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IN-SITU CONSERVATION OF THREATENED PLANT SPECIES IN VIET NAM

Do Quang Tung

Supervised by:

Prof. Felipe Bravo Oviedo

Prof. Rosario Sierra de Grado

Prof. Hoang Van Sam

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PhD Student: Do Quang Tung

Supervisors: Prof. Dr. Felipe Bravo Oviedo
Professor of Forest Management
iuFOR - Sustainable Forest Management Research Institute
Universidad de Valladolid
Palencia, Spain

Prof. Dr. Rosario Sierra de Grado
Associated Professor of Forest Genetics
iuFOR - Sustainable Forest Management Research Institute
Universidad de Valladolid
Palencia, Spain

Prof. Dr. Hoang Van Sam
Professor of Forestry
Viet Nam National University of Forestry
Ha Noi, Viet Nam

External reviewers: Prof. Dr. Susanne Stoll-Kleemann
Institue of Geography and Geology,
Chair of Sustainability Science and Applied Geography
University of Greifswald, Germany

Prof. Dr. Begoña Abellanas Oar
Departamento Ingeniería Forestal
Universidad de Córdoba, España

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BGCI	Botanic Gardens Conservation International
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties
DARD	Department of Agriculture and Rural Development
FPD	Forest Protection Department
GIZ	German Development Cooperation
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Areas
MARD	Ministry of Agriculture and Rural Development
METT	Management Effectiveness Tracking Tool
MONRE	Ministry of Nature Resources and Environment
NBSAP	National Biodiversity Strategy and a Biodiversity Action Plan
NP	National Park
NR	Nature Reserve
OECM	Other Effective Area-based Conservation Measures
PA	Protected Area
PAME	Protected Area Management Effectiveness Assessments
PPC	Provincial People's Committee
SDM	Spatial Distribution Modelling
Ramsar	Convention on Wetlands of International Importance
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCC	United Nations Framework Convention on Climate Change
VNFOREST	Viet Nam Administration of Forestry
WCMC	World Conservation Monitoring Centre
WDPA	World Database on Protected Areas
WHC	World Heritage Convention
WWF	World Wide Fund For Nature

ABSTRACT

The mountainous areas occupy over three quarters of Viet Nam's territory, and over 60% of its population living in rural and mountainous regions primarily have incomes from agricultural and forestry production, which are heavily dependent on natural conditions. Therefore, the forest ecosystems play a very important role and directly impact Viet Nam's social life, sustainable development goals, and environmental security. Recognizing their importance is critical, because in the early 1990s, forest coverage decreased to under 27% (compared to more than 43% in 1945) due to natural disasters such as floods, landslides, drought or soil salinity, war and over exploitation, etc. As a result, Viet Nam’s biodiversity was threatened, with multiple species on the brink of extinction. Since then, Viet Nam has implemented number solutions to protect and rehabilitate its forest through establishing a special-use forests system, participating in relevant International Conventions, carrying out numerous forest restoration programs or preserving biodiversity to protect and restore the forest ecosystem. Consequently, forest coverage has increased to 42.02% with over 14 million ha of forest, including more than 2 million ha being special-use forest in 2023. This coverage of special-use forests occupies nearly 7% of the territory, and they contribute a vital role in ensuring the sustainable maintenance and preservation of most significant ecosystems and their biodiversity values.

This dissertation shows the relationship between applying and promoting international commitments, implementing macro policies and practicing conservation activies for endangered flora species to ensure the development and sustainability of the forest ecosystem and biodiversity that are under pressure from the rising needs of land and other resources, and climate change. During the research, three questions were made: (i) How and to what extent are the targets on protected areas being pursued in Viet Nam? (ii) How and to what extent is the conservation status of threatened plant species addressed within protected areas? (iii) How and to what extent is the conservation status of specific threatened plant species addressed, using case studies of the *Juglandaceae* family and *Pterocarya tonkinensis* (Franch.) Dode species?

Overall, the study aimed to examine the in-situ conservation of Viet Nam's endangered plants while focusing on management at the national level. Various methods including

lliterature review, secondary research, field surveys, research at the herbarium room, and interviews with experts, managers, and the local community were implemented.

In the late 1980s and early 1990s, when Viet Nam's forest coverage was at its lowest (below 27%), Viet Nam joined related International Conventions and had a significant influence on policies regarding biodiversity conservation, forest protection, and development such as the Ramsar, CITES, CBD, and UNFCCC. In this research, we point out the International Convention’s positive impact on Viet Nam's actions and awareness about biodiversity conservation. For instance, since the Aichi Target 11, the Government paid more attention to establishing protected areas and conserving Vietnam's biodiversity, along with implementing laws like the 2008 Biodiversity Law and the 2017 Forestry Law.

We have designed questionnaires and worked directly with different protected areas around the country to evaluate the effectiveness of deploying policies on forest protection and biodiversity conservation. The survey result shows that the management boards of protected areas and local authorities prioritize endangered species on the IUCN Red List, Vietnam's Red Data Book, or the list of endangered and rare species issued by the government in their plans to expand protected areas. Hence, many vital ecosystems and endangered and vulnerable species have been fully preserved and restored. However, the survey also shows limitations in budget, expertise, and resources for conservation activities, scientific research, and propagation of endangered plants.

In order to evaluate the conservation value of endangered plants, we chose the *Juglandaceae* family as a research subject as it has high scientific, conservation, and economic value. *Juglandaceae* is widely distributed globally. Additionally, Viet Nam is identified as having the second-largest diversity of *Juglandaceae* species after China. We have conducted many field trips to collect, evaluate, and compare field and herbarium data, as well as interviewed locals and traditional healers, and people with knowledge and experience in the use of herbs. The result shows that Viet Nam has 3 sub-families, 7 genera, and 11 species in the *Juglandaceae* family, and most of them only exist in national parks and nature reserves. The *Juglandaceae* family is being extensively exploited for woods, firewood, and medicinal herbs. If it was not for the timely inclusion in conservation areas and the list of protected species, they would have gone extinct or had a high risk of extinction.

The conservation status of *Pterocarya tonkinensis* (Franch.) Dode (*Juglandaceae*) helped policymakers make better plans to conserve not only the species but the whole ecosystem where it is distributed, as well as, implement programs for further research, and expand international cooperation for supporting local endangered species conservation efforts. In this study, apart from field investigations, we utilize Maxtent, GuidosToolbox, and Zonation software to determine the distribution range of *Pterocarya tonkinensis* (Franch.) Dode. Some factors affecting the distribution of this species include temperature, precipitations, and distance to water streams. The study found two main centers of *Pterocarya tonkinensis* (Franch.) Dode: one in Southern China (Yunnan) and the other in Northern Viet Nam. They are geographically connected by the Red River and Da River, with both rivers occuring upstream from Yunnan.

Further research on endangered species, forest protection and biodiversity conservation in Viet Nam is essential to the responsibility in participating in International Conventions related to biodiversity conservation; this will ensure Viet Nam is aligned on and effective in the implementation of policies.

This PhD thesis defines six urgent and highly feasible conclusions, including: establishing nature reserves and national parks; expanding protected areas with high biodiversity; conducting research and surveys on endangered species; implementing solutions to preserve species of the *Juglandaceae* family; creating suitable habitats for the *Pterocarya tonkinensis* (Franch.) Dode; and, strengthening conservation solutions for endangered species that are not in protected areas.

RESUMEN

Las zonas montañosas ocupan más de tres cuartas partes del territorio de Vietnam, y más del 60% de su población, que vive en regiones rurales y montañosas, obtiene sus ingresos principalmente de la producción agrícola y forestal, que dependen en gran medida de las condiciones naturales. Por lo tanto, los ecosistemas forestales desempeñan un papel muy importante y repercuten directamente en la vida social, los objetivos de desarrollo sostenible y la seguridad medioambiental de Vietnam. Reconocer su importancia es fundamental, porque a principios de la década de 1990 la cubierta forestal había disminuido a menos del 27% (frente a más del 43% en 1945) debido a desastres naturales como inundaciones, corrimientos de tierras, sequías, salinidad del suelo, guerras y sobreexplotación, etc... Como consecuencia, la biodiversidad de Vietnam se vio amenazada, con múltiples especies al borde de la extinción. Desde entonces, Vietnam ha puesto en marcha una serie de soluciones para proteger y rehabilitar sus bosques mediante el establecimiento de un sistema de bosques de uso especial, la participación en los convenios internacionales pertinentes, la ejecución de numerosos programas de restauración forestal o la conservación de la biodiversidad para proteger y restaurar el ecosistema forestal. En consecuencia, la cobertura forestal ha aumentado hasta el 42,02%, con más de 14 millones de hectáreas de bosque, de las cuales más de 2 millones de hectáreas eran bosques de uso especial en 2023. Esta cobertura de bosques de uso especial ocupa casi el 7% del territorio, y contribuyen de forma vital a garantizar el mantenimiento sostenible y la preservación de los ecosistemas más significativos y sus valores de biodiversidad.

