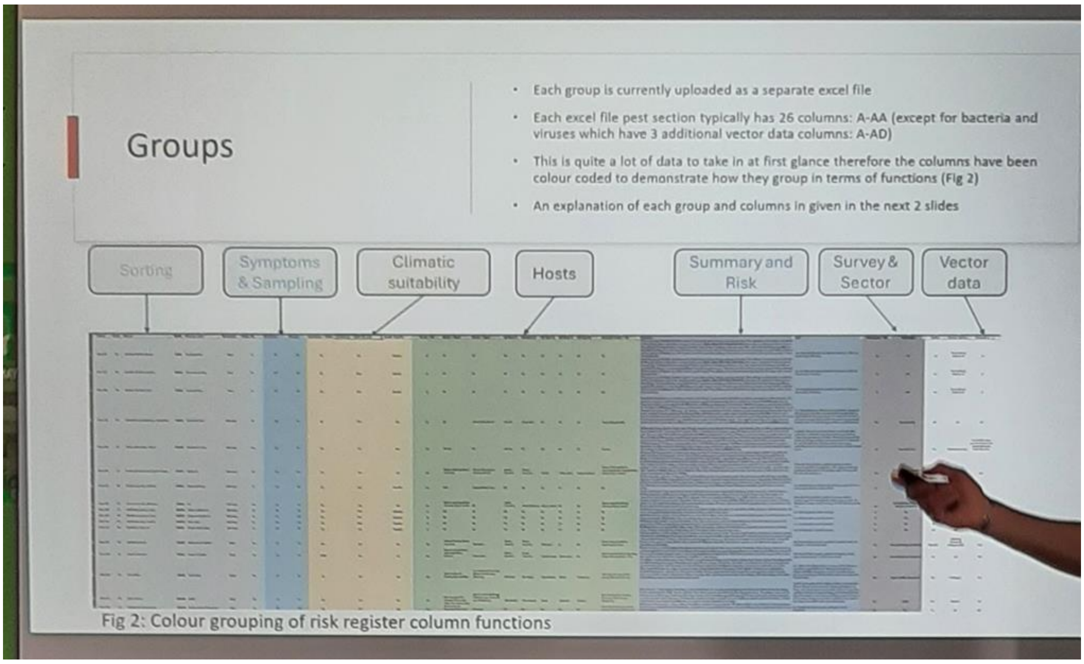
附圖

圖一、防檢署植物檢疫組及基隆分署派員參加 2024 年第 18 屆 IPRRG 年會，並與 IPRRG 前主席 Darren Kriticos 合影。

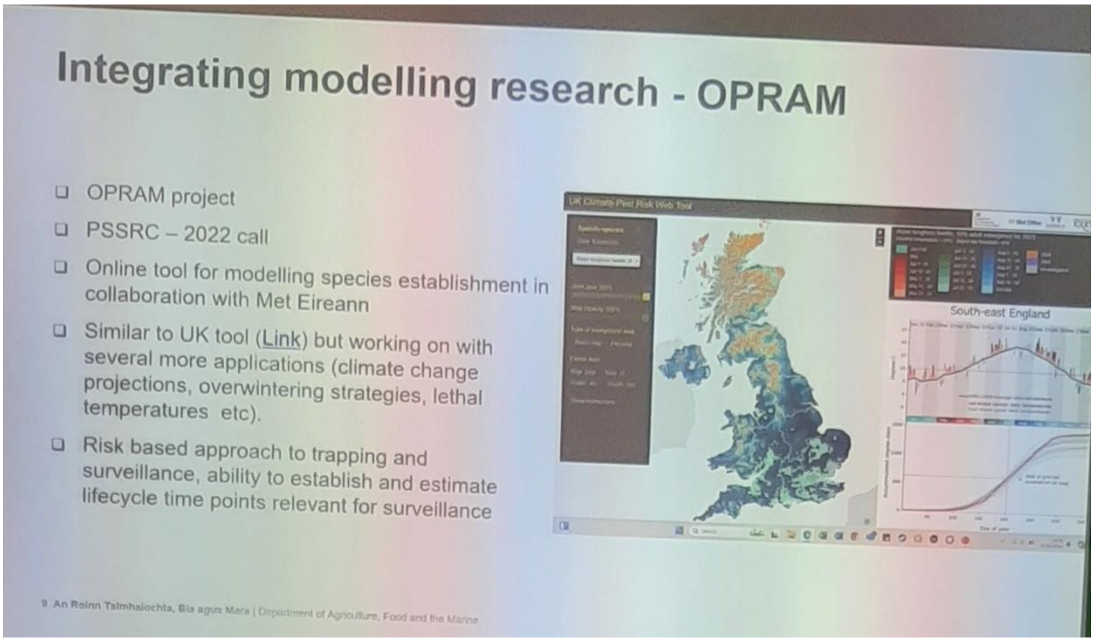
圖二、第 18 屆 IPRRG 年會各國與會人員大合照



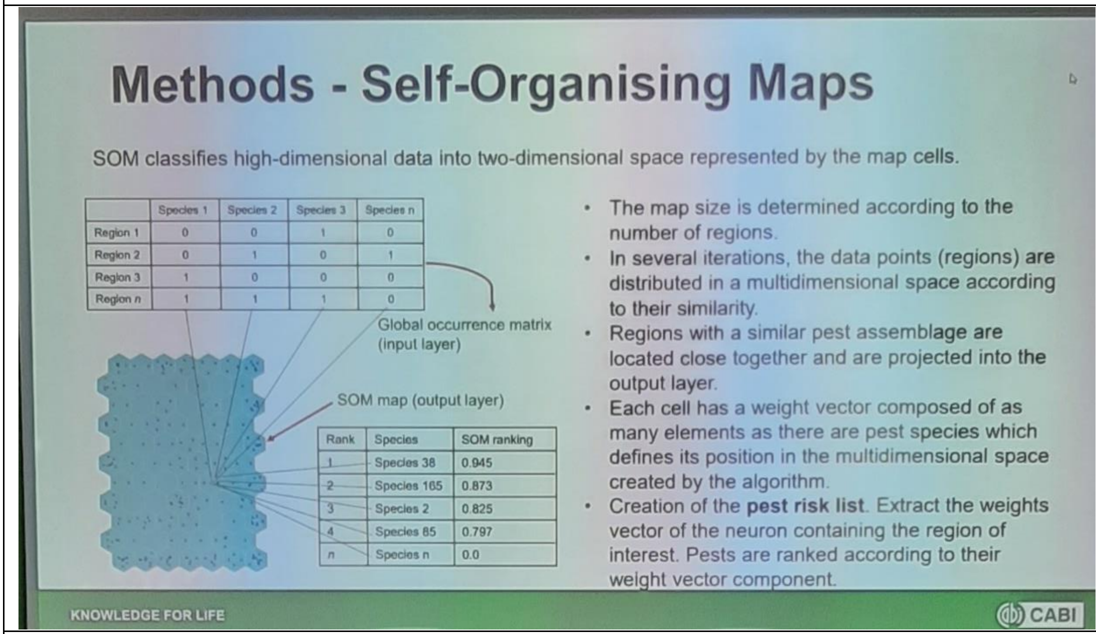
圖三、英國代表介紹新興有害生物進行風險登記的過程



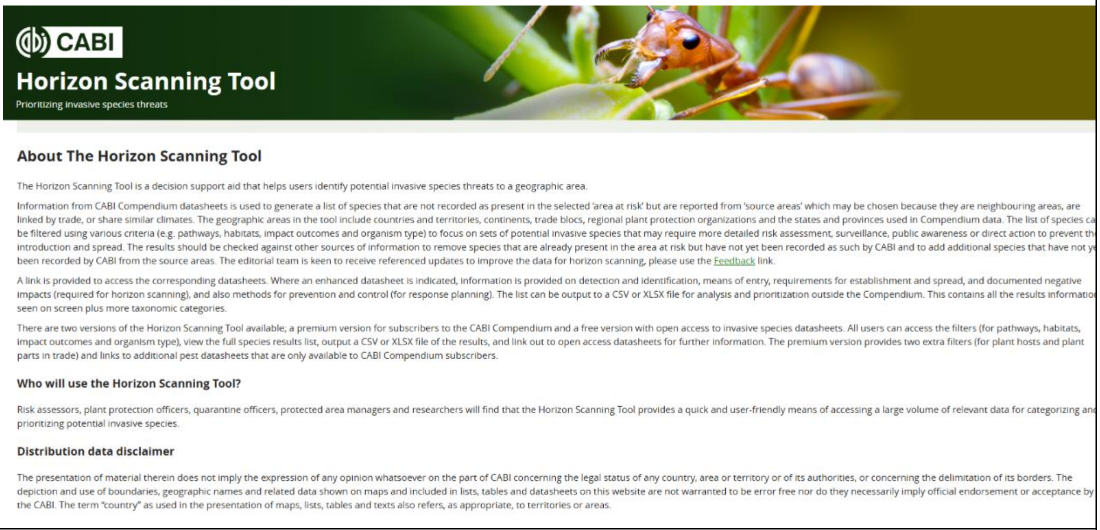
圖四、愛爾蘭代表介紹有害生物風險登記的項目與內容



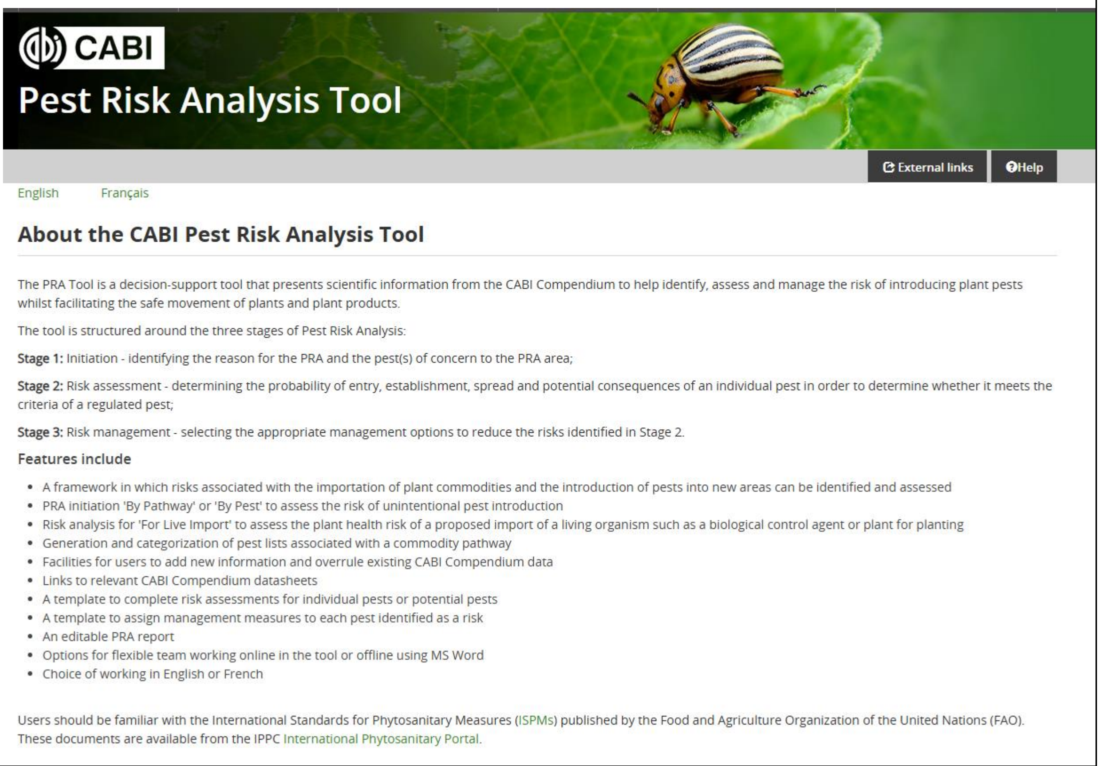
圖五、愛爾蘭開發之線上害蟲風險分析模型（Online Pest Risk Analysis Modelling, OPRAM），可協助植物有害生物風險評估，並為氣候變遷下的監測提供資訊。



