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THREATS TO GOLDEN-FLOWERED CAMELLIAS ALONG HON GIAO PASS

Anthony S. Curry[a*]

[a]*3 Ferguson Road, Springwood, NSW 2777, Australia*
[*]*Corresponding author: Email: anthonycurry55@gmail.com*

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Abstract

The identification, documentation, and discussion of the main threats affecting the golden-flowered Camellia species endemic to Hon Giao Pass are discussed. Observations, published literature, and collations of data accumulated from field trips throughout Vietnam since 1999 are analyzed and researched for the preparation of the article. The major anthropogenic risk factors affecting the golden-flowered Camellia species and their habitats on the Dalat Plateau and along the Hon Giao Pass are named and reviewed. These risk factors include habitat loss due to population growth, logging, habitat fragmentation and degradation, poaching, collection of wild plant species, fire, and the construction of dams and their associated water impoundments.

Keywords: Dalat Plateau; Golden-flowered camellias; Hon Giao Pass; Khanh Hoa; Lam Dong; Threats.

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1. INTRODUCTION

This study documents the main causative factors of habitat loss on the Dalat Plateau (DP) and how they may affect the golden-flowered *Camellia L*. species endemic to the Hon Giao Pass (HGP). The natural ecosystems of the DP are threatened by anthropogenic pressures and with the escalation of these stresses, the natural environments and the survival of the three golden-flowered *Camellia* species endemic to the HGP may be put at risk. The species in jeopardy along the HGP are *Camellia inusitata* Orel, Curry, and Luu; *Camellia sonthaiensis* Luu, V. D. Luong, Q. D. Nguyen, and T. Q. T. Nguyen; and *Camellia bidoupensis* Truong, Luong, and Tran. The major threats to the ecology of the DP and HGP include increasing population, logging, fragmentation and degradation of habitat, poaching, the over-exploitation of plants, wildfire, and the construction of dams and hydroelectric power stations (Beech et al., 2017; Critical Ecosystem Partnership Fund (CEPF), n.d.; Dang et al., 2018; Sterling et al., 2006).

Vietnam has drastically changed, undergoing an almost complete metamorphosis since 1999, the year I first visited Vietnam. Many advances have occurred, many for the betterment of the people of Vietnam and their livelihoods, while others have placed great pressure on plant habitats, people, and the regions where they live and work. The author has been impressed by the attitudes and experience of the staff of Bidoup-Nui Ba National Park (BNBNP) as he traveled around the DP and collaborated with staff on, or about, Hon Giao Mountain and HGP. The changes seen during this time are the main motivation for this article.

2. METHODOLOGY

The author completed a thorough search and analyzed the salient literature on the status of the effects and influences of the reported environmental impacts, both abiotic and biotic, on the ecosystems of the DP and the HGP. This analysis included an evaluation of how these factors affect the survival of the golden-flowered *Camellia* species endemic to this ecoregion. The author also collated data extracted from field notes and trip reports and aligned comments with topical and descriptive photographs taken during field trips from 1999 to 2018.

3. DISCUSSION

In the wild, more than 30% of all theaceous species, and 70% of *Camellia* L. species, are threatened with extinction due to urbanization and agricultural encroachment (Beech et al., 2017; Bourke, 2019). Along the HGP, three special *Camellia* species are at risk due to environmental vagaries and the pernicious actions of humans, e.g., *Camellia inusitata* Orel, Curry, and Luu, *Camellia sonthaiensis* Luu, V. D., Luong, Q. D. Nguyen, and T. Q. T. Nguyen, and *Camellia bidoupensis* Truong, Luong, and Tran. These three species occupy fragile habitats along the main tourist and arterial road linking Dalat, a small city in the Central Highlands, to Nha Trang on the coast.

Since the 1960s, the terms golden-flowered and yellow-flowered *Camellia* L. species have been applied to *Camellia nitidissima* C.W. Chi (syn. *Camellia chrysantha* (Hu) Tuyama). However, due to ongoing fieldwork and systematic research, this epithet now applies to more than 80 *Camellia* species found in southern China and Vietnam. About 50% of the golden-flowered *Camellia* species occur in each country. Refer to Figure 1 for images of three golden-flowered *Camellia* species, namely, *Camellia nitidissima*, *Camellia petelotii* (Merr.) Sealy, and *Camellia luteocerata* Orel.