Esta tesis muestra la relación entre la aplicación y promoción de los compromisos internacionales, la puesta en marcha de macropolíticas y la práctica de actividades de conservación de especies de flora amenazadas para garantizar el desarrollo y la sostenibilidad del ecosistema forestal y la biodiversidad, sometidos a la presión de las crecientes necesidades de tierras y otros recursos, y del cambio climático. Durante la investigación, se plantearon tres preguntas: (i) ¿Cómo y en qué medida se persiguen los objetivos de las áreas protegidas en Vietnam?; (ii) ¿Cómo y en qué medida se expresa el estado de conservación de las especies vegetales dentro de las áreas protegidas?; (iii) ¿Cómo y en qué medida se expresa el estado de conservación de especies vegetales amenazadas específicas, en particular de la familia *Juglandaceae* y de la especie Pterocarya tonkinensis (Franch.) Dode? Partiendo de esta base, este

estudio pretende examinar la conservación in situ de las plantas amenazadas de Vietnam, centrándose en la gestión a escala nacional; se aplicaron diversos métodos, como la revisión de la literatura, la investigación secundaria, las encuestas sobre el terreno, la investigación en la sala del herbario y las entrevistas con expertos, gestores y la comunidad local.

A finales de los años ochenta y principios de los noventa del siglo pasado, cuando la cobertura forestal de Vietnam estaba en su punto más bajo (por debajo del 27%), Vietnam se adhirió a los Convenios Internacionales relacionados y tuvo una influencia significativa en las políticas de conservación de la biodiversidad, protección de los bosques y desarrollo, como Ramsar, CITES, CDB y CMNUCC. En esta investigación, señalamos el impacto positivo de la Convención Internacional en las acciones y la concienciación de Vietnam sobre la conservación de la biodiversidad. Por ejemplo, desde la Meta 11 de Aichi, el Gobierno ha prestado más atención al establecimiento de áreas protegidas y a la conservación de la biodiversidad de Vietnam, junto con la aplicación de leyes como la Ley de Biodiversidad de 2008 y la Ley Forestal de 2017.

Hemos diseñado cuestionarios y trabajado directamente con distintas áreas protegidas del país para evaluar la eficacia del despliegue de políticas de protección forestal y conservación de la biodiversidad. El resultado de la encuesta muestra que los consejos de gestión de las áreas protegidas y las autoridades locales dan prioridad a las especies amenazadas de la Lista Roja de la UICN, el Libro Rojo de Vietnam o la lista de especies amenazadas y raras publicada por el Gobierno en sus planes de ampliación de las áreas protegidas. De ahí que muchos ecosistemas vitales y especies amenazadas y vulnerables se hayan preservado y restaurado por completo. Sin embargo, el estudio también muestra limitaciones de presupuesto, conocimientos y recursos para las actividades de conservación, la investigación científica y la proliferación de plantas amenazadas.

Con el fin de evaluar el valor de conservación de las plantas amenazadas, elegimos la familia *Juglandaceae* como tema de investigación, ya que tiene un alto valor científico, de conservación y económico. Las *Juglandaceae* están ampliamente distribuidas en todas las regiones. Además, Vietnam es el segundo país con mayor diversidad de especies de la familia después de China. Hemos realizado muchas campañas para recoger, evaluar y comparar datos de campo y de herbario, así como entrevistas a lugareños y sanadores tradicionales, y a personas con conocimientos y experiencia en el uso de hierbas. El resultado muestra que Vietnam tiene 3 subfamilias, 7 géneros y 11 especies de la familia *Juglandaceae*, y la mayoría de ellas sólo existen en parques nacionales y reservas naturales. La familia *Juglandaceae* está siendo ampliamente explotada para obtener madera, leña y hierbas medicinales. De no ser por la oportuna inclusión en zonas de conservación y en la lista de especies protegidas, se habrían extinguido o tendrían un alto riesgo de extinción.

Se estudió la situación de *Pterocarya tonkinensis* (Franch.) Dode (Juglandaceae) para ayudar a los responsables políticos a elaborar mejores planes para conservar no sólo la especie, sino todo el ecosistema en el que se distribuye, así como a disponer de programas para seguir investigando y ampliar la cooperación internacional para los esfuerzos locales de conservación de especies amenazadas. En este estudio, además de las investigaciones de campo, utilizamos los programas Maxtent, GuidosToolbox y Zonation para determinar el área de distribución de *Pterocarya tonkinensis* (Franch.) Dode. Algunos de los factores que afectan a la distribución de esta especie son la amplitud temperatura, la distribución de las precipitaciones y la distancia a los cursos de agua. El estudio encontró dos centros principales de *Pterocarya tonkinensis* (Franch.) Dode: uno en el sur de China (Yunnan) y otro en el norte de Vietnam. Están conectados geográficamente por el río Rojo y el río Da, y ambos ríos nacen en Yunnan.

Seguir investigando sobre las especies amenazadas, la protección de los bosques y la conservación de la biodiversidad en Vietnam es esencial para asumir la responsabilidad de participar en los convenios internacionales relacionados con la conservación de la biodiversidad; esto garantizará que Vietnam esté alineado y sea eficaz en la aplicación de las políticas.

Esta tesis doctoral define seis conclusiones urgentes y muy factibles, entre ellas: establecer reservas naturales y parques nacionales; ampliar las zonas protegidas con una gran biodiversidad; realizar investigaciones y estudios sobre las especies amenazadas; disponer de soluciones urgentes para preservar las especies de la familia *Juglandaceae*; crear hábitats adecuados para la *Pterocarya tonkinensis* (Franch.) Dode; y, reforzar las soluciones de conservación para las especies amenazadas que no se encuentran en zonas protegidas.

TÓM TẮT

Việt Nam với hơn ba phần tư lãnh thổ là đồi núi, trên 60% dân số sinh sống ở khu vực nông thôn và miền núi với nguồn thu nhập phần lớn đến từ sản xuất nông lâm nghiệp và phụ thuộc vào điều kiện tự nhiên, do vậy, hệ sinh thái rừng đóng vai trò đặc biệt quan trọng trong đời sống xã hội, quyết định tới mục tiêu phát triển bền vững và an ninh môi trường của đất nước. Nhận thức được tầm quan trọng của hệ sinh thái rừng, từ đầu những năm 1990 khi độ che phủ rừng chỉ còn dưới 27% so với hơn 43% năm 1945, các hiện tượng thiên tai như lũ lụt, sạt lở đất, hạn hán, ngập mặn, … xảy ra thường xuyên, đa dạng sinh học bị đe doạ nghiêm trọng và nhiều loài nguy cấp đứng trước bờ vực tuyệt chủng, Việt Nam đã thực hiện đồng bộ các giải pháp để bảo vệ và phục hồi các hệ sinh thái rừng như thiết lập hệ thống các khu rừng đặc dụng, tham gia các Công ước quốc tế có liên quan, triển khai nhiều chương trình trồng và phục hồi rừng, bảo tồn đa dạng sinh học, v.v. Do vậy, đến năm 2023, độ che phủ rừng đã đạt 42.02% với trên 14 triệu ha, trong đó hơn 2 triệu ha là rừng đặc dụng, chiếm gần 7% diện tích lãnh thổ, góp phần quan trọng đảm bảo việc duy trì và bảo tồn bền vững hầu hết các hệ sinh thái đặc trưng và các giá trị đa dạng sinh học đi kèm.