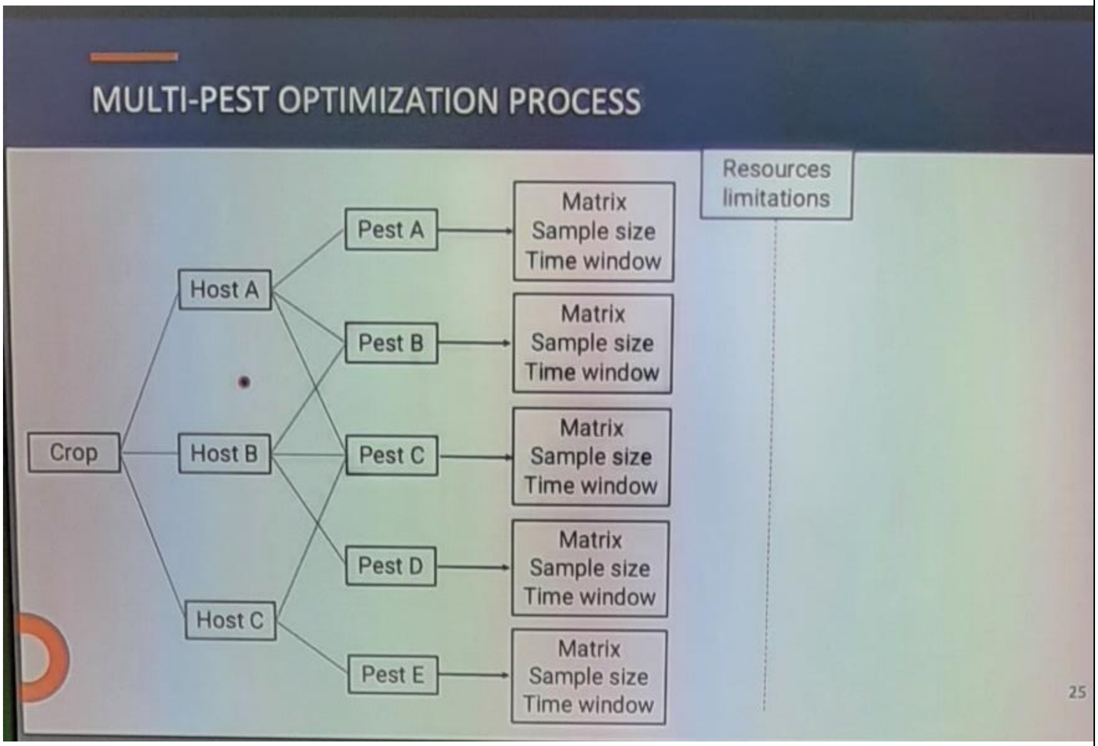
圖六、CABI 及加拿大 CFIA 代表進行前瞻性評估均會使用到 SOM 資料分析技術



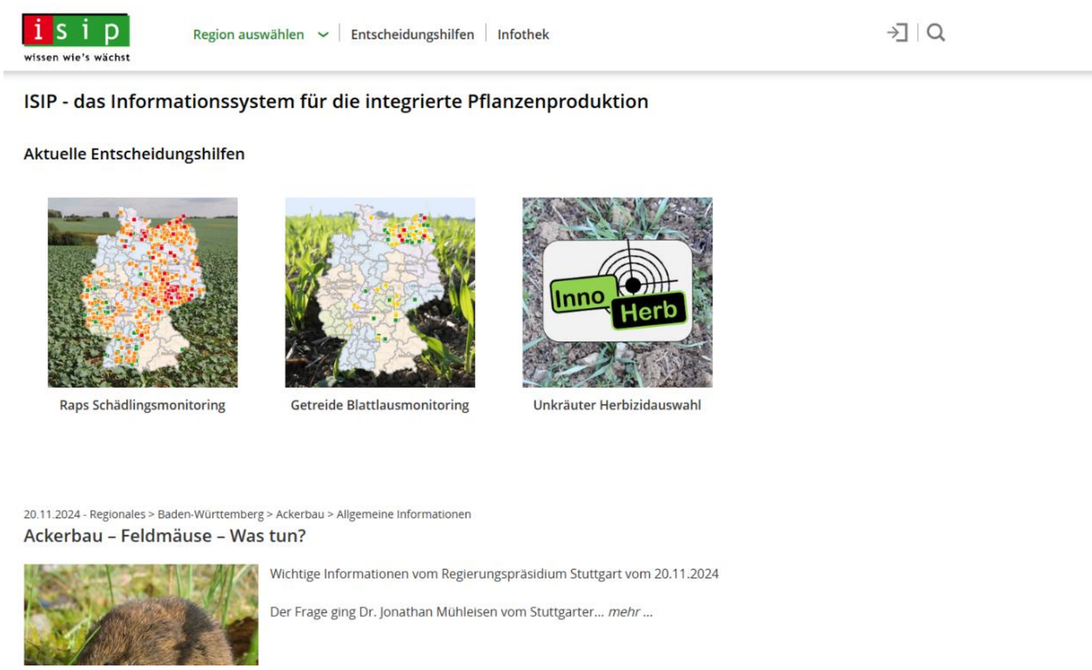
圖七、CABI 建置之前瞻性掃描線上分析工具



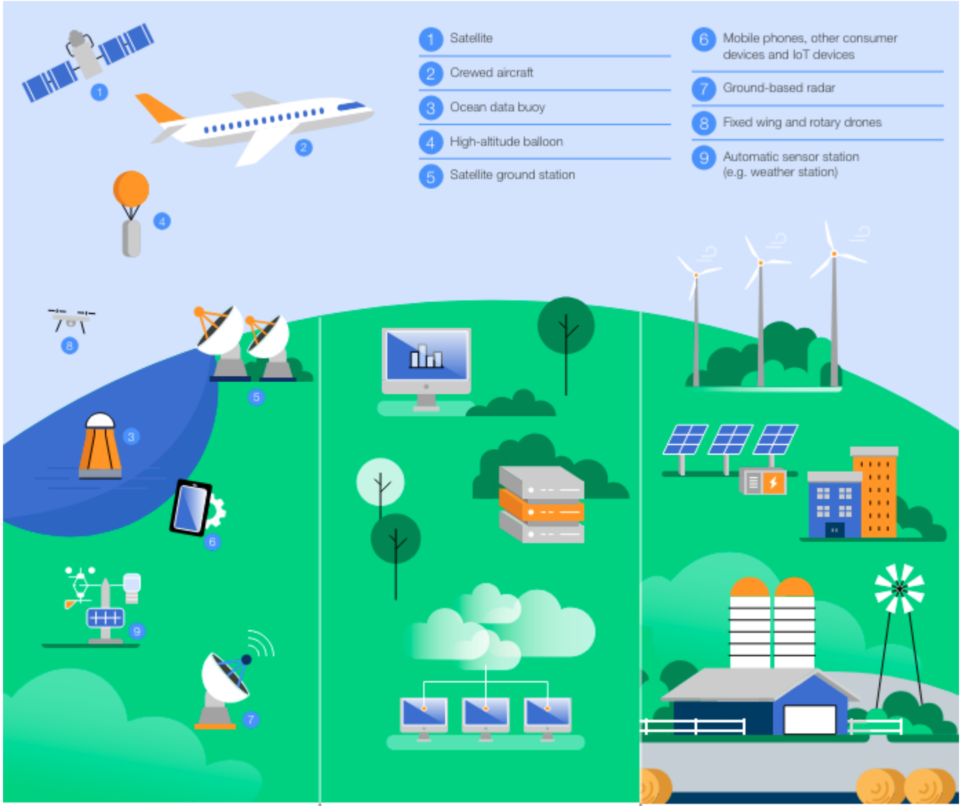
圖八、CABI 建置之 PRA 線上分析工具



圖九、EFSA 代表說明有害生物監測調查系統之優化概念



圖十、德國的作物預警監測系統（ISIP）



Data acquisition

The EO value chain begins with data acquisition from a variety of sensors and sources. Remotely-sensed data is collected from satellites, piloted aircraft, high-altitude balloons, drones and other platforms. In-situ data is gathered from GPS-enabled devices, IoT sensors and other human-collected or automated measurements in the field.

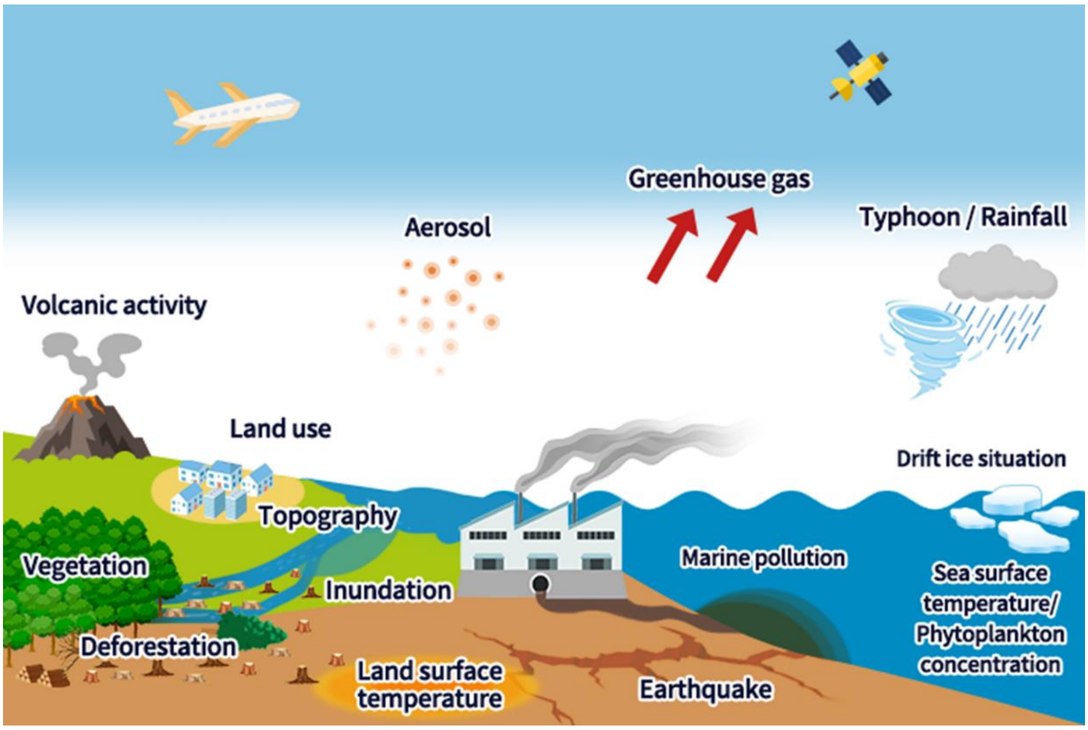
Data processing and analytics

The midstream segment, data processing and analytics, aims to make vast EO datasets more discoverable, accessible and ultimately actionable. Raw EO data needs to be calibrated, refined, contextualized, curated and fused with other data sources relevant to specific applications.[3]

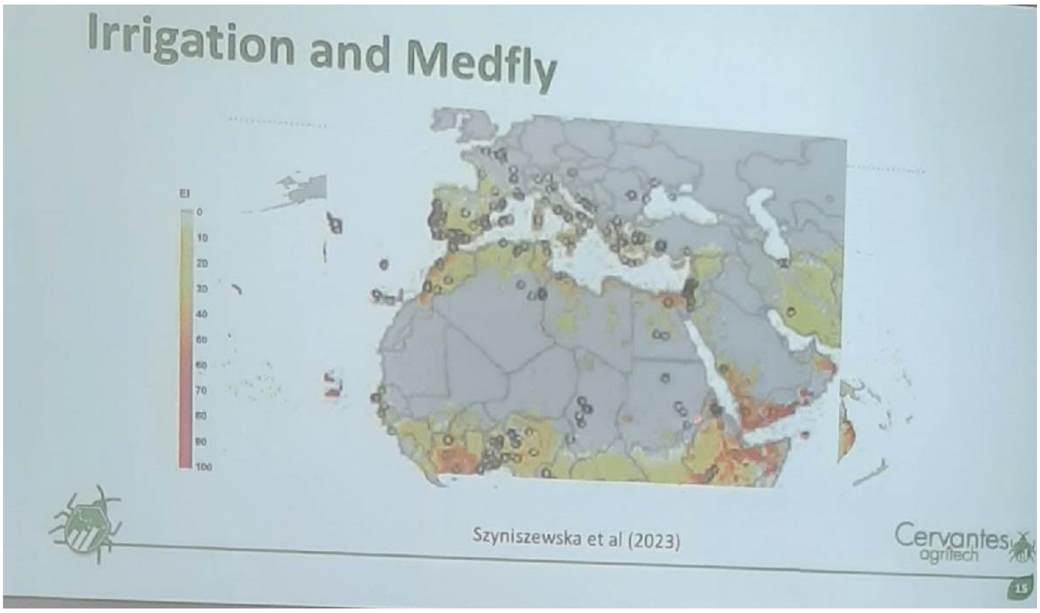
Data use

The downstream segment of the EO value chain is data use. Unlike depictions of the EO value chain that focus on the EO industry alone, this segmentation captures the role of end users in realizing the full value of EO data and the importance of stimulating downstream use to realize EO's full potential.