Flowers of *Camellia nitidissima*: Nanning Botanic Garden, Nanning, Guangxi, southern China (2013)

Flower and buds of *Camellia petelotii*: Tam Dao National Park, Vinh Phuc Province, northern Vietnam (2001)

Flower of *Camellia luteocerata*: Cat Tien National Park, Dong Nai Province, southern Vietnam (2010)

Figure 1. Three golden-flowered *Camellia* species

Camellia inusitata is a 3-m-tall shrub found growing in the environs of the Hon Giao Ranger Station in an ecotonal area between mid-mountain, evergreen, closed forest, and mossy forest on permanently wet, fertile soils. Refer to Figure 2 for illustrations of the morphology of *Camellia inusitata* and its habitat. *Camellia inusitata* is assessed as Critically Endangered (CR B2; C) fewer than 100 mature individuals have been found in an area of occupancy of less than 1 km^2 (Beech et al. 2017; Orel et al., 2012b).

Camellia sonthaiensis is a shrub growing to 5 m tall along streams on HGP at elevations of about 800 m in a moist, evergreen, middle mountain forest in Khanh Vinh District, Khanh Hoa Province. This species has arching stems and purple new growth, while the mature leaves are light green, leathery, pendulous, and shiny on both sides, and the flower color is mid-yellow (Luu, Luong, et al., 2015). Refer to Figure 3 for details of the flower, foliage, and habitat of *C. sonthaiensis*.

Camellia bidoupensis is a small tree growing from 3–7 m tall. The leaves are dark green, medium-sized, shiny, leathery, and shallowly impressed on the upper side. The flowers are pale yellow with purple striations at the base of the petals. The capsules are irregularly ovoid, having one seed, and the pericarp is smooth and thin. The shape of the capsules reminds me of a grape tomato (*Solanum lycopersicum* L. 'Grape') but with "a twist." The habitat of *C. bidoupensis* is moist, evergreen forests at an elevation of 1600 m scattered among rocky outcrops on mountain slopes and ridges. Figure 4 illustrates the flower and fruit of *C. bidoupensis*.

Flower of *Camellia inusitata*: Hon Giao Pass

Flattened stem and distichous leaves of *Camellia inusitata*: Hon Giao Pass (2014)

An upright stem and distichous foliage of *Camellia inusitata*: Hon Giao Pass

A dissected fruit and an entire immature fruit of *Camellia inusitata*

Open capsule of *Camellia inusitata* displaying wide-spreading valves, seeds, and columella

Mossy forest – the habitat of *Camellia inusitata*: Hon Giao Pass (2014) (Image: A. Curry)

Figure 2. *Camellia inusitata* (2010)

Note: Images adapted from Luu Hong Truong (2010) except as indicated.

Figure 3. *Camellia sonthaiensis*: flower, foliage, and habitat on Hon Giao Pass

Note: Images adapted from Truong Quang Cuong (n.d.) except middle mountain, evergreen, closed forest habitat along stream (RHS) – Hon Giao Pass (2014) (Image: A. Curry, RHS).

Figure 4. *Camellia* bidoupensis: flower and developing fruits

Note: Images adapted from Truong Quang Cuong (2018, LHS) & (2019, Center & RHS).

Additionally, in the Hon Giao region, there are many other endangered and endemic species of Theaceae (refer to Figures 5 and 6). Some of the species are *Polyspora huongiana* (Orel et al., 2012a) (Vulnerable), *Adinandra hongiaoensis* (Hoang & Luong, 2014), *Camellia hongiaoensis* (Orel & Curry, 2014) (Data Deficient), *C. quangcuongii* (Luong et al., 2016) (Critically Endangered), and *C. flosculora* (Le et al., 2021) (Endangered).

The number of theaceous and other newly discovered taxa on Hon Giao Mountain and along the HGP attests to the diversity and richness of the flora of this region (Luu, Pham, et al. 2015; Tagane et al., 2020).

Figure 5. Flowers of *Polyspora huongiana* at 1,670 m elevation (2010) and *Camellia hongiaoensis* at 800 m elevation (2018): two endemic Theaceae species on Hon Giao Pass

Figure 6. Flowers and buds of *Camellia quangcuongii* (left) and *Camellia flosculora* (right) at 800 m elevation on Hon Giao Pass

Note: Image of *Camellia flosculora* flower adapted from Truong Quang Cuong (n.d.).

The main threats to the golden-flowered *Camellia* species growing on the DP and along the HGP relate to habitat loss due to human activities. The International Union for Conservation of Nature (IUCN) has categorized these impacts into the Threats Classification Scheme (IUCN, 2021) which is used here:

- Residential and commercial development and tourism
- Agriculture – perennial non-timber crops, shifting agriculture, wood and pulp plantations, agroindustry plantations
- Energy production – hydroelectric power station construction and associated dams
- Transportation and service corridors – roads
- Biological resource use – gathering terrestrial plants, logging, and wood harvesting
- Natural system modifications – fire and fire suppression
- Invasive and other problematic species and climate change
- Geological events – landslides.