Nghiên cứu này chỉ ra mối quan hệ giữa việc áp dụng và thúc đẩy các cam kết quốc tế, thực thi chính sách ở tầm vĩ mô với hoạt động bảo tồn, phát triển các loài thực vật nguy cấp trong việc đảm bảo sự phát triển bền vững của các hệ sinh thái rừng và tính đa dạng sinh học tại Việt Nam trong điều kiện áp lực ngày càng lớn do nhu cầu sử dụng đất và nguồn tài nguyên, đặc biệt là tình trạng biến đổi khí hậu diễn ra nhanh chóng. Ba câu hỏi cụ thể được đặt ra trong quá trình thực hiện nghiên cứu gồm (i) Việc theo đuổi mục tiêu về các khu bảo tồn ở Việt Nam được thực hiện như thế nào?; (ii) Tình trạng bảo tồn các loài thực vật nguy cấp trong các khu bảo tồn như thế nào?; (iii) Tình trạng bảo tồn của loài thực vật nguy cấp cụ thể, nghiên cứu từ họ Hồ Đào - Juglandaceae và loài Cơi - *Pterocarya tonkinensis* (Franch.) Dode? Trên cơ sở đó, mục tiêu chung của luận văn là nghiên cứu về hoạt động bảo tồn nội vi các loài thực vật nguy cấp ở Việt Nam, tập trung vào công tác quản lý ở cấp quốc gia; các phương pháp khác nhau được thực hiện bao gồm nghiên cứu tài liệu thứ cấp, điều tra thực địa, nghiên cứu tại hệ thống phòng tiêu bản thực vật, phỏng vấn chuyên gia, nhà quản lý và người dân địa phương, v.v.

Vào giai đoạn cuối những năm 1980 và đầu những năm 1990, khi độ che phủ rừng của Việt Nam xuống thấp nhất (dưới 27%), Việt Nam đã tham gia các Công ước quốc tế quan trọng và đã có ảnh hưởng lớn tới những quyết sách về bảo tồn đa dạng sinh học, bảo vệ và phát triển rừng như Công ước Ramsar, CITES, CBD và UNFCCC. Trong nghiên cứu này, chúng tôi chỉ ra những tác động tích cực của các Công ước quốc tế về bảo tồn đa dạng sinh học mà Việt Nam đã tham gia đối với nhận thức và hành động của Việt Nam, cụ thể là mục tiêu Aichi 11, từ đó chính phủ đã có những quan tâm tới việc thiết lập các khu rừng được bảo vệ và các hoạt động bảo tồn đa dạng sinh học, cùng với đó là các chính sách, quy định liên quan được ban hành, đặc biệt là Luật Đa dạng sinh học năm 2008 và Luật Lâm nghiệp năm 2017.

Để đánh giá hiệu quả của việc triển khai các chính sách về bảo vệ rừng, bảo tồn đa dạng sinh học tại các vườn quốc gia, khu bảo tồn, chúng tôi đã thiết kế bảng điều tra, khảo sát và đồng thời làm việc trực tiếp với một số khu bảo tồn toàn quốc. Kết quả khảo sát cho thấy những loài nguy cấp thuộc danh mục đỏ của IUCN, sách đỏ của Việt Nam và danh mục các loài nguy cấp, quý, hiếm do Chính phủ ban hành là đối tượng để ban quản lý khu bảo tồn thiên nhiên và chính quyền địa phương thiết lập hoặc mở rộng các khu bảo tồn và lập kế hoạch để ưu tiên bảo tồn, trên cơ sở đó đã bảo tồn được toàn vẹn, phục hồi nhiều hệ sinh thái quan trọng và nhiều loài nguy cấp đứng trước nguy cơ tuyệt chủng hoặc bị đe doạ tuyệt chủng. Tuy nhiên, kết quả điều tra cũng cho thấy sự những hạn chế về ngân sách cũng như chuyên môn và nguồn lực dành cho các hoạt động về bảo tồn, nghiên cứu khoa học và phát triển các loài nguy cấp.

Để đánh giá vai trò của các loài thực vật nguy cấp đối với hoạt động bảo tồn chúng tôi đã lựa chọn họ Hồ Đào - Juglandaceae để nghiên cứu vì đây là họ thực vật có giá trị cao cả về khoa học, bảo tồn và kinh tế, có phân bố rộng ở hầu khắp các vùng, đồng thời, Việt Nam cũng được xác định là nơi có tính đa dạng các loài thuộc họ Hồ Đào Juglandaceae lớn thứ hai trên thế giới chỉ sau Trung Quốc. Trong quá trình nghiên cứu, chúng tôi đã thực hiện nhiều chuyến đi khảo sát thực địa để thu thập, đánh giá, so sánh các dữ liệu hiện trường, phòng tiêu bản thực vật, đồng thời phỏng vấn người dân địa phương cũng như các thầy lang, những người có kiến thức và kinh nghiệm trong sử dụng thực vật. Kết quả nghiên cứu cho thấy Việt Nam có 3 phân họ, 7 chi và 11 loài thuộc họ Juglandaceae và hầu hết các loài thuộc họ này hiện chỉ còn tồn tại trong các khu bảo tồn thiên nhiên, vườn quốc gia. Do đây là những loài có giá trị về kinh tế như sử dụng làm gỗ, củi và dược liệu, nên là đối tượng bị khai thác tận diệt trên diện rộng;

cùng với việc chuyển đổi mục đích sử dụng rừng, xây dựng cơ sở hạ tầng, nếu trước đây không kịp thời đưa các loài thuộc họ Juglandaceae vào danh mục các loài được bảo vệ và thiết lập, mở rộng các khu bảo tồn có loài này phân bố thì tới nay chúng đã có thể tuyệt chủng hoặc có nguy cơ tuyệt chủng cao.

Nghiên cứu về tình trạng của một loài nguy cấp cụ thể là *Pterocarya tonkinensis* (Franch.) Dode (Juglandaceae), trên cơ sở đó sẽ giúp các nhà hoạch định chính sách có kế hoạch để thực hiện các biện pháp bảo tồn không chỉ loài này mà cả hệ sinh thái chúng phân bố, đồng thời có các chương trình nghiên cứu sâu hơn, cũng như mở rộng hợp tác quốc tế cho những nỗ lực bảo tồn nội vi các loài nguy cấp. Trong nghiên cứu này, ngoài việc điều tra, khảo sát thực địa, chúng tôi sử dụng các phần mềm Maxent, GuidosToolbox và Zonation để xác định những dải phân bố của loài *Pteracarya tonkinensis* (Franch.) Dode, những yếu tố tác động tới sự tồn tại của loài thực vật này như nhiệt độ và lượng mưa và nguồn nước. Kết quả nghiên cứu cho thấy có hai trung tâm chính phân bố loài *Pteracarya tonkinensis* (Franch.) Dode là ở Nam Trung Quốc (tỉnh Vân Nam) và khu vực phía Bắc Việt Nam, về mặt địa lý, chúng được kết nối qua dòng nước mà cụ thể là sông Hồng và sông Đà, đều có nguồn gốc từ Vân Nam.

Tăng cường hoạt động nghiên cứu về các loài nguy cấp, công tác bảo vệ rừng và bảo tồn đa dạng sinh học ở Việt Nam là cần thiết để tham gia có trách nhiệm các Công ước quốc tế có liên quan đến bảo tồn đa dạng sinh học; điều này đảm bảo việc triển khai đồng bộ, có hiệu quả các cơ chế, chính sách tại Việt Nam.

Với những đánh giá, phân tích trên cơ sở kinh nghiệm, lý luận và thực tiễn, Luận án này đã đưa ra 06 kết luận mang tính cấp thiết và khả thi cao bao gồm tiếp tục thiết lập các khu bảo tồn, vườn quốc gia hoặc mở rộng khu bảo tồn ở những diện tích hiện còn tính đa dạng sinh học cao; tiến hành các nghiên cứu, khảo sát đối với những loài nguy cấp, quý hiếm; có những giải pháp cấp thiết để bảo tồn các loài thuộc họ Hồ Đào - Juglandaceae; tạo sinh cảnh phù hợp cho loài *Pterocarya tonkinensis* (Franch.) Dode; tăng cường các giải pháp bảo tồn cho những loài nguy cấp mà không phân bố trong các khu bảo tồn.

CHAPTER 1. GENERAL INTRODUCTION

1.1 Geography, Nature, People of Viet Nam: at a glance

Viet Nam's territory lies in the east of mainland Asia, covering 331,345 km^2, of which more than 310,070 km^2 is land and 21,140 km^2 is water. The country has a coastline of 3,444 km (excluding islands). Shaped like a S letter, Viet Nam stretches 1,650 kilometers from north to south, with its widest point of 600 kilometers in the north and its narrowest point of approximately 50 kilometers in the middle. China borders Viet Nam to the north, while Lao People's Democratic Republic (Laos) and Cambodia lie to the west (Figure 1.1).