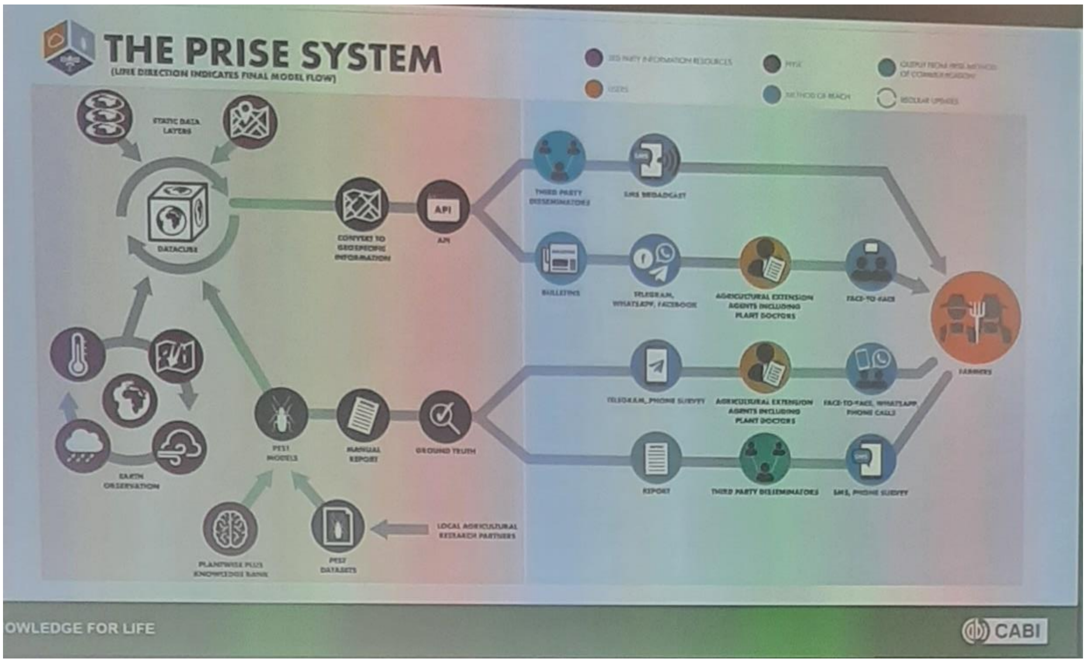
圖十一、地球觀測技術的收集、資料處理及使用



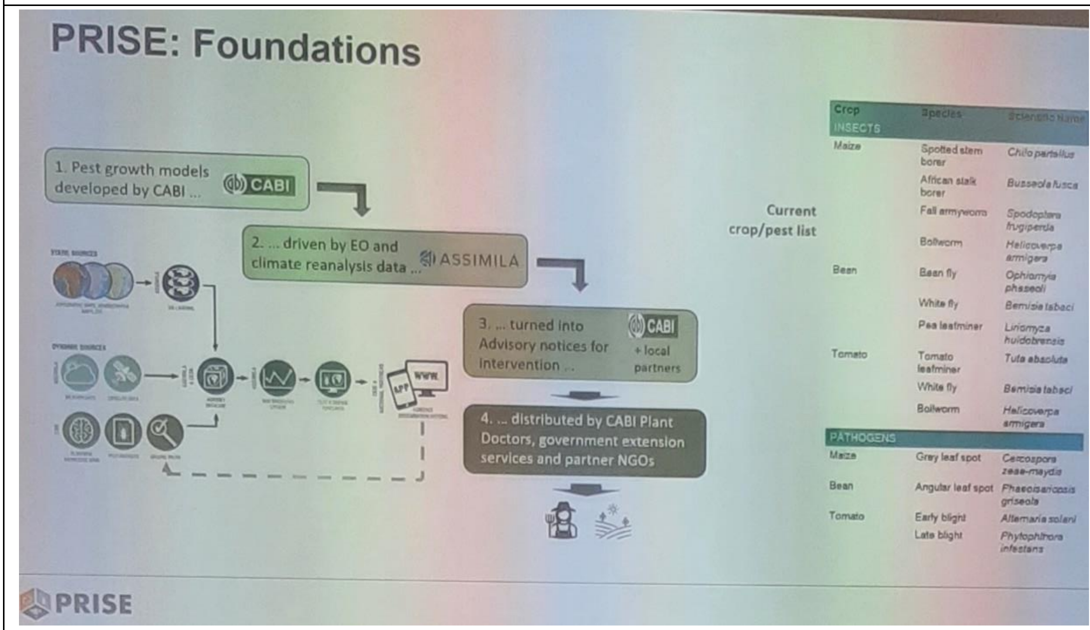
圖十二、地球觀測技術的應用範圍



圖十三、灌溉系統影像結合地中海果實蠅發生熱點圖譜



圖十四、CABI 團隊重點計畫「有害生物風險資訊系統建置（PRISE）」，利用 EO 技術導入害蟲預測模型處理流程。



圖十五、CABI 建置有害生物風險資訊系統（PRISE）之應用規劃

圖十六、防檢署基隆分署花蓮檢疫站呂技士柏寬向 CABI 研究人員 Alyssa 提問有關 EO 技術應用於溫網室的可行性

圖十七、防檢署植物檢疫組寧技正方俞代表口頭報告我國現行植物有害生物風險評估作業與最大熵值模型預測之方法學比較

	Qualitative Analysis Method of PRA in Taiwan	MaxEnt Prediction Model + Distribution Maps of Host Plants
Advantage	1. The process is easier to follow (economical). 2. Provide more details on text information, so the result is easier to interpret. 3. It is suitable for data with high uncertainty, or the main factors are hard to describe numerically.	1. SDM provides quantitative , causal or correlation analysis results. 2. SDM provides potential distribution predictions through computer mapping, which can be analyzed interactively when combined with host plant distribution maps.
Short-coming	1. The analysis results lack an objective and quantitative approach. 2. There is no clear causal relationship between some of the qualitative descriptions and the climate factors. 3. There needs to be sufficient access to scientific papers to support the results. 4. Insufficient interactive analysis of host plant distribution and potential areas for pest establishment.	1. Operators must have data processing and information tool application capabilities. 2. The process takes more time to confirm the reliability of the data and to validate the accuracy of the model. 3. The quantity and quality of climate variables and distribution samples limit the prediction results of the model. 4. Lack of qualitative explanation, decision makers must have the ability to interpret.

圖十八、防檢署代表說明 MaxEnt 物種分布模型與定性分析方法之風險分析結果與優缺點比較

圖十九、與會人員參觀西班牙研究委員會（CSIC）的 La Mayora 熱帶園藝作物工作站

Torre del Mar, Malaga 2024

2024 Annual Meeting of the International Pest Risk Research Group

Pest risk assessments: Embracing new technologies and understanding socio-economic impacts of plant pests amidst rapid global change

17th – 20th September 2024, Torre del Mar, Malaga, Spain

PROGRAMME BOOKLET

in Association with the Spanish National Research Council and University of Malaga

Dear Attendee,

We are pleased to welcome you to the 2024 annual meeting of the International Pest Risk Research Group, which will be held in the picturesque city of Torre del Mar, Malaga, Spain. Known for its rich history, stunning landscapes, and warm Mediterranean climate, Malaga provides an inspiring backdrop for our important discussions.

This year's theme, *"Pest Risk Assessments: Embracing New Technologies and Understanding Socio-Economic Impacts of Plant Pests Amidst Rapid Global Change,"* is particularly timely as we navigate the challenges of an ever-evolving global landscape. Malaga, with its history of fostering innovation and collaboration, serves as a fitting venue to explore how new technologies and socio-economic considerations can enhance our approach to pest risk assessment.

Spain, with its diverse agricultural sectors and varying climates, offers a unique context for our discussions. The rapid pace of global change, influenced by climate shifts, trade dynamics, and technological advancements, has profound implications for pest management. As we gather in Torre del Mar, we are reminded of the critical need to adapt our strategies to these evolving conditions and to consider the broader socio-economic impacts of plant pests.

Our goal is to advance our collective understanding and application of new technologies in pest risk assessment while also integrating socio-economic perspectives. By bringing together researchers, industry professionals, and policymakers, we aim to build a more holistic and resilient approach to managing pest risks. The insights and collaborations developed here in Malaga will contribute to a more sustainable future, not only for Spain but for the global community.

This year's meeting will focus on the following key topics:

1. Innovations in Pest Risk Modelling

2. Socio-Economic Impacts of Plant Pests

3. Adapting Pest Risk Assessments to Climate Change

4. Policy and Decision Support Tools

5. Stakeholder Engagement in Pest Management

6. Case Studies on Successful Pest Management

7. Emerging Threats in Plant Health

8. Digital Innovations in Pest Monitoring

9. Global Networks for Pest Surveillance

Through these discussions, we intend to foster stronger collaborations across research, industry, and policy spheres, building a foundation for a sustainable future. This collaborative effort will enable us to share innovative strategies and best practices, ensuring a proactive approach to pest risk management in the face of global changes.

As we explore the key themes of this conference, our goal is to pave the way for stronger collaboration and enhanced capacity building in pest risk analysis. We will examine innovative strategies and share best practices that address the dynamic challenges in pest risk management.

We encourage you to engage fully in the discussions, establish meaningful connections, and contribute your expertise to our collective mission. Malaga, with its welcoming atmosphere and rich cultural heritage, offers the perfect setting to foster collaboration and strengthen our efforts in this field.

The upcoming annual meeting of the International Pest Risk Research Group will take place in Torre del Mar. The conference will be hosted at the "La Mayora" research station, in Algarrobo-Costa located, 5 km east of Torre del Mar. This esteemed facility is co-managed by the Spanish National Research Council (CSIC) and the University of Malaga.

This event promises to be a dynamic gathering, bringing together experts from various disciplines to discuss and exchange insights on the latest trends, challenges, and opportunities in pest risk assessment. We are confident that this conference will offer valuable knowledge and networking opportunities that will enrich you both personally and professionally.

This meeting has been made possible through the dedicated efforts of the Spanish National Research Council, the University of Malaga, and Cervantes Agritech. We extend our sincere gratitude to all involved.

We warmly welcome you to this important event and look forward to a productive and inspiring meeting in Torre del Mar. Thank you for joining us in this significant endeavour.

Sincerely,

INTERNATIONAL PEST RISK RESEARCH GROUP EXECUTIVE COMMITTEE

CHAIR: Frank Koch (Research Triangle Park, North Carolina, USA)

VICE-CHAIR: Rose Souza Richards (Nyon, Switzerland)

SECRETARY-TREASURER: Melanie Newfield (Wellington, New Zealand)

COMMUNICATIONS OFFICER: Tomasz Kaluski (Parma, Italy)

STUDENT REPRESENTATIVE: Jessica Kriticos (Canberra, Australia)

POLICY LIAISON OFFICER: Alan MacLeod (York, UK)

LOCAL ARRANGEMENTS ORGANISERS: Eduardo de la Peña, Helena Romero, Mónica Aquilino (Malaga, Spain)

IMMEDIATE PAST CHAIR: Darren Kriticos (Canberra, Australia)

DAY 1 – TUESDAY, SEPTEMBER 17, 2024

Location: The Institute for Mediterranean and Subtropical Horticulture "La Mayora" (IHSM-UMA-CSIC)

12:30pm Shuttle service organized from Torre del Mar to "La Mayora"

13:00 – 14:00PM - LUNCH & REGISTRATION

14:00pm Welcome to the day and local announcements

14:10pm Welcome to IPRRG 2024 – Director & Eduardo de la Peña & Iñaki Hormaza

14:10pm An Overview of IPRRG

14:20pm Introduction - In 30 seconds or less, please introduce yourself by sharing your name, location, organization, and what brings you to this meeting

14:45pm GROUP PHOTO

TECHNICAL SESSION 1: HORIZON SCANNING AND RISK MODELLING

15:00 - 15:30pm Horizon Scanning: A UK Perspective

Presenter: Duncan Allen (York Biotech Campus, Defra, UK)

15:30 – 16:00pm Potential of Generative Models to Model Likely Establishment Locations from Past Reports of First Establishments

Presenter: Wopke van der Werf (Wageningen University, Netherlands)

16:00 -16:30PM COFFEE BREAK

16:30 – 17:00pm Modelling Invasion Risk of Plant Pests Using Self-Organising Maps to Support Pest Risk Assessment Activities

Presenter: Libertad Sanchez-Presa (CABI, UK)

17:00 - 17:30pm Multi-Layer Method for Quantitative Horizon Scanning and Rapid Risk Assessment

Presenter: Joseph Stinziano (Canadian Food Inspection Agency, Canada)

17:30 – 18:00pm EPPO Information on Pests: Where to Find Them, How to Best Use Them?