3.1. Residential and commercial development and tourism

When I visited Vietnam in 1999, the population of the country was estimated to be about 80 million people. At the time of my last visit in 2018, the population had risen to approximately 95 million people (Countryeconomy.com, n.d.), an average annual population growth rate of 790,000 people. Rapid population growth rates and urbanization place inordinate pressure on the region's natural resources and ecosystems, including the DP and HGP. The population density on the DP is moderate due to the higher altitudes and rugged, steep terrain. Nonetheless, the effects of human activity are ubiquitous here, mainly due to the struggle of people for survival and their striving for a better life, better housing, food security, improved diets, higher incomes, and a fairer share of the region's wealth (van Dijk et al., 2013). As the population grows, the availability and capability of the land decreases making the land less productive under slash and burn practices. This, in turn, leads to degraded plant communities of scrubland or grasslands known locally as *tranh* (Hacker et al., 1999; Facts and Details, 2014; Wikipedia, 2021a).

Also, a high proportion of forests on the plateau have been cleared for settlements and their expansion as deemed necessary, e.g., Dalat; Bnor B and Bon Dung I (Lac Duong Town); Da Ra Hoa, Da Blah, and Da Tro (Da Nhim Commune); Klong Klanh and Dung K'si (Da Chais Commune); and the Lang Dinh An (Lat Commune) (Sobey, 2008; VAMVO, n.d.; van Dijk et al., 2013). Figures 7 and 8 exemplify the degree of deforestation of the plateau for human habitation, industry, and agricultural production.

Figure 7. Dalat (2014) and horticultural developments in the environs (2012)

In the future, researchers expect that smaller regional centers and villages will grow faster than Vietnam's larger cities, i.e., Hanoi, Ho Chi Minh City, Haiphong, and Danang. As urban areas undergo resettlement and immigration programs, this puts further pressure on regions, plant communities, and agricultural lands (Fox et al., 2000; Sobey, 2008; van Dijk et al., 2013).

UAZ-469 Jeeps for transporting tourists to the summit of Rada Peak

Lat congregation hall, Lat Commune, Lang Biang Plateau

Figure 8. Rada Peak (left) and Lat Commune (right), Lang Biang Reserve (2006)

A scenario discussed in van Dijk et al. (2013) is the possibility that as people's incomes grow and standards of living rise, the pressure on administrators and governments to relax certain safeguards on reserved and protected lands will intensify, e.g., nature reserves, national parks, Ramsar designated areas, and World Heritage sites. Researchers have predicted this as a solution for Vietnam's diminishing area of available arable land as well as land for urbanization and residential purposes. Planners and administrators will suggest formerly protected lands for conversion and exploitation for "productive" purposes or settlements (van Dijk et al., 2013). Environmentalists hope that such a short-sighted policy would not be implemented until the relevant administrators complete a thorough scientific scrutiny, environmental evaluation, and cost-benefit modeling of such an approach.

Ecotourism leads to the loss of farming land (Pham & Le, 2016; Bui, 2020). "Ecological developments" directed towards the tourism industry to widen and deepen the access and scope of tourist experiences in threatened habitats and conservation areas may be just as contentious and problematic to the sound maintenance and management of primary forests and protected areas. Examples of such schemes include ecotourism

proposals in BNBNP, the introduction of pilot schemes for birdwatching trails and night walks in and around Hon Giao, and in the vicinity of K'long K'lanh Ranger Station, along Provincial Road 723 between Giang Ly and Hon Giao ranger stations, Gia Rich Mountain and Xa Lat Commune, Lam Dong Province, and Tam Dao in Vinh Phuc Province, northern Vietnam (ASEAN Centre for Biodiversity & ASEAN Clearing House Mechanism, n.d.; Sobey, 2008; Tran & Le, 2013; Van et al., 2009). Figure 9 illustrates how ecotourism experiences, e.g., Thien Thai Eco-trail in BDNBNP, may eventually degrade and fragment habitats through which they pass. Sections of this trail cut through the habitat of *Camellia cuongiana* Orel and Curry (2015) and so may jeopardize the habitat of this *Camellia* species.