Located within the Indo-Burma Biodiversity Hotspot (IBBH), which hosts the largest number of species in Southeast Asia, Viet Nam possesses unique and complex natural resources that rank it as the 15th most biodiversity-rich country in the world (Rhett A. Butler, 2023). The nation is estimated to have approximately 16,500 species, of which about 30 percent are endemic. Diverse terrestrial, freshwater, marine and coastal ecosystems alongwith varied climates make it an ideal habitat for a wide range of species, including mammals, birds, fishes, reptiles and plants. Additionally, Viet Nam's location at the junction of two major biogeographical regions, the Indochinese and Sino-Japanese, makes it an ideal habitat for species to migrate, adapt, and evolve.

Viet Nam has more than 100 million inhabitants and is considered a multi-ethnic country, comprising of 54 ethnic groups (Vietnam general statistics office, 2023). The Kinh (Vietmamese) makes up nearly 86% while the remaining 53 ethnic groups account for just more than 14%. Forest-based cultures and natural resources are the main sources of livelihood for most of these minorities.

Despite Viet Nam being recognized as a global biodiversity hotspot, Viet Nam suffers from the effects of population growth, economic development, and serious biodiversity degradation. The Vietnamese government has taken many steps to protect its biodiversity such as establishing protected areas, creating incentives for sustainable forest management, and strengthening conservation policies.

Figure 1.1 Geography map of Viet Nam

(Source: Department of Survey and Mapping Viet Nam – official use for public “https://www.bandovn.vn/vi/page/mau-ban-do-hanh-chinh-nuoc-cong-hoa-xa-hoi-chu-nghia-viet-nam-181?AspxAutoDetectCookieSupport=1”)

1.2 Definition of protected area system of Viet Nam

According to Article 5, Law on Forestry (2017) the protected area system[1] is designed to (a) conserve natural forest ecosystems andgenetic resources of forest organisms; (b) facilitate scientific research; (c) preserve historical - cultural relicts, beliefs, places of scenic beauty associated with ecotourism; (d) provide hospitality and entertainment (except in strictly protected sub-zones); and (e) provide forest environmental services. The system comprises of five types of protected areas: i) national parks, ii) natural reserves, iii) species and habitat reserves, iv) landscape protection areas, and v) forest used for scientific study and ex-situ conservation and development. The first two types account for nearly 94% of the total area (Do et al., 2022).

1.3 Threatened plant species in Viet Nam

According to IUCN Red List 2022 (IUCN, 2022), there are 2190 globally threatened plant species in Viet Nam (including 66 Near Threatened, 136 Vulnerable, 136 Endangered and 77 Critically Endangered, 1552 least concern and 222 Data Deficient). Vietnam's Red Data Book (2007) adopted a similar approach to IUCN for assessment. The most recent version of this book in 2007 listed 428 threatened vascular plants, indicating a remarkable increase in the number of threatened plants, which was only 356 in the book's first version in 1996. The Vietnamese Government has implemented several measures to protect the species, such asmonitoring, maintaining and expanding the existing protected areas and conducting surveys; Aditionally, Vietnam has also signed various international agreements to help protect the country's biodiversity. However, there is no data available on the percentage of threatened plant species conserved in situ in Viet Nam (MONRE, 2019).

1.4 Thesis development and research questions

Currently, 16.02 percent of the global terrestrial surface is formally protected areas (UNEP-WCMC, 2023). In situ conservation of trees through protection of existing forests is widely recognized as the most effective method for conserving tree diversity (Di Sacco et al., 2021; Moomaw, Masino, & Faison, 2019). Approximately 64 percent of all the known tree species are found in at least one protected area, and about 56 percent of threatened tree species are found in-situ (BGCI, 2021). By 2030, one of the

[1] Equivalent to special-use forest system in Vietnamese, more detail in chapter 2

global targets for reducing threats to biodiversity is to ensure that at least 30 percent of terrestrial areas are effectively conserved through protected areas and other effective area-based conservation measures (Target 3, Kunming-Montreal Global Biodiversity Framework, 2022). To achieve this goal, countries must both enforce existing protected area systems and create new ones.

One of the primary purposes of establishing protected area systems is to conserve threatened species (Mohd Nazip, 2018). To protect threatened plant species, understanding their conservation status, distribution, and conservation actions are critical. Conservation status can be determined through species surveys, field studies, and population assessments. These assessments are also important for identifying species at risk and for evaluating the effectiveness of conservation efforts. Conservation actions can include habitat protection, species reintroduction, and habitat restoration. These actions should be tailored to the specific needs of the species and should consider factors such as their biology, habitat, and population size. Using this information is important (or) crucial for conservation planning and action at local, national, and international levels, for priority taxonomic groups.

Globally, in-situ conservation is one of two strategies (alongside ex-situ) practiced primarily through PAs for the preservation of various living species. In Vietnam, although there is a strong commitment to protected areas, limited research has been conducted to date to provide an overview of protected areas within international biodiversity conventions. Several studies have been conducted on the in-situ conservation of specific threatened species, such as *Cunninghamia konishii* Hayata; *Cinnamomum parthenoxylon* Meissn, *Cupressus torulosa* D. Don, and *Aquilaria crassna* Pierre, etc. but it remains unclear whether these practices follow for extinct taxa.

Given this background information, my thesis revolves around protected area and threatened tree species conservation in Viet Nam. The overall research question of this thesis is: *How and to what extent are protected areas and threatened plant species distributed and conserved in-situ in Viet Nam?*

In order to make the overall research question more operational, it was formulated into three smaller questions that focus each on particular sections of in-situ conservation. These sections are:

(i) protected areas at the national level,

(ii) conservation programs of threatened plant species within protected areas, and

(iii) the conservation status of specific threatened plant species.

Protected areas are universally acknowledged as crucial for in situ conservation (UNDP, SCBD, & UNEP-WCMC, 2021). An essential strategy for ensuring effective biodiversity conservation involves both maintaining existing protected areas and expanding their coverage. The Convention on Biological Diversity has endorsed this strategy since the last century (Aichi Target 11, CBD, 2010), and it is expected to gain significant prominence in the coming decade (Target 3, Kunming-Montreal Global Biodiversity Framework, 2022). Viet Nam, as a participating member of these conventions, endorses these strategies. In Vietnam's National Biodiversity Strategy to 2020, vision to 2030, set a target that protected areas will account for 9% of the total terrestrial area. Considering all types of protected areas in the national context, the first specific question of the thesis was formulated as:

1. *How and to what extent can the target on protected areas can be pursued in Viet Nam?*

As one of the primary purposes of protected areas is to conserve threatened plant species from extinction, the logical objective is to take a deeper look at this implementation at work. Hence the second specific question:

2. *How and to what extent is the conservation status of threatened plant species addressed within protected areas?*

Questions 1 and 2 are abstract in the sense that they do not address what may be called the threatened plant species in the field. To achieve this, we assess the actual status of threatened plant species by examining one family and one species, specifically Juglandaceae and *Pterocarya tonkinensis* (Franch.) Dode. This information will also contribute to reducing the situation in the IndoMalay region (tropical Asia) which includes Viet Nam where the "Not Evaluated and Data Deficient" status is highest (BGCI, 2021).

3. *How and to what extent is the conservation status of specific threatened plant species addressed, using case studies of the* Juglandaceae family *and* Pterocarya tonkinensis (Franch.) Dode *species?*

Earth's life depends on plants. They provide a variety of essential ecosystem goods and services, including food, medicines, genetic material for crop production, clothing and shelter, as well as great cultural, and economic values. The loss of plant biodiversity has been a significant issue over the last centuries. Despite efforts made to conserve plant diversity, the situations remain very alarming today. Through the Global Tree Assessment, 30% of 58,497 tree species worldwide are threatened with extinction (BGCI, 2021).

Plant play an indispensible role in sustained human life, thus protecting plants from their threats is necessary. There are many solutions for protecting plants, I myself with capacity as a natural forest resource manager, I developed the third question in a way to gain on-field experience as a botanist. Identifying and understanding plants in their natural environment is key to managing their resources. Being able to recognize plants, their habitats, abundance and threats are essential for making informed conservation decisions.