Presenter: Muriel Suffert (EPPO)

DAY 2 – WEDNESDAY, SEPTEMBER 18, 2024

TECHNICAL SESSION 2: INNOVATIONS IN PEST MONITORING AND MANAGEMENT

08:30am – 9:00am Comparison of Methodologies for Assessing the Risk of Potential Distribution of Quarantine Pests due to Climatic Factors: A Case Study of Taiwan's Qualitative Analysis Method and the MaxEnt Model

Presenter Fang-Yu Ning (Animal and Plant Health Inspection Agency, Ministry of Agriculture, Taiwan)

09:00 – 09:30am New Strategies for Monitoring Pests in Tropical Crops: Insights from DNA Barcoding and Field Surveys

Presenter: Eduardo de la Peña (CSIC, Spain)

09:30 – 10:00am Optimisation of Plant Pest Survey Efforts

Presenter: Tomasz Kaluski (European Food Safety Authority, Italy)

10:00 - 10:30am A Field-Level, Epidemiological Risk Forecast Model for Sclerotinia in Winter Rapeseed in Germany

Presenter: Anto Raja Dominic (Julius Kühn Institute, Germany)

10:30 - 11:00AM COFFEE BREAK

TECHNICAL SESSION 3: POLICY AND DECISION SUPPORT TOOLS

11:00 - 11:30am Identifying the Top Damaging Pests in Country's Cropping Systems: Two Case Studies

Presenter: Gabriella "Gaby" Oliver (CABI, UK)

11:30 – 12:00pm Integrating Plant Pest Risk Registers with National Pest Surveillance Programs

Presenter: Conor Francis McGee (Department of Agriculture, Food and the Marine, Ireland)

12:00 - 13:30PM LUNCH

TECHNICAL SESSION 4: IPRRG EARTH OBSERVATION (EO) SESSION - DEDICATED EO & PEST RISK SESSION

13:30 – 17:00PM (INCLUDING WORKING COFFEE)

1. **Introduction**

Presenter: Tim Beale (CABI)

2. **Anthropogenic climate-modifying pest risk factors: Sketching out the pest risk challenges and the current options for modelling them**

Presenter: Darren Kriticos (Cervantes Agritech)

3. **Current and future uses of Earth Observation data in Pest Risk Assessment:**
   - Outline some existing EO applications
   - Describe some of the latest and future EO products, their opportunities, limitations and relative costs

Presenter: Gerardo Lopez Saldana (Assimila)

4. **Case studies: EO projects improving datasets for pest risk modelling and early warning**
   - Case Study 1: EO4Ag Irrigation data layer
   - Case Study 2: EO4Ag Protected Agriculture data layer
   - Case Study 3: EO4Ag Canopy temperature

- Case Study 4: Wheat Blast project

Presenters: Alex Cornelius (Assimila), Gerardo Lopez Saldana (Assimila), Tim Beale (CABI), Libertad Sanchez Presa (CABI), Darren Kriticos (Cervantes Agritech), Connor McGurk (STFC), Matt Payne (University of Leicester).

5. **Group sessions:**

Logistics are to be confirmed, but based on the group size and available facilities, we will divide the attendees into smaller groups to discuss the key topics outlined below.

A. Collect Feedback on EO4Ag Data Layers

- Discuss potential use cases.

B. Identify Current Data Challenges in Pest Risk Assessment

- Explore data gaps, quality, and availability issues.

C. Explore How EO Technologies Can Support the Assessment of Pest Entry, Establishment, and Spread

- Focus on habitats, pathways, and climate factors.

D. Assess How EO Technologies Can Aid in Evaluating Pest Impact

- Consider impacts on hosts, damage, and crop yield.

E. Investigate How EO Technologies Can Support Pest Management

- Address management strategies concerning hosts, damage, and crop yield.

REGROUP, REPORT BACK, AND SUMMARIZE DISCUSSIONS

NOTE: The project team intends to draft a stakeholder engagement report after the session. If there is interest from IPRRG members, this effort could potentially be expanded into a publication. We should also explore methods for developing a paper based on insights from stakeholder workshops.

17:00 - 18:00: SOCIAL PROGRAMME: MANGO TASTING

DAY 3 - THURSDAY, SEPTEMBER 19, 2024 - EXCURSION - HOURS ARE TENTATIVE

9:00am - 12:00pm - Visit to the historical village of Frigiliana in the Axarquía - https://www.andalucia.org/en/frigiliana

12:00 - 14:00PM LUNCH

14:00 – 17:00pm - Visit to la Mayora Experimental Station and germplasm collections of subtropical fruit crops

19:00PM CONFERENCE DINNER AT THE SEASIDE

DAY 4 – FRIDAY, SEPTEMBER 20, 2024 (HALF DAY):

TECHNICAL SESSION 5: CASE STUDIES ON PEST MANAGEMENT

08:30 - 09:00am Utilizing Population Dynamics to Optimize Integrated Pest Management (IPM) Strategies: *Phthorimaea absoluta* on Tomatoes in Kenya Case Study

Presenter: Alyssa Lowry (CABI, UK)

09:00 - 09:30am Comparing Inward and Outward Strategies for Delimiting Non-Native Plant Pest Outbreaks

Presenter: Hongyu Sun (Wageningen University, Netherlands)

09:30 - 10:00am Assessing Potential IPM Strategies for Cabbage Stem Flea Beetle and the Implications from Climate Change in the UK

Presenter: Catherine Bradshaw (Met Office Hadley Centre, UK)

10:00 - 10:30AM COFFEE BREAK

10:30 - 11:00am Approaches to Estimating Factors Contributing to Yield Losses in the Global Burden of Crop Loss Project

Presenter: Anna M Szyniszewska (CABI, UK)

11:00 - 11:30am Prioritizing Species from the List of EU Quarantine Pests for a Full Analysis

Presenter: Kevin Schneider (European Commission, Spain)

TECHNICAL SESSION 6: POSTER/FLASH TALK SESSION

11:30 – 11:45am Towards Sustainable Coffee Farming: Enhancing CBB Control Using Earth Observation Data and Predictive Modelling

Presenter: Alyssa Lowry

11:45am – 12:00pm Characterization of Arthropod Species Associated with Mango and Cherimoya in a Mediterranean Context

Presenter: Helena Romero

12:00 - 12:15pm Knowing the Full Value of the Trees in Your Country - A Review for Environmental Risk Assessments of Non-native Plant Pests in Sweden

Presenter: Johanna Boberg

12:15 – 12:30pm CLIMEX and DYMEX 4.1: New Advances and Strategic Outlook for an

Important PRA Toolkit

Presenter: Darren Kriticos

12:30 – 13:30pm IPRRG business meeting, Executive Committee election results, discussion about the next venue for the annual IPRRG meeting

13:30 Lunch

ORAL PRESENTATION/POSTER ABSTRACTS

(ARRANGED IN ORDER OF PRESENTATION)

TECHNICAL SESSION 1: HORIZON SCANNING AND RISK MODELLING

Horizon scanning: a UK perspective

Authors: Duncan Allen[1]

York Biotech Campus, Defra, Room 11G19, Sand Hutton YO411LZ United Kingdom[1].

Presenting Author's email: Duncan.Allen@defra.gov.uk

This presentation will be an introduction to our approach to horizon scanning in the UK. What it is, and how do we go about it. I will describe the different information sources that are used while horizon scanning and give examples of pests and diseases that have been found via horizon scanning. I will also explain how collected information is processed and how decisions are made on which pests to follow up using the UK Plant Health Risk Register as a rapid screening tool, along with some examples of Pest Risk Analyses that have been conducted as a result of horizon scanning activities. I will highlight some of the more serious pests that have become regulated in the UK's plant health legislation as a result of horizon scanning efforts and look ahead to technologies that can support horizon scanning. I will close with a brief overview of the International Natural Hazard Forward Look and how the Defra Risk and Horizon scanning team intend to contribute to this cross government forward look of potential international hazards.

Potential of generative models to model likely establishment locations from past reports of first establishments

Authors: Robbert T van den Dool[1], Alejandro Morales[1], Wopke van der Werf[1], Jacob C Douma[1]

Wageningen University, Centre for Crop Systems Analysis, Wageningen University, Centre for Crop Systems Analysis, P.O. Box 430, 6700 AK Wageningen, The Netherlands[1]

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Non-native tree pests impact the health of perennial crops, ornamental trees and forest trees. Understanding where first establishment occurs and characterizing the attributes of these locations can help shift management attention to areas that are most at risk, thus allocating resources more efficiently. Earlier analyses have suggested that areas that are heavily influenced by human activity are more at risk of establishment of new exotic pests. Especially cities are most likely first establishment sites. Since most observations of first establishments are accidental, and non-observations are not recorded, the data are presence-only with a likely bias towards areas with increased sampling intensity, usually areas with higher human density. Conclusions from such data may be wrong if no allowance is made for the sampling bias. In a recent 4-year project, we explored the potential of generative models to model likely establishment locations from past reports of first establishments. Generative models are composed of a model for the attributes of the actual establishment reports and another model for the attributes of locations where observations are likely to be made, e.g. due to proximity to cities, or based on records such as GBIF. The two models are combined into a final model for likely establishment locations

based on the application of Bayes' rule. In the presentation we will explain the methodology and show its application to correcting for sampling bias.

Modelling invasion risk of plant pests using Self-Organising Maps to support pest risk assessment activities

Authors: Libertad Sanchez-Presa[1], Tim Beale[1], Hannah Fielder[1], Lucinda Charles[1], Roger Day[1]

CABI, Wallingford, United Kingdom[1]

Presenting Author's email: l.sanchez@cabi.org

Horizon scanning activities that identify potential plant health threats to a country or region can generate long and unmanageable lists of pest species. With limited resources, organisations responsible for pest risk assessment and management cannot address them all. To prioritise long lists of pests with the potential to invade or establish in an area, we used Self-Organising Maps (SOM), an artificial neural network model used to identify pest species assemblages and identify species that have the potential to invade a particular geographical area. We modelled the risk of invasion of pests to an area to monitor the pests that represent a high risk of invasion or are possibly already present in an area but not yet identified. A global data set extracted from CABI's Distribution Database comprising 182,535 records in 485 geographic areas and 8,492 pests containing insects, fungi, microbes and other groups except weeds were included in the analysis. SOMs allowed us to identify areas with similar pest assemblages and determine the potential risk of invasion of pests based on their strength of association with other species within the clusters of geographical areas. We tested this method with plant health experts in Ghana, Kenya and Zambia and assessed the suitability of this method for broad-scale pest risk assessment and prioritisation.

Multi-layer method for quantitative horizon scanning and rapid risk assessment identifies several high priority candidates for formal risk assessment from an initial list of over 10,000 species

Authors: Joseph R Stinziano[1], Wanying Zheng[1], Megan Abergel[1], Martin Damus[1].

Plant Health Science Directorate, Canadian Food Inspection Agency, Ottawa, Canada[1]

Presenting Author's email: joseph.stinziano@inspection.gc.ca

Wood-boring beetles are a significant threat to forests, imposing high economic and environmental costs. With a high level of biodiversity, it is difficult to assess all wood-boring beetles for their potential to invade a particular region, making horizon scanning a viable option for prioritizing targets. While horizon scanning has the potential to focus risk assessment and regulatory efforts, it is often conducted in a resource-intensive manner, creating potential blind spots in the horizon scan due to resource constraints. Here we use a multi-layered horizon scan, including Self-Organizing Maps and climate suitability modeling combined with rapid risk assessment, to produce a short-list of high priority wood-boring beetles for formal risk assessment in Canada. This method relies entirely on open-source data and is readily applicable to any country. From an initial list of 10,824 species with available observations, our method yielded short lists of between 9 and 13 species, representing a 99.9% target reduction efficiency. As well, the method can identify

already-regulated species within Canada as priority targets, suggesting that this method is appropriate for identifying potential regulatable pests and suggests that formal risk assessment procedures in Canada have successfully identified between 22% and 46% of the highest-priority wood boring beetle pests. The primary limitations on the method are the availability of confirmed established species occurrence data, relevance of climate norms for species establishment, available data for rapid risk assessment, and available computational power.

EPPO information on pests: where to find them, how to best use them?

Authors: Muriel Suffert[1]

EPPO[1]

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EPPO is a Regional Plant Protection Organization covering 52 countries in Europe, the Mediterranean Basin and Central Asia. To help its member countries address pest risks, EPPO collects and process information on regulated and emerging pests. The presentation will briefly present the lessons learned from the EPPO datasheets projects during which 321 datasheets of regulated pests were revised over 4 years. We will also present the different EPPO databases that may be useful for pest risk analysts (EPPO Global Database, EPPO Platform of PRAs), and useful tips to make best use of them. We will finally present the online tools that have been developed to help assessors in their tasks (e.g. produce pest lists, check quarantine status in other countries), as well as the future plans. We will welcome feedback of users to continue improving our databases and tools.

TECHNICAL SESSION 2: INNOVATIONS IN PEST MONITORING AND MANAGEMENT

Comparison of Methodologies for Assessing the Risk of Potential Distribution of Quarantine Pests due to Climatic Factors: A Case Study of Taiwan's Qualitative Analysis Method and the MaxEnt Model

Authors: Fang-Yu Ning[1,2], Po-Kuan Lu[3], Chun-Hung Chen[1], Jhih-Rong Liao[4]

Plant Quarantine Division, Animal and Plant Health Inspection Agency, Ministry of Agriculture, Taipei City, Taiwan[1]; Department of Entomology, National Taiwan University, Taipei City, Taiwan[2]; Hualien Inspection Station, Keelung Branch, Animal and Plant Health Inspection Agency, Ministry of Agriculture, Hualien City, Hualien County, Taiwan[3]; Systematic Zoology Laboratory, Department of Biological Sciences, Tokyo Metropolitan University, Hachioji City, Tokyo, Japan[4]

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Taiwan conducted Pest Risk Analysis (PRA) for imported plant products by a qualitative analysis method. This method evaluates the consequences and likelihood of harmful organisms being introduced. Recently, Species Distribution Models (SDMs) have gained recognition for assessing habitat suitability of invasive organisms, focusing on climate factors and host plant interactions. It is important to note that habitat suitability represents the suitability of the environment for the organism's survival, not a direct

reflection of invasion risk. This study targets five quarantine pests (Anarsia lineatella, Ceratitis capitata, Cydia pomonella, Dasineura mali, and Grapholita molesta) using the MaxEnt model to predict their potential suitable habitat distribution in Taiwan. We compare these predictions with current PRA results. The qualitative analysis primarily evaluates biogeographic realm, host distribution and temperature impacts on their developments, lacking objective analysis process of other climatic factors and host plant interactions. In contrast, the MaxEnt model provides accurate potential distribution predictions through computer mapping, combining with township distribution maps of host plants. Integrating quantitative analysis techniques with current qualitative methods is essential for future PRA optimization.