Juglandaceae and *Pterocarya tonkinensis* (Franch.) Dode was chosen as case-study species, because Juglandaceae is one of the most emblematic angiosperm families composed entirely of woody species (Simpson, 2010). Additionally, since all its members are relict trees, the Walnut family has a high scientific and conservation value (Schaarschmidt, 2014; Kozlowski et al., 2018). Viet Nam, as one of the plant biodiversity centers (Hoang et al., 2011; Hoang, Baas, & Keβler, 2008), is considered a hotspot of Juglandaceae and the second (after China) geographic region of generic diversity of Juglandaceae (Kozlowski et al., 2018). However, the number of Juglandaceae species in Viet Nam is still uncertain. Wu & Raven (1999) recorded 7 genera and 11 species of Juglandaceae, while (Pham, 2003) described the morphological characteristics and distribution of 5 genera, 5 species and 7 varieties, and (Tran, 2002) reported 5 genera and 8 species. The most current data by (Kozlowski et al., 2018) report 10 species representing 6 genera.

Pterocarya tonkinensis (Franch.) Dode is currently endangered due to habitat destruction and fragmentation, especially in the southern China and Northern Viet

Nam (Kozlowski 2018). It is listed on the IUCN Red List with the category "Vulnerable" (Kozlowski 2019). Since the species is strongly associated with water ways, any changes related to water management (e.g., dam construction) as well as climate impacts on rivers (e.g., more drought) could threaten natural sites (Kozlowski 2019). The species may be important in pharmacy, as it exhibits antifungal properties (Ngo et al., 2021). It is also traditionally used as a poison for fishing and as an insect repellent (Hoang et al., 2021). Even though the *Pterocarya tonkinensis* (Franch.) Dode is endangered and occurs in the biodiversity hotspot; it attracts less attention from researchers than other members of the genus. So far, the potential range and influence of environmental variables on its conservation status has not been estimated for this species.

Regarding modern dissertations that are intended to be published as separate papers in peer-reviewed journals, the three specific questions have been divided into independent units that appeal to their own readership. Each unit is written as a stand-alone paper with its own introduction, literature review, methods, results, and discussion sections. Each paper is tailored to the specific journal's guidelines. Chapters 2,3, and 4,5 can be easily consulted for specific research questions 1, 2, and 3.

The final Chapter 6 summarizes and concludes on the three specific questions and further provides an argument for advancing conservation by looking beyond PAs.

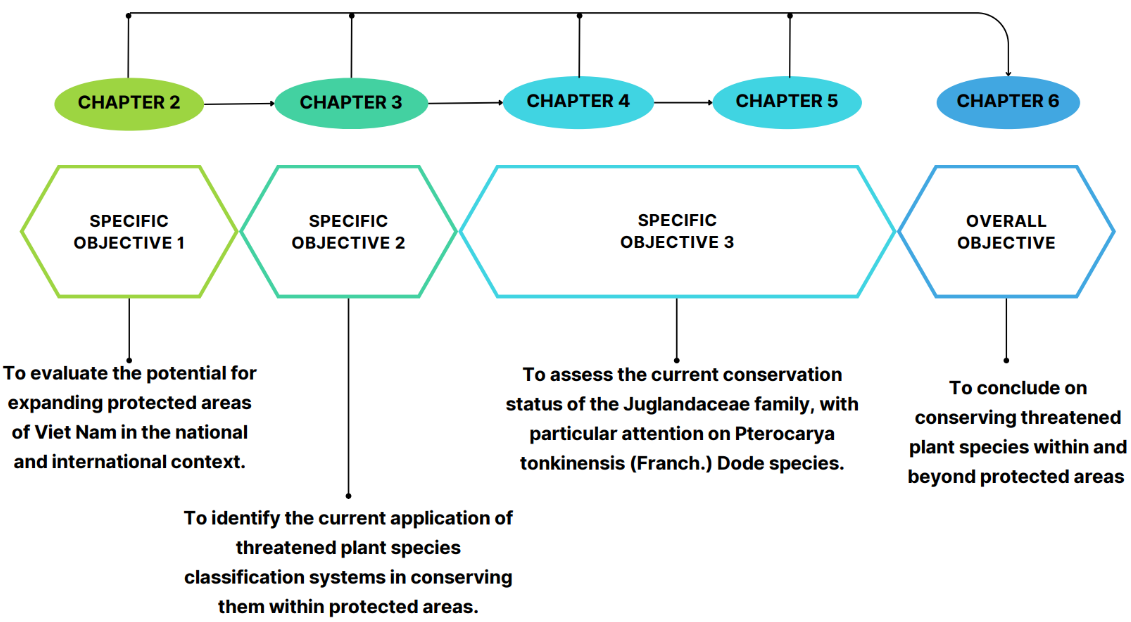

Figure 1.2 The thesis workflow approach

1.5 Objectives

1.5.1 General objective

The overal objective of present study is to investigate the in-situ conservation of threatened plant species in Viet Nam, with particular attention to national management and conservation measures for a specific plant family.

1.5.2 Specific objectives

To achieve the overall objective, I have set the following specific objectives:

Specific objective 1. To evaluate the potential for expanding protected areas in Viet Nam within both national and international context.

Specific objective 2. To identify the current application of threatened plant species classification systems in conservation efforts within protected areas.

Specific objective 3. To assess the current conservation status of the *Juglandaceae* family, with particular attention on *Pterocarya tonkinensis* (Franch.) Dode species.

1.6 Methods

Depending on the nature of the research objective, questions, and scope in each chapter, a wide range of approaches were applied. Literature review and questionnaire surveys were the means for collecting data in Chapter 2 (potential for expanding protected areas in Viet Nam) and 3 (threatened plant species classification systems in conserving them within protected areas), respectively. Herbarium specimen study and field surveys for understanding conservation status of threatened plant species were used in Chapter 4 (the Juglandaceae family) and 5 (*Pterocarya tonkinensis* (Franch.) Dode species.) (Table 1.1). Hence, each chapter has its own methodological discussion, describing the details of the methods for sampling, data collection, data analysis and so on. Following is an overview of the methods used to address the specific objectives.

To address the specific objective 1 (To evaluate the potential for expanding protected areas of Viet Nam in the national and international context), a grey literature review was applied. Grey literature is defined by Schopfel (2010) as: "manifold document types produced on all levels of government, academics, business and industry in print and electronic formats that are protected by intellectual property rights, of sufficient quality to be collected and preserved by library holdings or institutional repositories, but not controlled by commercial publishers". I reviewed biodiversity-related in-situ conservation conventions Viet Nam had participated in and analyzed how these conventions are related to protected area development history. Most of the analyzed grey literature is in Vietnamese. Thus, this thesis (and associated papers) is the first opportunity to analyze this information for an international audience in a consistent manner. Next, I examined how Viet Nam adopted Aichi Target 11 as the national goal of protected areas. As well, I evaluated the current status of the Vietnamese protected area system to determine whether it was able to meet the nation's needs. For example, I looked at the National Biodiversity Strategy for 2020, vision 2030. This states that Viet Nam is committed to creating a network of protected areas covering 9% of the country's land area by 2020.

To address specific objective 2 (To identify the current application of threatened plant species classification systems in conserving them within protected areas), I sent survey questionnaires to 32 Vietnamese national parks and nature reserves in 26 provinces (**Error! Reference source not found.**). I collected general information about each protected area, including its name, date, and size. My next step was to examine threatened plant conservation profiles, including monitoring frequency, challenges encountered, funding sources, and conservation methods. The names of threatened plant species they selected and proposed to conserve were also requested. Using the national management lists for threatened plant species, I classified conserved and proposed species according to their threat level.

To address specific objective 3 (To assess the current conservation status of the Juglandaceae family, with particular attention on *Pterocarya tonkinensis* (Franch.) Dode species), the present study was conducted on the ecology, distribution, uses, and threats of the Juglandaceae species throughout Viet Nam. Taxonomy, data for distribution, and occurrence in specific site conditions were studied at herbaria in Vietnam. Specimens from the National Museum of Natural History of Paris (P) were also checked online (https://www.mnhn.fr/en). The tabular summary of examined specimens is included in Supplement 1. To confirm herbarium specimens and assess the current situation in Viet Nam, field surveys were carried out in 20 provinces (Bac

Giang, Bac Kan, Cao Bang, Dong Nai, Gia Lai, Ha Giang, Ha Tinh, Khanh Hoa, Kon Tum, Lam Dong, Lang Son, Lao Cai, Ninh Thuan, Thai Nguyen, Thanh Hoa, Nghe An, Phu Tho, Quang Ninh, Vinh Phuc, and Hoa Binh) in which herbarium records of Juglandaceae were found. During the field surveys, the morphological, biological, ecological characteristics, location, and visible threats of Juglandaceae species were recorded (Nguyen, 2007). Moreover, the use of the different species and their value were determined by interviewing local people and traditional doctors. To evaluate the conservation status of the species, we used the IUCN Red List (IUCN, 2020) and the Viet Nam Red Data Book (Tran et al., 2007). The conservation status of Juglandaceae species in Viet Nam was double-checked by botany experts, management officers, and local people. Distribution maps were created using ArcMap 10.4.1. and Qgis 3.10.11.

To estimate the potential range of *Pterocarya tonkinensis, through a probablistic model, t*he software MAXENT version 3.3.2 (Elith et al. 2011; Philips et al. 2006 (Phillips et al., 2017)); GuidosToolbox software (Vogt and Riitters, 2017) and Zonation 5.0 (Moilanen et al. 2022) were used. Models were created using a set of 45 localities of *Pterocarya tonkinensis* and bioclimatic variables from the CHELSA database with a resolution of 30 arc-sec (Karger et al. 2017; 2018). In addition, a raster of the distance from the nearest river was used, as the species is found near (in close proximity) to watercourses.

Table 1.1 Method approach summary

	Specific research question 1: *How and to what extent can the target on protected areas can be pursued in Viet Nam?*	**Specific research question 2:** To identify the current application of threatened plant species classification systems in conservation efforts within protected areas?	**Specific research question 3:** *How and to what extent is the conservation status of specific threatened plant species addressed, using case studies of the* Juglandaceae family *and* Pterocarya tonkinensis (Franch.) Dode *species?*
Methods	Grey literature review	Online questionaire survey and field visits	National and international herbarium study, field study, and interview with stakeholders and local people.
Administration level	Nation (Viet Nam)	Nation (26 provinces arcross the country)	Nation (20 provinces for study *the Juglandaceae family and for the Pterocarya tonkinensis (Franch.) Dode species?)*
Geographical scale	Macro	Meso	Meso and Micro

1.7 The core chapters

Designed as modern dissertations, which are expected to be published as individual papers in peer-reviewed journals as much as possible, I structured the Chapter 2 to 5 as four separate research articles with three of them already published (Chapter 2, 4 and 5), the other one has been accepted (Chapter 3). This design has the advantage of allowing these chapters to be read independently. The disadvantage is that at some degree there exists repetitions (e.g., general information on protected areas and an overview of threatened plant species in Vietnam) could not be avoided. As stated, each chapter contains its own detailed description of methods.

Chapter 2 ('Global biodiversity-related conventions on facilitating biodiversity conservation in Viet Nam', DOI: https://doi.org/10.24259/fs.v6i2.14473) aims to propose a solution for Viet Nam to pursue Aichi Target 11. Besides observing positive influenced by global biodiversity-related conventions that is the key aspects of the biodiversity policy evolution, we sugguest that Viet Nam has high potential to meet the target on protected area by advancing a wide range of types within its protected areas system.

Chapter 3 ('Plant conservation in protected areas in Viet Nam: An analysis from the threatened species lists, DOI: https://doi.org/10.3767/blumea.2024.69.01.05) provides a picture of threatened plant species conservation programs within 32 protected areas across the country (**Error! Reference source not found.**). IUCN Red Lists, Viet Nam's Red Data Book, and national decrees on threatened plant species management were used to determine the threat level of conserved and proposed species. We found that the species selected for both in the past or in the future programs have not always been based on extinction taxonomy, which is principal guide when using the lists. Considering the limited amount of funding available and the desire to maximize the number of protected species, we highlight that it is not necessarily a bad implementation, but rather matter of better selection and better implementation. Thus, to enhance the utility of the lists for threatened plant species conservation, users should recognize that the lists are not always updated, and to employ them as a reasonable guide, in conjunction with other sources of information to ensure complete and accurate species identification, rather than as the sole guideline.

Chapter 4 ('Diversity, distribution, and threats of the Juglandaceae in Viet Nam', DOI: https://doi.org/10.12657/denbio.086.005) provides a complete and up-to-date profile of the Juglandaceae. Characterized by exclusively woody species and all members being relict trees, the Juglandaceae family holds significant scientific and conservation values. Viet Nam stands as the world's second hotspot for Juglandaceae. We study taxonomy and gather distribution data for specific site conditions at Viet Nam's herbaria, verifying them by using digital specimens at the Paris herbarium. We also conduct field surveys, mainly in NPs and NRs in Viet Nam, to collect data on morphological, biological, and ecological traits, alongside the locations and visible threats to the species. In addition, to understand the use and value of different species, we interview with local communities and traditional healers. Lastly distribution maps are created. The chapter's outcomes can be used to inform for *Juglandaceae* conservation planning and action at local, national, and international levels.

Chapter 5 ('Risk Assessment of Habitat Suitability Decline for the Endangered Riparian Tree *Pterocarya tonkinensis* (Juglandaceae): Conservation Implications, DOI: https://doi.org/10.1007/s10342-024-01679-9) provides a complete and up-to-date profile of one threated plant species. We combined methods of field surveys, specimen analysis and application of Maxent, GuidosToolbox, and Zonation software, to identify potential range of *Pteracarya tonkinensis Dode. There are* two main centers for this species, one in southern Yunnan (China) and one in Northern Viet Nam. They are connected to each other through a network of watercourses. Environmental factors include temperature amplitude; seasonality of precipitation; and distance from watercourses play a significant role in defining species occurrence. Unfortunately, the species' potential range is predicted to shrink in the future, due to climate impact on water level changes, flooding episodes of rivers. This requires the establishment of protected areas in southern China and the expansion of existing reserves in Viet Nam.

Chapter 6 (Discussion and Conclusions) provides a further discussion based on the overall observations of this study. We analyze reasons why conservation needs both thinking within and beyond protected areas. Suggesting tools for advancing the conservation tool outside protected areas. Lastly, we provide concrete conclusions of the thesis as a whole.

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CHAPTER 2. GLOBAL BIODIVERSITY-RELATED CONVENTIONS ON FACILITATING BIODIVERSITY CONSERVATION IN VIET NAM

Do Quang Tung | Felipe Bravo | Rosario Sierra-de-Grado | Hoang Van Sam

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Abstract

Global biodiversity-related conventions have positively influenced nature conservation in Viet Nam. Adhering to the international policies and strategies is considered as one of the critical guidelines for the nation against the status of biodiversity loss. As holistically highlighted in Aichi Target 11, protected areas are central for this effort and Viet Nam is not an exception. In this study, we reflected and proposed solutions for pursuing this Target in the future of Viet Nam. Of which, besides preserving the status of special-use forests, uplifting protection forests to special-use forests category should be a priority, especially for forest areas in rich biodiversity condition.

Key words: Aichi Target, Protected areas, Special-use forests

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CHAPTER 3. PLANT CONSERVATION IN PROTECTED AREAS IN VIET NAM: AN ANALYSIS FROM THREATENED PLANT SPECIES LISTS

Do Quang Tung | Felipe Bravo | Rosario Sierra-de-Grado | Hoang Van Sam

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Abstract

In order to guide national conservation policies, lists of national threatened plant species are a useful tool. To facilitate the national biodiversity commitments, Viet Nam published a conservation management guide. We evaluated the application of these guidelines, focusing on the conservation programs within protected areas across the country. We sent a survey to management offices of 32 protected areas to assess to extent the threatened plant species lists have been used in official conservation efforts. We found that the IUCN red list, the Viet Nam Red Data Book and the national decrees are the principal guidelines for conservation prioritization. Besides describing characteristics of conservation programs of threatened plant species, we discovered that the species selected for the programs have not always adhered to extinction taxonomy as the rule of thumb of using the lists. We highlight that this is not necessarily a bad implementation if taking into account the shortage of finance and maximizing the number of protected species. Thus, to enhance the utility of the lists for threatened plant species conservation, we advise users to recognize that the lists are not always updated, and to employ them as a reasonable reference rather than as the sole guideline.