New strategies for monitoring pests in tropical crops: Insights from DNA barcoding and field surveys

Authors: Helena Romero[1], Mónica Aquilino[2], Rosario Planelló[2], Eduardo de la Peña[1].

Instituto de Hortofruticultura Subtropical y Mediterránea "La Mayora" (IHSM-UMA-CSIC) Spanish National Research Council (CSIC), Finca Experimental La Mayora, Algarrobo-Costa, Málaga, 29750, Spain[1]; Entomology, Biomarkers and Environmental Stress Group, Faculty of Science, Universidad Nacional de Educación a Distancia (UNED), 28232, Las Rozas de Madrid, Spain[2]

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The early detection and monitoring of crop pests are crucial for preventing the introduction and spread of phytophagous pests and ensuring their effective management. Traditional sampling surveys and morphological identification methods pose significant challenges, especially for pest species from unexplored or hyper-diverse regions, such as tropical areas. Molecular techniques, such as DNA barcoding, have revolutionized the characterization of insect communities, offering an efficient alternative for pest identification. However, the use of DNA barcoding for detecting quarantine or regulated pest insect species still requires validation under realistic field conditions. In recent years, the increasing global demand for tropical crops, such as mango and cherimoya in Europe, has led to a rise in the import of fruits and plants for planting, which heightens the risk of introducing new pests that could also affect native crops. Therefore, it is essential to establish effective detection protocols for pest surveys in these areas. The main aim of this study was to assess the diversity of phytophagous insects associated with mango and cherimoya in production orchards in a Mediterranean context and to validate the use of DNA barcoding for detecting two specific pest species: Aulacaspis tubercularis in mango and Parasaissetia nigra in cherimoya. Through several field surveys, we visually examined trees and identified the presence of these pests in several production orchards. Simultaneously, we conducted non-specific field samplings using Malaise traps to sample insect macro-communities occurring in the same orchards. These samples were then analyzed using DNA barcoding to determine whether these two species or other relevant pests were present. The results of the two approaches will be discussed, highlighting the pros and cons of these detection methods.

Optimisation of plant pest survey efforts

Authors: Tomasz Kaluski[1], Sybren Vos[1]

European Food Safety Authority, Parma, Italy[1]

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The European Food Safety Authority (EFSA) has been mandated by the European Commission (EC) to support Member States (MSs) in the planning and designing of plant pest surveys. In response to this mandate, EFSA has developed a suite of tools and guidelines, including general and specific guidelines, Pest Survey Cards, the Risk-based Pest Survey Tool (RiPEST), and the multipest optimisation tool (OptiPest).

While RiPEST allows users to design for each pest statistically sound and risk-based surveys, the OptiPest tool, launched in July 2024, represents a significant advancement in the optimisation of survey efforts as it is designed to help MSs make better use of available resources by optimizing the allocation of survey efforts when surveying for multiple pests within a same crop.

To support the implementation and effective use of these tools, EFSA has scheduled a series of training sessions. These include a Network meeting in October, a Better Training for Safer Food (BTSF) training session in September, and a dedicated workshop focusing on the surveys of pests affecting broadleaved trees, citrus, and potatoes. These training sessions aim to enhance the capacity of MSs to conduct risk-based and optimised pest surveys, contributing to better pest management and protection of plant health in the European Union

A field-level, epidemiological risk forecast model for sclerotinia in winter rapeseed in Germany

Authors: Vera Krause[1], Nazanin Zamani-Noor[2], Lena Müller[3], Kathleen Kohrs[3], Julianne Schmitt[3], Anto Raja Dominic[4]

Julius Kühn Institute, Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assesment, Stahnsdorfer Damm 81, Kleinmachnow, Germany[1]; Julius Kühn Institute, Federal Research Centre for Cultivated Plants, Institute for Plant Protection in Field Crops and Grassland, Braunschweig, Germany[2]; Central Institute for Decision Support Systems in Crop Protection, Bad Kreuznach, Germany[3]; Julius Kühn Institute, Federal Research Centre for Cultivated Plants, Institute for Strategies and Technology Assesment, Stahnsdorfer Damm 81, Kleinmachnow, Germany[4]

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Sclerotinia stem rot, caused by Sclerotinia sclerotiorum, poses an increasing threat to winter oilseed rape (Brassica napus) in Germany, potentially reducing yields by 20-30%. Decision Support Systems (DSS) for pest management offer field-specific recommendations to reduce pesticide use and optimize yields. However, the performance of the current Sclerotinia risk forecasting model, SkleroPro, has declined under the changing climatic conditions. We introduce an improved model that enhances prediction accuracy for fungicide application recommendations during flowering. This new model incorporates a phenological model based on daily temperature and photoperiod to simulate the BBCH flowering phases. Additionally, we developed a sclerotia germination and spore availability *module using the random forest algorithm to identify key weather variables influencing sclerotia germination. A generalized linear model then predicts infection risk using daily maximum temperatures and relative humidity levels of specific time windows.*

Our model assumes spores can survive up to 7 days post-germination, when infection is possible under optimal conditions. We also adjusted infection thresholds to account for crop rotation effects. Testing on data from 2020 to 2023 demonstrated the phenological model's accuracy in predicting flowering stages (BBCH 58-69) within ±4 days, starting simulations on February 1st. The enhanced SkleroPro model achieved a 78% accuracy rate in predicting Sclerotinia infections and recommending fungicide applications. These improvements promise more precise and timely fungicide treatments, reducing unnecessary sprays and yield losses. Field trials in 2024 are planned to validate the model before its DSS implementation.

TECHNICAL SESSION 3: POLICY AND DECISION SUPPORT TOOLS

Identifying the top damaging pests in country's cropping systems: two case studies

Authors: Gabriella "Gaby" Oliver[1], Anna Szyniszewska[1], Tim Beale[1], Alyssa Lowry[1], Alice Milne[2], Andrew Mead[2], Richard Hull[2], Sarah Gilhespy[2], Dan Bebber[3]

CABI, Wallingford, UK[1]; Rothamsted Research, Harpenden, UK[2]; University of Exeter, Exeter, UK[3]

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Identifying the pests causing the majority of the damage in a cropping system in a particular location with data-based evidence presents a significant challenge due to a lack of systematic surveillance and knowledge gaps. This presentation intends to explore some of the challenges and opportunities involved in developing an effective pest ranking system, with insights drawn from two distinct case studies conducted by the Global Burden of Crop Loss project. Key considerations such as data collection and integration will be examined. We identify sources of information available to determine the distribution, incidence, and potential impact of pests on crops. Two pest impact ranking studies are presented: one focusing on wheat conducted across three European countries, the UK, France, and Germany. The process involves reviewing pest species of wheat retrieved from CABI Crop Protection Compendia (CPC) and identifying those present in selected regions, reviewing literature on reported pest impact on yield, and seeking information from reputable reports and expert opinions to identify the top species. The second case study focuses on the top pests affecting maize in Kenya. We integrate a range of data and proxies to estimate the relative importance of the species, including a literature review on pest distribution and impacts, climatic niche models, and CABI Plant Clinics data. This segment underscores the methodological adaptations of pest ranking with differing available data sources. Through these case studies, the presentation aims to explores the opportunities and methodologies in identifying the most impactful pests using data and data proxies.

Integrating plant pest risk registers with national pest surveillance programs

Authors: Conor Francis McGeea[1]

Pest risk analysis unit, Plant Sciences Division, Department of Agriculture, Food and the Matine, Ireland[1]

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The Irish pest risk analysis unit (PRAU) was recently tasked with assessing the risk posed to Irish biosecurity by the EU quarantine plant pests listed in EU Reg 2072/2019. The Irish NPPO is required to undertake surveillance for EU quarantine pests on a multi-annual basis over 7-years period to comply with EU legislation unless it can be justified that the Irish climate is unsuited to the pest's biology or host plants are not cultivated in Ireland. The PRAU used this opportunity to develop a national pant pest risk register for EU quarantine pests, align it with national pest surveillance activities and integrate it with plant health inspector training. The aim of the Irish plant pest register was to (1) assess each pest's climatic tolerances using a combination of qualitative assessment and quantitative climatic matching to determine their ability to complete a lifecycle in the Irish climate (2) analyse the known host plants to identify the most high-risk plants to improve efficacy of surveillance activities. The pest risk rating and justification given by the PRAU was made available to plant health inspectorate divisions for justification of their pest selection for the EU multi-annual surveillance program. The goal of this project was to (1) improve inspection efficacy by selecting only relevant pests for surveillance and targeting these inspections at the most relevant plant sectors (2) make the risk register a public live database and (3) develop plant pest booklets covering the relevant pests to aid inspectors in the field when undertaking surveillance activities.

TECHNICAL SESSION 5: CASE STUDIES ON PEST MANAGEMENT

Utilizing population dynamics to optimise Integrated Pest Management (IPM) strategies - *Phthorimaea absoluta* on Tomatoes in Kenya case study

Authors: Alyssa Lowry[1], Bryony Taylor[1], Charlotte Day[1], Tim Beale[1], Joe Beeken[1], Suzy Wood[2], Jackline Chirchir[3], Stacey Odunga[4], Mary-Lucy Oronje[4].

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Phthorimaea absoluta, a notorious pest of tomato crops, has become a significant threat to tomato production in Africa, causing severe yield losses and economic damage. This study investigates the within-season population dynamics of Phthorimaea absoluta on tomatoes at in Kenya from 2019 to 2022, encompassing both short and long rain seasons. Utilizing EO data to model pests in the field, our research aimed to understand the temporal patterns of P. absoluta adults and larvae to inform better Integrated Pest Management (IPM) strategies. Results indicated that adult P. absoluta populations were consistently high from the time of planting, whereas larval populations, which are the primary damaging stage, took significantly longer to accumulate. Currently, IPM practices rely on adult P. absoluta numbers as the main indicator for initiating control measures, such as spraying. However, our findings demonstrate that adult trap catches do not directly correlate with larval numbers, particularly during the initial stages of infestation.

Therefore, relying on adult trap data may lead to mistimed interventions. We recommend that larval-specific scouting be incorporated into pest management protocols to accurately determine the appropriate timing for control actions. This adjustment in monitoring practices could lead to more effective and timely management of P. absoluta, ultimately reducing the damage to tomato crops and improving yields. Our study underscores the importance of understanding the pest specific life cycle when attempting to understand within season pest risk, when developing responsive and effective IPM strategies for P. absoluta in Kenyan tomato cultivation.

Comparing inward and outward strategies for delimiting non-native plant pest outbreaks

Authors: Hongyu Sun[1], Jacob C Douma[1], Martijn F Schenk[2], Wopke van der Werf[3].

Wageningen University and Research, Centre for Crop Systems Analysis, P.O. Box 430, 6700 AK Wageningen, The Netherlands[1]; Netherlands Food and Consumer Product Safety Authority (NVWA), P.O. Box 43006, 3540 AA Utrecht[2]; The Netherlands, Wageningen University and Research, Centre for Crop Systems Analysis, P.O. Box 430, 6700 AK Wageningen, The Netherlands.

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The delimitation of outbreaks is an essential step in the containment and eradication of non-native plant pests. Outbreaks are habitually delimited by sampling around the initial finding, moving away from this locus in several directions as long as infestations are found (outward strategy). An alternative, inward, strategy would entail starting delimitation with an initial estimate of the location of the frontier, and then sampling inward until the first infestations are found or outward until no more infestations are found. We used individual-based modelling to compare the effectiveness and sampling effort of the two strategies. Both strategies successfully contained > 99% of infested plants within the delimited infested zone, but both also had a low probability (< 15%) of enclosing all the infested plants. The number of samples of the inward strategy depended greatly on the size of the initially hypothesized infested zone. Best performance of this strategy was obtained with an accurate initial estimate of the infested zone width while the number of samples was quite high if the initial estimate was far beyond the true location of the frontier. On average, the outward strategy used fewer samples than the inward strategy. Both strategies were prone to error when delimiting outbreaks caused by pests with fat-tailed dispersal. Whether the inward or outward strategy is more effective depends on the certainty about the true position of the leading frontier of the outbreak. Possibilities are discussed for maximizing the cost-effectiveness of sampling for outbreak delimitation.