Keywords: IUCN classification system, Viet Nam Red Data Book, Mornitoring, Limitation, Management

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CHAPTER 4. DIVERSITY, DISTRIBUTION, AND THREATS OF THE JULANDACEAE IN VIET NAM

Hoang Van Sam | **Do Quang Tung** | Anna K. Jasińska | François Rion | Phung Thi Tuyen | Duong Thi Bich Ngoc | Do Thanh Tam | Sébastien Bétrisey | Yi-Gang Song | Gregor Kozlowski

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Abstract

Viet Nam is one of the main centers of generic diversity for Juglandaceae worldwide. In this study, we present for the first time a province-wide distribution of all 3 subfamilies, 7 genera, and 11 Vietnamese species, and give an update on the habitats of all Vietnamese Juglandaceae species, their uses, and current threats. Juglandaceae are found throughout Viet Nam. However, most species occur predominantly in the northern part of the country between 600 and 1200 m. Some taxa range is found extensively from sea level up to 2,500 meters above sea level. According to the IUCN Red List, Rhoiptelea chiliantha, Carya sinensis, and Pterocarya tonkinensis are threatened while Engelhardia spicata, E. serrata, Alfaropsis roxburghiana, Pterocarya stenoptera are classified as least concerned (Carya tonkinensis is threatened locally, and Engelhardia spicatavar. colebrookiana and Platycarya strobilacea merit "threatened" designation in Viet Nam's Red Data Book. The most frequent threats are logging, land-use change, and habitat destruction due to artificial wood plantations or road construction. Until now, no conservation measures have been applied for any of the species in Viet Nam, although some species occur in national parks. Our study gives an important update on the current diversity and distribution of Juglandaceae in Viet Nam. We point out the need for a correct assessment of the threat status of various species on a national and international scale to protect the rarest and most endangered of them. Further research, the use of various forms of protection of individual taxa and/or their habitats, and drawing the attention of an international group of researchers to the urgent need to work together to protect biodiversity in Viet Nam hot spots are necessary.

Keywords: *Conservation biology, relict trees, Rhoiptelea, Engelhardia, Alfaropsis*

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CHAPTER 5. RISK ASSESSMENT OF HABITAT SUITABILITY DECLINE FOR THE ENGANGERED RIPARIAN TREE PTEROCARYA TONKINENSIS (JUGLANDACEAE): CONSERVATION IMPLICATIONS

Łukasz Walas, **Do Quang Tung,** Marcin Pietras, Katarzyna Sękiewicz, Felipe Bravo, Gregor Kozlowski, Hoang Van Sam

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Abstract

Tonkin wingnut is the rarest specimen from the genus Pterocarya, and occurs in few stands in the Indo-Burman biodiversity hotspot. Despite the fact that this species is endangered, it attracts less attention than other wingnut species and the knowledge on its occurrence pattern is limited. The main aim of the presented work was the estimation of the potential range of species and fragmentation of this range, determining the most important climatic factor which influences species occurrence, and the designation of potential conservation areas. Maxent, GuidosToolbox, and Zonation software were used for this purpose. The results indicate two main centers of potential range - one in southern Yunnan (China) and the other in Viet Nam. They are connected to each other through a network of watercourses. Unfortunately, the species' potential range is likely to be reduced in the future, unlike that of related species from the genus Pterocarya. The most important factors shaping the species occurrence turned out to be those related to temperature amplitude; seasonality of precipitation and distance from watercourses also have a significant impact. Analysis in Zonation software has identified the need for protected areas in southern China and also points to the possibility of expanding existing reserves in Viet Nam.

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CHAPTER 6. DISCUSSIONS AND CONCLUSIONS

In the preceding chapters, this thesis has provided information on Vietnam's national status of protected areas and its potential to reach Aichi Target 11, serving as a foundation for in-situ conservation (Chapter 2). This was followed by a discussion on how extinction taxonomy is applied to threatened plant species conservation programs within the protected areas (Chapter 3). The thesis then demonstrated this approach with a specific threatened plant family (the Juglandaceae - Chapter 4) and a single species belonging to this family (*Pterocarya tonkinensis* (Franch.) Dode*)* - Chapter 5).

All these chapters have their own conclusions and discussions. Instead of repeating these here, the present chapter first provides further discussion based on overall results obtained. I can argue that Viet Nam needs to think both within and beyond protected areas (Section 6.1 and 6.2, respectively). Following this, I propose policies that extend beyond protected areas to provide more diverse habitats for threatened plant species. (Section 6.3). Lastly, I provide concrete conclusions about the thesis as a whole (Section 6.4).

6.1 Thinking within protected areas: reason to pursue

6.1.1 Far from meeting the 2010-2020 and post-2020 CBD frameworks on expanding protected areas

It is reported in Chapter 2 that protected areas in Viet Nam have reached just half of the Aichi Target 11 (7.57% versus 17%), and met about 84% of the national target for 2020 (7.57% versus 9%). Moreover, Vietnam, as one of 190 nations, adopted the Kunming-Montreal Global Biodiversity Framework (2022). In which, among the 2030 goals, countries pledged to protect at least 30% of terrestrial and marine areas by 2030, often referred to as "30x30". With this global movement, Viet Nam continues to set the same limit of 9% protected areas in its National Strategy for Biodiversity until 2030 and Vision to 2050 (MONRE, 2022). This percentage is still significantly lower than the new global goal for protected areas. Although, Viet Nam has implemented a variety of strategies to meet its conservation goals, such as establishing nature reserves, and creating national parks,there is still a long way to go and Viet Nam needs to continue to make a lot of effort.

6.1.2 Ensuring stable habitats for threatened plant species

As a result of strict management rules, protected areas can prevent the overexploitation of threatened plants (Souza & Prevedello, 2020). Protected areas are even more important when it comes to species with only recognised ecological values. Protected areas may be the only hope for their survival. Due to their low timber quality and lack of non-timber products, these species receive much less attention from local people. For example, in our study, *Carya tonkinensis Lecomte, Carya poilanei (A.Chev.) J.-F.Leroy*, and *Platycarya strobilacea Siebold & Zucc* were classified at a high threatened level but rarely found outside protected areas (Table 6.1). Whereas it is very likely that threatened plant species with high economic values receive more resources for development outside protected areas. Because they could contribute to securing their income, the locals are interested in growing them, for example, in home gardens and production forests. *Juglans regia L.,* for instance, is very attractive to households since it provides high-quality timber and rich nutritional content nut (chestnuts). Consequently, protected areas may significantly reduce the extinction of species with economic disadvantages.

6.2 Thinking beyond protected areas: the reasons to regard

There is no doubt that the designation of protected areas is the cornerstone for halting native species decline (Watson et al., 2014) but this may not be enough. Protected areas alone can't stem the loss (Gurney et al., 2021). To protect threatened plants and allow them to regenerate, specific management interventions are often needed both within and outside protected areas. Throughout this section, we argue for a need to think beyond protected areas to conserve biodiversity and mitigate the decline of threatened plant species.

6.2.1 Awareness of the impacts of climate change on biodiversity in protected areas

Protected areas in tropical and sub-tropical countries are predicted to be the most affected by climate anomalies. Globally, protected areas with large climate anomalies tend to be located at high elevations and are highly irreplaceable for threatened species, increasing their vulnerability to climate change (Hoffmann & Beierkuhnlein, 2020). These species often have a narrower niche, lower survival rates, and are less able to cope with climate change than widespread species. They tend to shift upwards, leading to mountaintop extinctions of species endemic to isolated peaks (Nwe, Zomer, & Corlett, 2020; Vincent et al., 2020).

Located in the tropical zone, Vietnam has about 75% of its total terrestrial area classified as mountainous. Viet Nam has been ranked among the five nations most affected by climate change (Climate Risk Country Profile: Vietnam, 2021). In our study (**Error! Reference source not found.**), climate change was also considered a serious challenge, so threatened plants might suffer greatly in the in-situ conservation. Therefore, prioritization schemes will need to consider climate-driven changes to the biodiversity in protected areas.