Assessing potential IPM strategies for cabbage stem flea beetle and the implications from climate change in the UK

Authors: Catherine Bradshaw[1], Holly Alpren[2]

Met Office Hadley Centre, Exeter, UK & The Global Systems Institute, University of Exeter, Exeter, UK[1]; Evidence and Analysis team in Chemicals, Pesticides and Hazardous Waste, DEFRA, UK[2]

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Oilseed rape is a major source of vegetable oil and biodiesel feedstock. The crop is subject to biotic stresses from 16 diseases, 37 insect pests, nematodes, slugs, and snails, but Cabbage stem flea beetle (CSFB), Psylliodes chrysocephala, is ranked the top major pest of winter oilseed rape in Europe. In the past, early immigrating adults were controlled by neonicotinoid seed treatments, however, the ban of neonicotinoids in the European Union in 2013 meant that there was a shift to synthetic pyrethroids and early invading beetles have more time to cause damage. However, there is now thought to be widespread resistance against pyrethroids. Some UK populations of CSFB now have 100% resistance and as a result production of oilseed rape has markedly declined and there has been a lot of focus on potential alternative IPM strategies.

A simple proof-of-concept case modelling study has been conducted for CSFB in oilseed rape, in which the impacts of temperature have been incorporated into some aspects of the lifecycle of the pest, and a predator and a set of IPM strategies have been tested under present day climate and under a potential future climate scenario. The results show that IPM strategies are likely to be crucial for CSFB control in the absence of neonicotinoids or a suitable alternative pesticide, and that a combination of IPM strategies is likely to be required as the climate warms.

Approaches to estimating factors contributing to yield losses in the Global Burden of Crop Loss project

Authors: Anna M Szyniszewska[1], Salar Mahmood[1], Gaby Oliver[1], Edward Lavender[2], Dan Bebber[3], Alice Milne[4], Nicola Pounder[5], Cambria Finegold[1], Bryony Taylor[1]

CABI, Wallingford, UK, ETH-Bereichs, Eawag, Switzerland[2], University of Exeter, Exeter, UK[3], Rothamsted Research, Harpenden, UK[4], Assimila, Reading, UK[5]

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Agricultural activities contribute significantly to global greenhouse gas emissions, with the expansion of land use for food production further exacerbating environmental pressures. FAO estimates that pests reduce global crop production by 20% to 40%. However, precise data on the magnitude and causes of yield loss tend to be outdated, lack broad spatio-temporal coverage and are often based solely on expert opinion. While crop loss due to biotic and abiotic factors causes significant impacts on food systems globally, we lack robust, actionable evidence on the problem. We present our framework for estimating attainable yield in local context for maize, yield loss and apportioning losses to abiotic and biotic factors. We also present the framework and data opportunities for estimating the contribution of individual pests to the losses.

Prioritizing species from the List of EU Quarantine Pests for a full analysis

Authors: Kevin Schneider[1], Estefania Vazquez Torres[1], Emilio Rodriguez-Cerezom[1], Jesus Barreiro-Hurle[1]

European Commission, Joint Research Centre, D4 Economics of the Food System[1]

Presenting Author's email: kevin.schneider@ec.europa.eu

The Commission adopted Commission Delegated Regulation (EU) 2019/1702, establishing a list of Union Quarantine pests, which qualify as priority pests, as by Article 6(2) of

Regulation (EU) 2016/2031 on protective measures against pests of plants. This list of pests was partially based on scientific evidence generated through the I2P2 model, which requires a time-consuming expert-knowledge elicitation process. Here, we present work that aims at assessing the full List of EU Quarantine Pests for supporting a decision on regulation at EU-level. As full-fledged I2P2 analyses on all 400 organisms are not feasible, a shortlisting step is required to inform the decision-making process on which pests should be analysed in detail. EFSA compiled a database on hosts for all pests on the list, which we subsequently linked to the entire Eurostat and FAOstat databases and national forestry surveys to obtain data on area, production, and prices. Furthermore, EFSA constructed an index of pests' invasiveness based on scientific information. We ranked pests based on a composite index for two scenarios: i) host value and invasiveness, and ii) host area and invasiveness. We assessed robustness of these rankings via different scenarios of host ranges. The top-ranked pests were subsequently discussed by the Member States and a subset was requested for a full-fledged I2P2 analysis. Our results highlight how data-driven approaches may support the decision-making process by guiding attention toward a subset of species.

TECHNICAL SESSION 6: POSTER/TALK SESSION

Towards Sustainable Coffee Farming: Enhancing CBB Control Using Earth Observation Data and Predictive Modelling

Authors: Alyssa Lowry[1], Steve Edgington[2], Gerardo Lopez Saldana[3], Lawrence Whittaker[4], Pablo Gonzales[5], Laura Jaramillo[6], David Quintero[6], Sean Murphy[7]

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Coffee Berry Borer (CBB) is the most damaging insect pest of coffee worldwide, causing an estimated $500 million in damages to the coffee sector annually. Despite extensive research, particularly over the past 20 years, CBB remains notoriously difficult to control. This challenge stems from its life cycle, as the pest predominantly resides inside the coffee berry, rendering most pesticides and bio-controls ineffective. The current study builds on a system developed during a pilot program in 2019 in Aguadas, a key coffee-growing region in Caldas, Colombia. The initial modelling system utilizes Earth Observation (EO) data to predict the emergence patterns of CBB, aiming to improve targeted intervention strategies. By analysing environmental factors such as temperature, humidity, and crop growth indices, we developed a robust system that forecasts CBB emergence, allowing for more precise timing of control measures. Preliminary results from the pilot program indicate that the EO-based model significantly enhances the accuracy of predicting CBB emergence. Building on these findings, the next phase of the program is returning to Caldas, Colombia, to pilot the model's outputs with the original cohort of farmers. In addition phase two aims to further improve the use of bio-pesticides by utilizing predictive EO products, such as rainfall and temperature data, to inform farmers of the optimal time to apply these control measures for maximum efficacy. This will be implemented alongside the original system to provide a comprehensive approach to the management of CBB. These efforts seek to refine and expand the application of EO-based modelling for more effective management of CBB, promoting sustainable coffee farming practices.

Characterization of arthropod species associated with Mango and Cherimoya in a Mediterranean context

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Understanding plant-arthropod interactions within specific geographical contexts is essential for effective crop management. By doing so, targeted management practices can be implemented for pest control while minimizing impacts on other functional groups crucial for crop management, such as pollinators and natural enemies of pests. The demand for tropical fruits like mango and cherimoya has risen in Europe in recent years, leading to an increase in the importation of fruits and planting material. This activity heightens the risk of introducing new pests, which could negatively impact native crops. Additionally, native arthropod species may also become pests of these introduced crops. In this study, we aimed to characterize the arthropod diversity associated with mango and cherimoya in Mediterranean orchards to better understand the potential risks and inform sustainable pest management strategies. We utilized Malaise traps for macro-community sampling and DNA barcoding for species identification. Here, we present the initial results of this approach.

Knowing the full value of the trees in your country - a review for environmental risk assessments of non-native plant pests in Sweden

Authors: Víťa Maňák[1], Niklas Björklund[2], Sebastian Sundberg[1], Johanna Boberg[2]

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Plant pests, particularly non-native species, can have a profound impact on their host plants. Trees are the foundation of forest ecosystems and also serve as important structures in agricultural landscapes and urban areas. In Sweden, forests cover around 70% of the land area and serve as an important natural resource for both the economy and the environment. Consequently, introductions of non-native tree pests can not only cause significant economic impact but also far reaching environmental damage by affecting the biodiversity and ecosystem services provided by trees and forests. When conducting PRAs, there are general guidelines for the assessment of the potential impact a new pest could cause, including economic, environmental, and social aspects. There is, however, no consensus of how environmental assessments in PRAs should be performed and generally there is a need for a more comprehensive understanding of the environmental consequences of plant pest invasions.

The aim of this review was to summarize the main values provided by trees to provide guidance for estimating risks in the context of pest risk assessments. We compiled the

available information on i) the biodiversity associated with different tree species and ii) the ecosystem services to which different trees contribute for all major tree and shrub species in Sweden.

CLIMEX and DYMEX 4.1: New advances and strategic outlook for an important PRA toolkit

Authors: Darren J. Kriticos, Tania Yonow, Lauren Glina, and Jessica M. Kriticos

Cervantes Agritech

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The latest versions of CLIMEX and DYMEX include an exciting series of new features and functions, as well as exceptional performance enhancements. At the time of this presentation the software has been released for beta testing, with a commercial release expected within a month. While the most immediate apparent difference is the facelift to the interface, most of the advances are beneath the surface, addressing usability issues and extending the capability of the tools. Since taking over responsibility for the development of CLIMEX and DYMEX, Cervantes Agritech has invested heavily in upgrading these software packages and has committed to a new program of relatively frequent software updates. In this presentation we briefly describe the new features and functionality in V4.1 and outline exciting developments

Comparison of Methodologies for Assessing the Risk of Potential Distribution of Quarantine Pests due to Climatic Factors:

A Case Study of Taiwan's Qualitative Analysis Method and the MaxEnt Model

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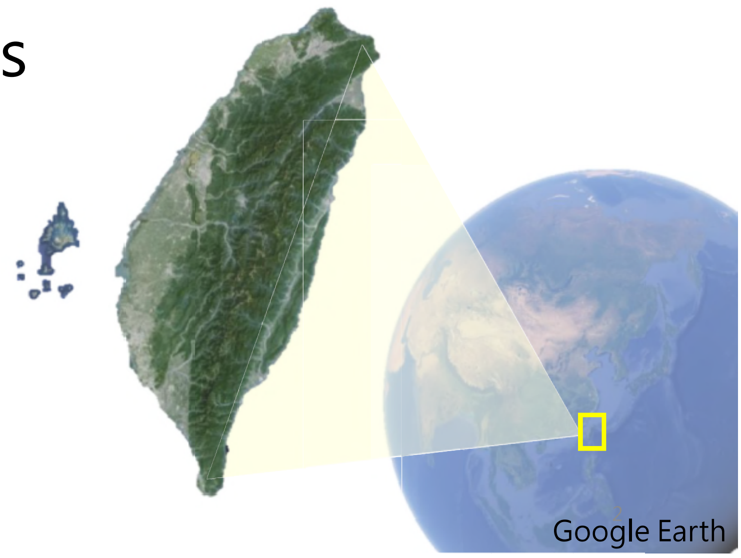
Figure from Dr. C. C. Chen

Outline

- Introduction
- Material and Methods
- Results
- Conclusion and Recommendation



Qualitative Analysis Method of PRA in Taiwan

Pest Risk Potential = Likelihood of Introduction + Consequences of Introduction

Pest	Risk Element 1 (climate/host interaction)	Risk Element 2 (host range)	Risk Element 3	……	Cumulative Risk Rating
	L, M, H (1, 2, 3)	L, M, H (1, 2, 3)	L, M, H (1, 2, 3)		

（ISPM 2、ISPM11）

Deconstructing the Completed PRA Reports in Taiwan - A Case Study of Mediterranean Fruit Fly[1]

Risk Element 1 (climate/host interaction)

地中海果實蠅目前已分布於全球五大洲，包括歐洲、非洲、中南美洲大部份國家、澳洲、夏威夷、馬里亞納群島、西亞及中東地區，顯然已適應熱帶和溫帶地區各種天候環境及各種寄主植物相。在溫暖地區果實無缺的情形下，地中海果實蠅全年均可繁殖；於涼冷地區，則在冬季以蛹或成蟲越冬。成蟲產卵在寄主果皮下，卵孵化後幼蟲在果內取食，幼蟲老熟後離開寄主進入土中化蛹，成蟲羽化後爬出土面。在26℃時，卵期2-3天，幼蟲期6-10天，發育時間依季節氣溫高低而有差異，蛹期10-12天。成蟲壽命約2個月，氣溫高則縮短，氣溫低則延長。成蟲在低於12.8℃或高於36.1℃不會羽化，每年發生1-12代，因地區而異。台灣的氣候溫和，同時具有熱帶、亞熱帶和溫帶寄主植物之分布，應極適合地中海果實蠅的立足及繁衍。因此，此項風險因子評定等級為高(3分)。↵

世界生物地理分布區 (Biogeographic realm) and 昆蟲分布(insect distribution)

滯育 (diapause)

發育起點 (developmental / growth threshold)

生理時間 (physiological time)

化性(Voltinism)

寄主植物之分布(host plant distribution)

Deconstructing the Completed PRA Reports in Taiwan - A Case Study of Mediterranean Fruit Fly[2]