6.2.2 Threatened plant species found outside protected areas: a call for more attention

Most of plant diversity occurs outside of protected areas (Heywood, 2019). For instance, freehold lands have been important for those species at greatest risk of extinction in Australia. Despite this tenure covering only 29% of the continent, nearly half (48%) of Australian threatened species' distributions occur on these lands (Kearney et al., 2022). Similarly, in the New Caledonia biodiversity hotspot, among 25% of the risked endemic plants, 83% of them did not occur at all in a conservation area (Jaffre, Bouchet, & Veillon, 1998). Additionally, only 56% of threatened trees are likely to be found in protected areas, compared to 85% of non-threatened species (BGCI, 2021).

Our studies (Chapters 4 and 5) found that the species were also found outside protected areas, although their occurrence and frequency of occurrence were less than those in the in-situ (Table 6.1). As an example, the *Pteracarya tonkinensis Dode* can be found both inside and outside protected areas occasionally. Species with high economic values were often found in home gardens of households (*e.g., Juglans regia L.),* the others could be found along the streams, rivers, and valleys. Thus, we highlight a need to account for these species in these areas to advance collective conservation efforts.

Table 6.1 Current distribution of the studied species inside and outside protected areas

N0	Name of species	Classification				Observation			
						Inside PAs		Outside PAs	
		IUCN 2022	Viet Nam Red Book 2007	Proposed for IUCN	Proposed for Viet Nam Red Book (next edition)	Occurrence	*Estimated frequency of occurrence by field observation*	Occurrence	*Estimated frequency of appearance by field observation*
1	*Alfaroa roxburghiana (Lindl. ex Wall.) Iljinsk*	LC				X	Very Frequently	X	Frequently
2	*Carya tonkinensis Lecomte*		VU	EN	EN	X	Rarely	X	Very Rarely
3	*Carya poilanei (A.Chev.) J.-F.Leroy*					0	Never	X	Very Rarely
4	*Carya sinensis Dode*	EN	EN	EN	EN	X	Rarely	X	Very Rarely
5	*Engelhardia spicata Blume*	LC				X	Rarely	X	Rarely
6	*Engelhardia spicata var. colebrookiana Lindl.*			VU	VU	X	Rarely	0	Never
7	*Engelhardia serrata Blume*	LC				X	Rarely	X	Very Rarely
8	*Juglans regia L.*					0	Never	X	Occasionally
9	*Platycarya strobilacea Siebold & Zucc*			VU	VU	X	Rarely	0	Never
10	*Pteracarya tonkinensis Dode*	VU		VU		X	Occasionally	X	Occasionally
11	*Pterocarya stenoptera C.DC.*	LC				X	Rarely	0	Never
12	*Rhoiptelea chiliantha Diels & Hand.-Mazz*	VU	EN	EN	EN	X	Rarely	0	Never
	Overal					**83%**		**67%**	

Note: Occurrence: X is present; 0 is not present; Estimated frequency occurrence by field observation (using Likert scale 5-point to estimate).

6.3 Advancing other tools for threatened plant species conservation

In addition to expanding protected areas, there are a variety of other instruments and mechanisms available to retain and broaden habitat quality and quantity of threatened plant species. We cannot discuss them all here. Instead, we will focus on those we encountered during our extensive fieldwork.

6.3.1 Private land conservation areas: The role of home gardens

Private land conservation areas (PLCAs) are gaining a lot of attention as a complementary conservation strategy (Nolte et al., 2019; Shumba et al., 2020; Stolton et al., 2014). PLCAs are pieces of land managed by a variety of means. They can be protected with or without formal government recognition, owned or otherwise secured by individuals, communities, non-governmental organizations, religious groups etc., (Stolton et al., 2014).

As one type of private land, home gardens are receiving more attention for their roles in in-situ conservation of genetic diversity in plants and endangered trees. Around the world, home gardens have been acknowledged for conserving species, for example, in Benin (Salako et al., 2014), in the Philippines (Tobias et al., 2021), in Ethiopia (Arayaselassie Abebe Semu, 2018), and in many other countries (Watson, 2001).

Since the end of the 20th century, Viet Nam has raised fundamental questions about home gardens in conservation, such as how home gardens are dynamic and used for multiple purposes affecting their stability and viability as conservation units. As part of developing complementary in situ conservation strategies and methods that incorporate microenvironments, home gardens are recommended (Hodel & Gessler, 1999).

Recently, a study was conducted in 120 home gardens in the North East and North Central Coast regions of Viet Nam (Mulia et al., 2022). It was found that ten of sixteen recorded timber trees were native to the country, including one 'critically endangered' (*Aquilaria crassna* Pierre), two 'endangered' (*Erythrophleum fordii* Oliver and *Parashorea chinensis* H. Wang), and one 'vulnerable' (*Dalbergia tonkinensis* Prain), according to the global Red List of threatened tree species. This study provides evidence for the potential role of home gardens as a plant genetic source and for in-situ conservation.

The Viet Nam National Biodiversity Strategy to 2030, with a vision to 2050, encourages 'on-site conservation' as a solution for conservation and restoration of endangered wild species. The focus, however, is limited on valuable medicinal plant species (MONRE, 2022). Thus, recognized as a viable conservation unit, I recommend that the Government of Viet Nam should support programs for the diversification and domestication of native tree species in home gardens, including many threatened species.

6.3.2 Other effective area-based conservation measures (OECMs): a potential option for conservation in Viet Nam

Since 2010, the new term ‘other effective area-based conservation measures’, or OECMs, was introduced into Aichi Target 11 of the Convention on Biological Diversity Strategic Plan (CBD, 2010). Comparedg to protected areas, which must have a primary conservation objective and have much action focused on expanding, OECMs may be managed with conservation as a primary or secondary objective but must deliver effective conservation and have received rather less attention (Laffoley et al., 2017).

OECMs can be produced through three different approaches. "Primary conservation" refers to areas that meet all the elements of the IUCN definition of a protected area. However, they are not yet recognized as protected by the relevant governance authorities. "Secondary conservation" refers to the management of an area with biodiversity outcomes as a secondary management objective. "Ancillary conservation" refers to areas that provide in-situ conservation as a by-product of management activities, even though the conservation of biodiversity is not one of the management objectives (IUCN-WCPA Task Force on OECMs, 2019). Under the context of global support for a goal to conserve 30% of the planet by 2030, also known as the 30x30, (Target 3, Kunming-Montreal Global Biodiversity Framework, 2022), OECMs could contribute to achieving the 30% target, alongside protected areas and increase the effectiveness of global conservation system in many ways (Gurney et al., 2021).

Currently, OECMs have emerged as promising for biodiversity conservation in Viet Nam (Duong & Pham, 2021). With nearly 14.8 million hectares of forest, of which more than 2 million are special-use forests (mainly national parks and nature reserves); more than 4 million are protection forests (MARD, 2023). As discussed in chapter 2, special-use forests are reported as protected areas, but protection forests are not included, though they may be qualified. Many protection forests are rich in biodiversity (GIZ, 2020). Nevertherless, protection forests primarily aim is to retain environmental services such as protecting watersheds, preventing flash floods, landslides, and soil erosion etc., while conserving biodiversity is set as secondary purpose (Clause 3, Article 5, Law on Forestry, 2017). Enduring long-term watershed management policies may contribute to effective biodiversity conservation in such watersheds. Hence, protection forests have high potential to be recognized as OECMs if they are not (yet) designated as protected areas.

6.4 Conclusions

1. Along with other stated purposes, protection forests are mainly defined as forests protected for maintaining environmental services. Hence, these forest areas, especially those with high biodiversity values, are well-suited to being designated as protected areas.

2. It is critical to supplement threatened plant species lists with field surveys to ensure efficient conservation actions due to the lack of permanent updates to these lists.

3. Juglandaceae inhabit a wide range of ecological situations in Northern Viet Nam. Being most frequent between 500 and 1200 meters above sea level. Up to now, no conservation measures have been established for the Juglandaceae species most endangered. Therefore, conservation measures should be implemented to protect these species and avoid extinction.

4. Two main potential ranges or *Pterocarya tonkinensis Dode* have been identified in Yunnan (China) and Northern Viet Nam. The species' potential range is predicted to shrink in the future so the establishment of protected areas in Yunnan and the expansion of existing reserves in Viet Nam is proposed along the interconnecting watercourse network.

5. In addition to protected areas, threatened plant species conservation should extend outside protected areas as well. Additional proactive conservation strategies such as private land conservation measures (e.g., home gardens) or other effective area-based conservation measures (OECMs), are needed to advance more resources and diversity conservation areas.

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