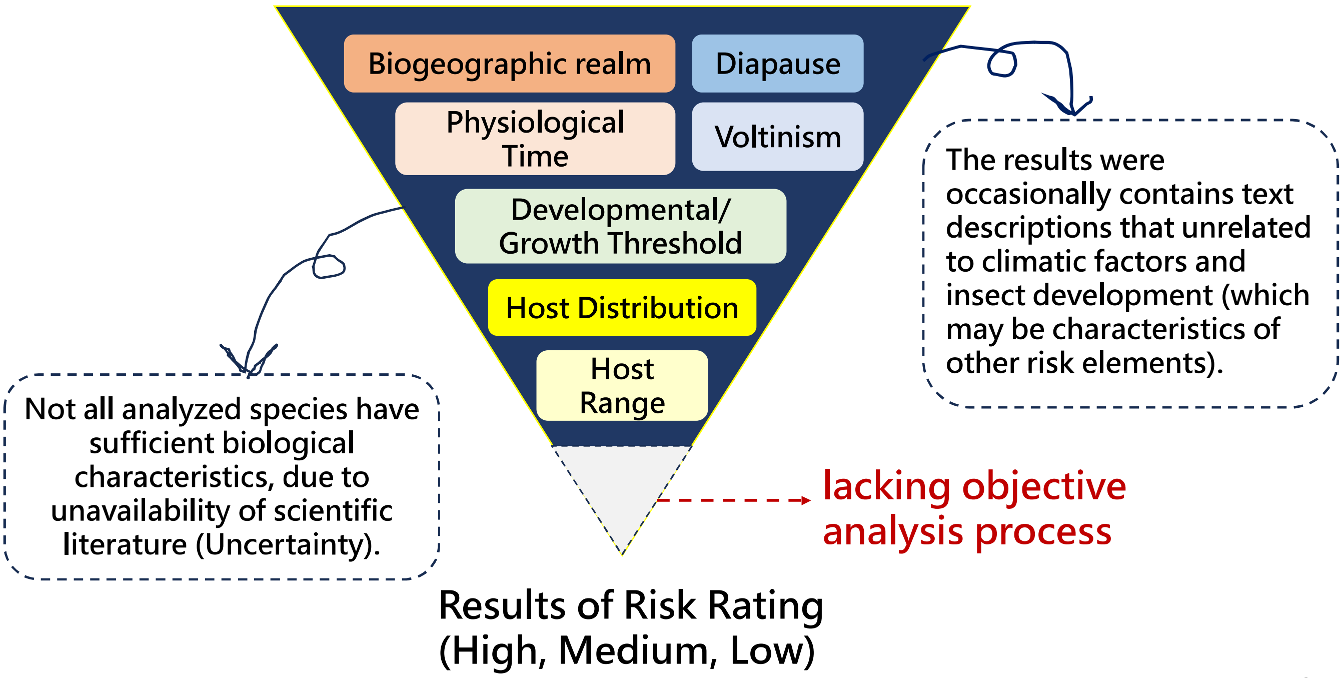
Risk Element 2 (Host range)

寄主範圍廣泛，計有67科353種，其中40%歸屬在5個科中，包括桃金孃科(Myrtaceae)佔6%、薔薇科(Rosaceae)佔10%、芸香科(Rutaceae)佔9%、山欖科(Sapotaceae)佔9%和茄科佔6%。在野外的調查中紀錄受地中海果實蠅為害的寄主則有200餘種(趙，1982；梁&姚，1998；CABI 2018；EPPO 2018)。在歐洲地區主要危害作物為蘋果、柑桔、酪梨、奇異果、芒果、梨、桃。此項風險因子評定為高(3分)。

自然條件及非自然條件下的植物寄主
(natural host and conditional host)

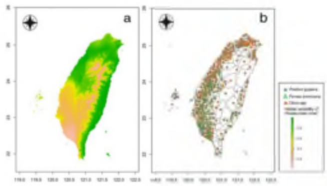
自然條件下的植物寄主
(natural host)

After analyzing 34 reports……

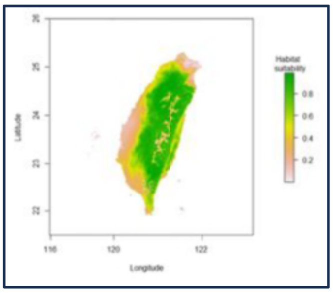


The MaxEnt model as a quantitative tool for assessing habitat suitability of invasive organisms

- The MaxEnt model was first published by Phillips *et al.* in 2004 and has been improved and refined over the past 20 years and is now widely used in biogeography, ecological conservation, and invasive biology.
- MaxEnt is one of the most popular ENM methods because of its high accuracy and the fact that only occurrence data for the predicted species are required.
- Yeh *et al.* (2021) applied MaxEnt to predict habitat suitability for six potentially invasive species to inform further monitoring.



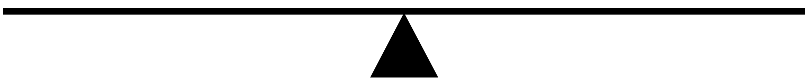
Objective



Grapholita molesta
Anarsia lineatella
Ceratitis capitata
Cydia pomonella
Dasineura mali

Pest Potential Distribution Map by MaxEnt Model

Completed PRA Reports in Taiwan



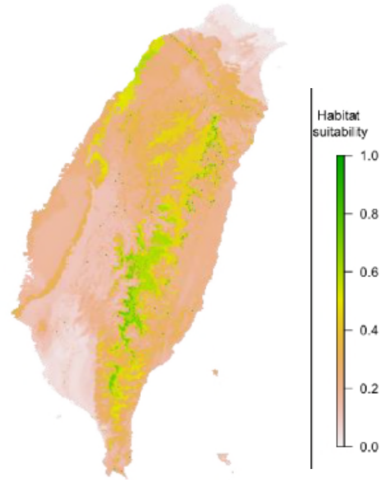
Focusing on climatic factors and host-plant interactions, differences in the results of the two assessment methods are compared and recommendations are provided for future PRA operations.

General methods for MaxEnt

- Species occurrence dataset and 19 bioclimatic variables
- Variable selection process
- Model parameter settings and optimization
- Model prediction and map visualization
- Model validation

GBIF Global Biodiversity Information Facility
CABI
iNaturalist
WorldClim
WorldClim version 2.1

Historical climate data (1970-2000)

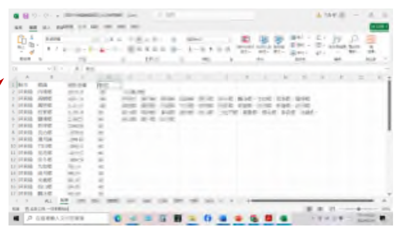


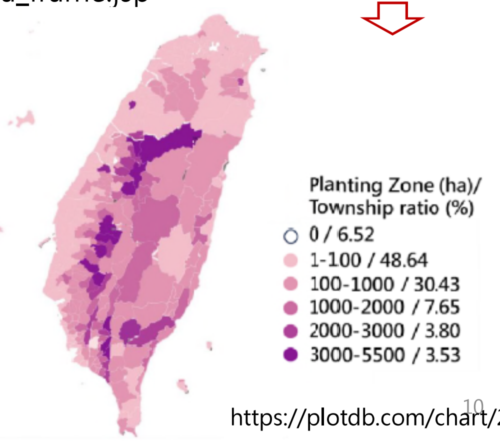
MaxEnt (v.3.4.4) (Phillips et al. 2023) in R (version 4.3.2) (R Core Team 2023) and RStudio (version 2023.09.01+494) (RStudio Team 2023), utilizing the R package 'dismo' (Hijmans et al. 2022)

Mapping process for cultivation area of plant hosts

- Agricultural production dataset from Agriculture and Food Agency
- Statistics on cultivation area of host plants in 368 townships
- Data standardization
- Map visualization

https://agr.afa.gov.tw/afa/afa_frame.jsp





https://plotdb.com/chart/2200/#

Results of *Grapholita molesta*

(Oriental fruit moth)

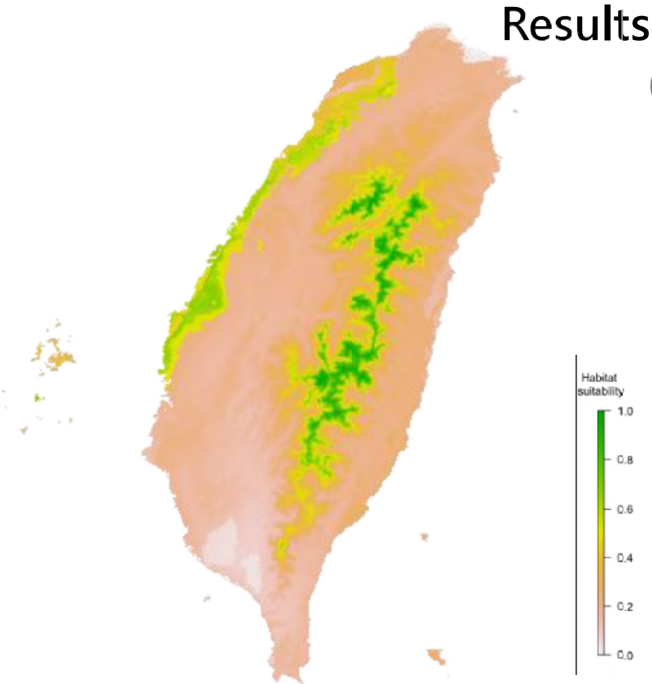


Fig. 1.1 Potential suitable distribution area of *Grapholita molesta* in Taiwan based on MaxEnt.

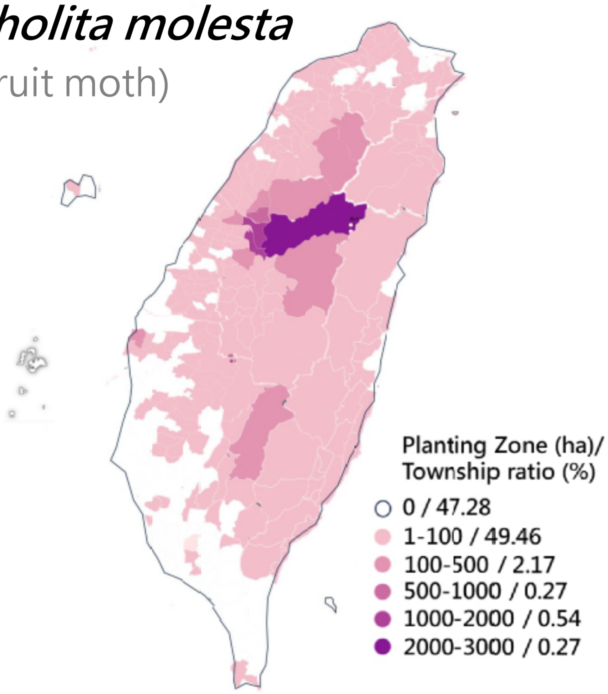


Fig. 1.2 The cultivation area of peach, pear, plum, loquat and apple in Taiwan.

Results of *Anarsia lineatella*

(Peach twig borer)

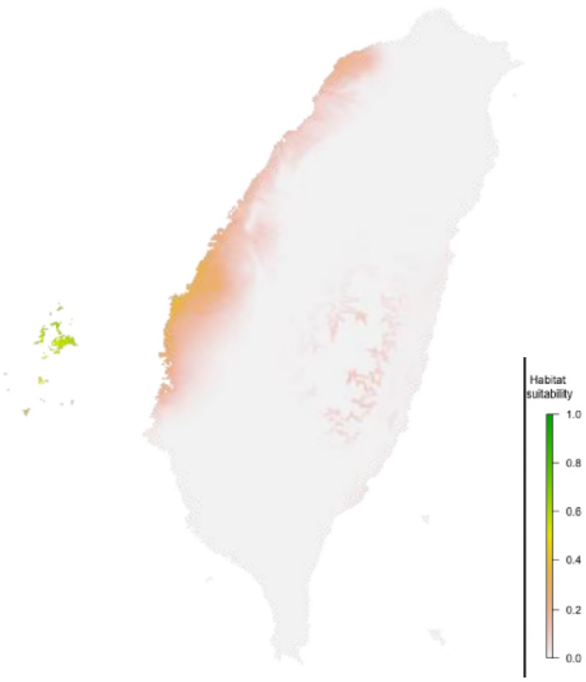


Fig. 2.1 Potential suitable distribution area of *Anarsia lineatella* in Taiwan based on MaxEnt.

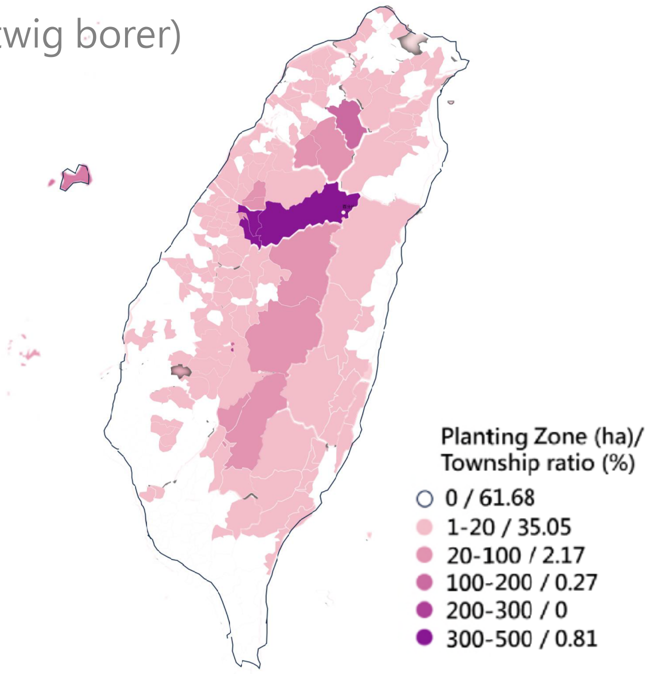


Fig. 2.2 The cultivation area of peach in Taiwan.

Results of *Ceratitis capitata*

(Mediterranean fruit fly)

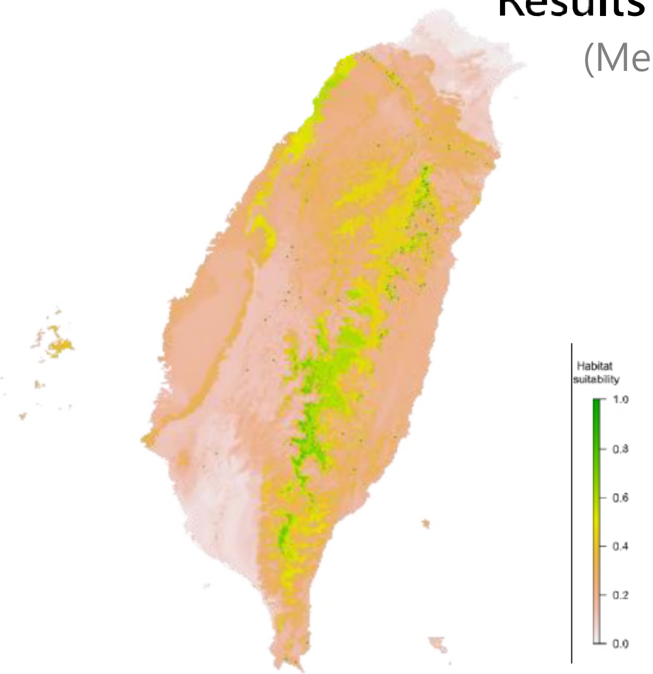


Fig. 3.1 Potential suitable distribution area of *Ceratitis capitata* in Taiwan based on MaxEnt.

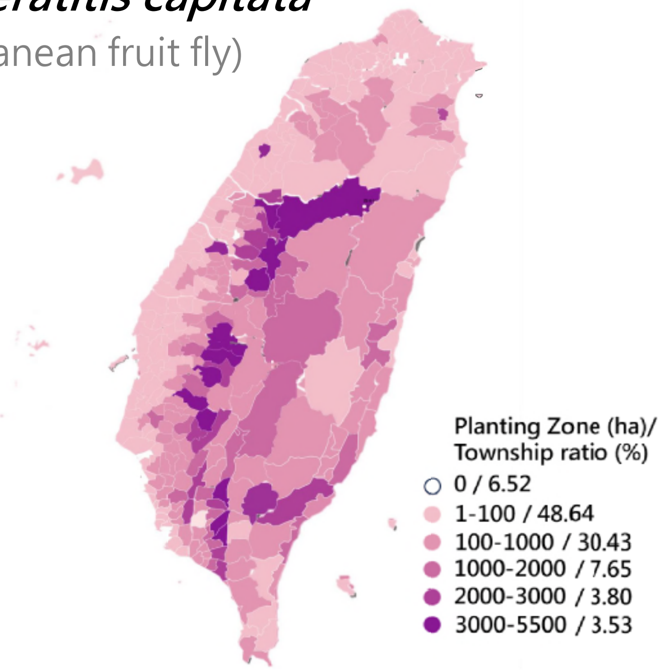


Fig. 3.2 The cultivation area of fruit in Taiwan.

Results of *Cydia pomonella*

(Codling moth)

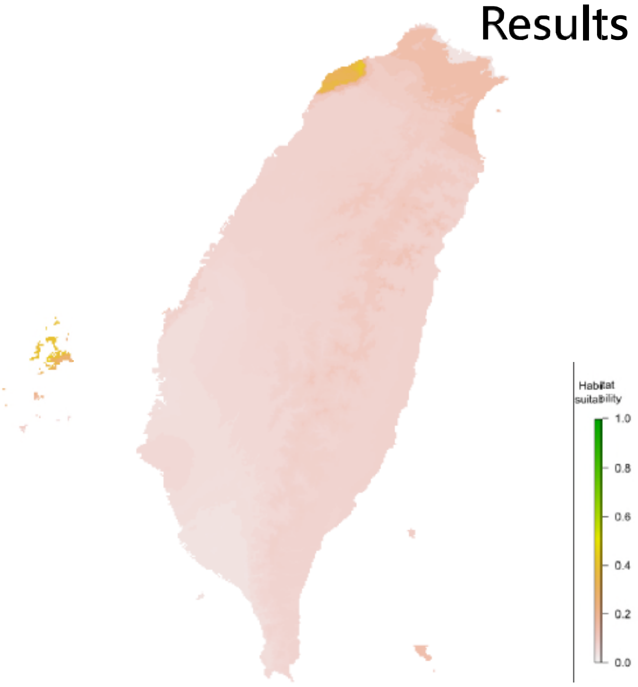


Fig. 4.1 Potential suitable distribution area of *Cydia pomonella* in Taiwan based on MaxEnt.

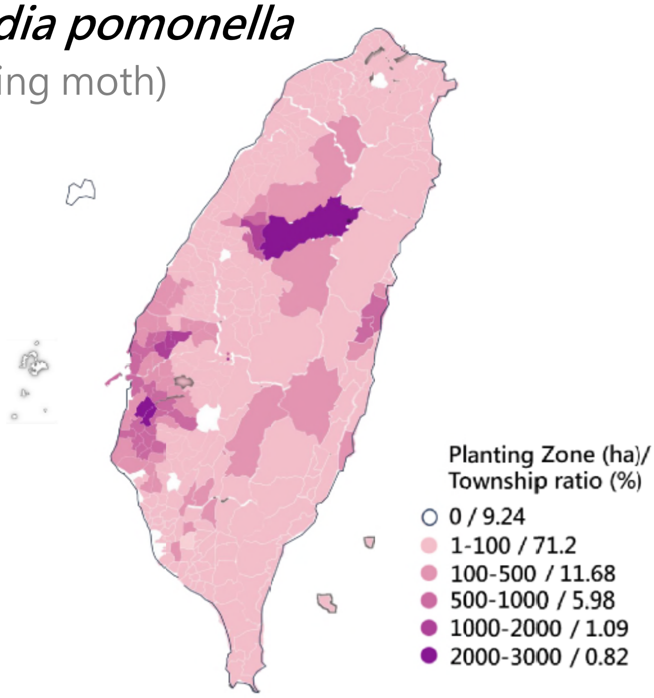


Fig. 4.2 The cultivation area of apple, peach, pear, corn and Japanese plums in Taiwan.

Results of *Dasineura mali*

(Apple leaf midge)

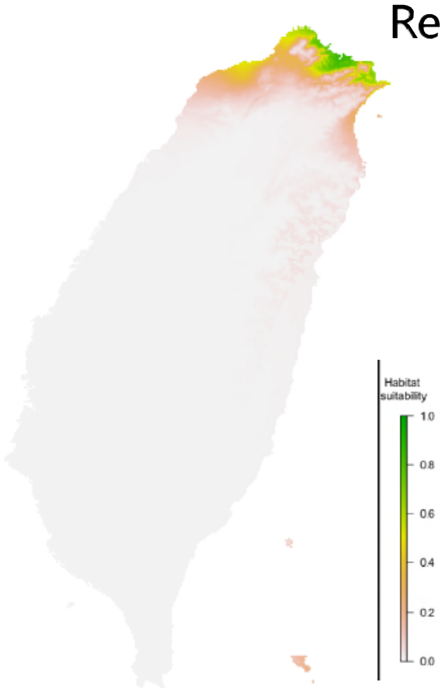


Fig. 5.1 Potential suitable distribution area of *Dasineura mali* in Taiwan based on MaxEnt.

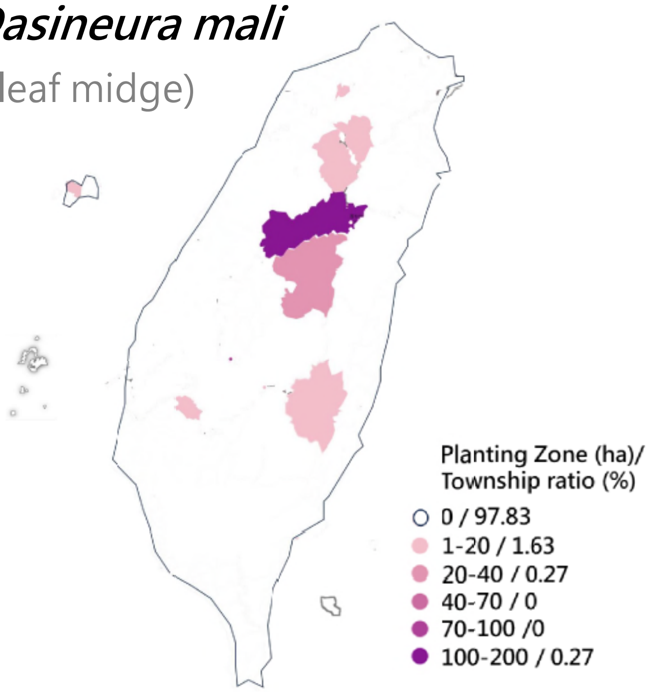


Fig. 5.2 The cultivation area of apple in Taiwan.

Table 1. Differences in the results of the two assessment methods

	The results of the completed PRA by Qualitative Analysis Method (Risk Element #1+Risk Element #2)	Risk Rating	MaxEnt Prediction model + Distribution Maps of host plants	Risk Rating
Grapholita molesta (Oriental fruit moth)	4 PRA results were analyzed, and the main characteristics underlying the qualitative analyses were, in order, insect and host distribution, voltinism, diapause and physiological time.	H(1) M(2) L(1)	High-moderate habitat suitability in more than 2/3 of the region + Nearly 53% of the townships in Taiwan grow host crops.	H
Anarsia lineatella (Peach twig borer)	7 PRA results were analyzed, and the main characteristics underlying the qualitative analyses were, in order, insect and host distribution, voltinism, diapause and physiological time.	H(3) M(4)	Moderate habitat suitability in the western coast and a few areas + Only about 3% townships in Taiwan have more than 20 hectares of peach planted area and they are concentrated in the middle and high altitude areas.	L
Ceratitis capitata (Mediterra-nean fruit fly)	11 PRA results were analyzed, and the qualitative analyses were based on the following main characteristics: insect distribution, developmental threshold and physiological time.	H(11)	High-moderate habitat suitability in more than 2/3 of the region + Nearly 94% of the townships in Taiwan grew host crops. Recommend	H

Table 1. Differences in the results of the two assessment methods (continued)

	The results of the completed PRA by Qualitative Analysis Method (Risk Element #1+Risk Element #2)	Risk Rating	MaxEnt Prediction model + Distribution Maps of host plants	Risk Rating
Cydia pomonella (Codling moth)	10 PRA results were analyzed, and the main characteristics underlying the qualitative analyses were insect and host distribution.	H(3) M(7)	Moderate habitat suitability in Taiwan + Nearly 90% of the townships in Taiwan grew host crops.	M
Dasineura mali (Apple leaf midge)	2 PRA results were analyzed, and the qualitative analyses were based on the main characteristics of insect and host distribution, voltinism, diapause, in that order.	M(1) L(1)	High-moderate habitat suitability in a few areas along the northern coast + Only about 2% townships in Taiwan have more than 20 hectares of apple planted area, and they are concentrated in the middle- and high-elevation areas.	L Recommend

Table 2. Discussion for the results of the two assessment methods

	Qualitative Analysis Method of PRA in Taiwan	MaxEnt Prediction Model + Distribution Maps of Host Plants
Advantage	1. The process is easier to follow (economical). 2. Provide more details on text information, so the result is easier to interpret. 3. It is suitable for data with high uncertainty, or the main factors are hard to describe numerically.	1. SDM provides quantitative , causal or correlation analysis results. 2. SDM provides potential distribution predictions through computer mapping, which can be analyzed interactively when combined with host plant distribution maps.
Short-coming	1. The analysis results lack an objective and quantitative approach. 2. There is no clear causal relationship between some of the qualitative descriptions and the climate factors. 3. There needs to be sufficient access to scientific papers to support the results. 4. Insufficient interactive analysis of host plant distribution and potential areas for pest establishment.	1. Operators must have data processing and information tool application capabilities. 2. The process takes more time to confirm the reliability of the data and to validate the accuracy of the model. 3. The quantity and quality of climate variables and distribution samples limit the prediction results of the model. 4. Lack of qualitative explanation, decision makers must have the ability to interpret.

Conclusion and Recommendation

1. There is no single PRA method that is universally the most accurate; each method offers valuable insights into species-environment relationships.
2. To achieve more accurate and precise predictions , it is crucial to gather comprehensive information, utilize citizen science and continuously work on reducing uncertainties.
3. We recommend combining SDM and new PRA tools with qualitative analysis methods. This integrated approach will allow for a more thorough assessment of the complex factors influencing species distribution patterns.

農業部動植物防疫檢疫署
ANIMAL AND PLANT HEALTH INSPECTION AGEN
MINISTRY OF AGRICULTURE

Thanks for your listening

Figure from Dr. C. C. Chen