Thien Thai Eco-trail entry sign (2018)

Eroded section of Thien Thai Eco-trail (2018)

Camellia cuongiana Thien Thai Eco-trail (2012)

Figure 9. Thien Thai Eco-trail Bidoup-Nui Ba National Park

An operational fish farm, Bidoup-Nui Ba National Park

Forest degradation in the environs of the fish farm

Figure 10. A consequence of fish farming: Bidoup-Nui Ba National Park (2017)

Sobey (2008) recounts conservation-development contradictions associated with developments of any kind in protected areas. For example, the K'long K'Lanh Agri-Tech Zone is a wetland site in proximity to a documented habitat of the yellow-cheeked crested gibbon (*Nomascus gabriellae*) (Van et al., 2009). This situation is problematic for planners, as it could become a small nature reserve with ecotourist trails and scenic vantage points, hosting a population of gibbons and wild bird populations, riverine habitats, wetlands, and forested areas; alternatively, the investors could develop the wetland site as a fish farm. Such a development would involve partially draining the wetlands, excavation and construction of breeding ponds, and the accompanying impact

of this mode of infrastructure (see Figure 10). Investors have considered the development of the 600-ha K'long K'Lanh Agri-Tech Zone for cattle grazing on the moist wetland areas. This activity would need the construction of drainage channels as well as the application of aperiodic, seasonal inundation. All three proposals (nature reserve, fish farm, and grazing land) have pros and cons, and whatever development the investors select for implementation needs to be in joint consultation with the villagers regarding alternative land-use practices due to "political sensitivity of this area." (Sobey, 2008, p. 8)

Unless managers of protected areas sensitively implement, set up, and supervise ecotourism schemes, they too can contribute to the eventual degradation or loss of natural ecosystems. Additionally, they can increase the accessibility of plant poachers to the inner sanctums and more isolated areas of protected environments (Jandl & Price, 2011; Rhind, 2012; Sobey, 2008; Tran & Le, 2013).

Bidoup-Nui Ba National Park is about 50 km from Dalat and 112 km from Nha Trang via the PR723 and HGP (Bui, 2020). Dalat has two major industries, agriculture and tourism. The accessibility of Dalat drives the expansion of ecotourism and socioeconomic change within the city as well as in the environs of the BNBNP (Asia-Pacific Economic Cooperation Secretariat, 2020). The management and staff of BNBNP have implemented a program of guided, educational ecotours for school children and tourists using the knowledge and skills of the local peoples, i.e., the K'ho (ASEAN Centre for Biodiversity & ASEAN Clearing House Mechanism, n.d.). However, the ease of access to the park facilitates illegal logging, as well as poaching and plant collecting within the park and surrounding areas (Bui, 2020; Goldammer & Mutch, 2001). These disruptive, destructive, and dynamic factors, especially in golden-flowered *Camellia* habitats, have the potential to threaten *Camellia* species, as well as other rare and endangered plants along the HGP (Jandl & Price, 2011; Rhind, 2012).

3.2. Agriculture: perennial non-timber crops, shifting agriculture, wood plantations, agro-industry plantations

Over the last 30 to 40 years, investors have established orchards of power oranges (*Citrus* × *sinensis* (L.) Osbeck 'Cara Cara') (see Figure 11) and plantations of pine (*Pinus* L. species) and wattle (*Acacia* Miller spp.).

Commercial agricultural and horticultural enterprises, such as coffee (*Coffea canephora* Pierre ex A. Froehner), tea (*Camellia sinensis* (L.) Kuntze) (refer to Figure 12), longan (*Dimocarpus longan* Lour.), and African mahogany or khaya (*Khaya senegalensis* (Desr.) A. Juss.) for commercial charcoal production, have been rapidly expanding for local and world markets. Agro-industry has set up many enterprises at the expense of the ecoregion's forests and other plant communities (Beech et al., 2017; Sterling et al., 2006; Tordoff et al., 2020; Uhart, 1953; Vinachaki, 2020; Wikramanayake et al., n.d.).

Figure 11. A plantation of power oranges (*Citrus* × *sinensis* 'Cara Cara'), Dalat Plateau (2013)

A coffee (*Coffea canephora* Pierre ex A. Froehner) plantation

A tea (*Camellia sinensis* (L.) Kuntze) plantation and a quarry in the background

Figure 12. A coffee plantation (2004) and a tea plantation (2013), Dalat Plateau

The production and income from these ventures contribute to and support the local, national, and international economies, yet they are a major cause of deforestation with the potential of causing severe loss of *Camellia* habitats and their concomitant species on the DP and HGP. Additionally, not only the golden-flowered *Camellia* species along the HGP, but more widely on the DP, there are several *Camellia* species that are Endangered or Critically Endangered, e.g., *Camellia piquetiana* (Pierre) Sealy, *Camellia langbianensis* (Gagnep.) P. H. Ho, *Camellia vidalii* Rosmann, *Camellia dongnaiensis* Orel, *Camellia oconoriana* Orel, Curry and Luu, *Camellia dalatensis* V. D. Luong, Ninh and Hakoda, and *Camellia dilinhensis* Ninh and V. D. Luong (Beech et al., 2017; Orel, 2006; Orel et al., 2013; Quach et al., 2021; Richards et al., 2003; Rosmann, 1999; Sealy, 1958; Tran & Luong, 2013).

Refer to Figures 13 and 14 for images of some of the Endangered or Critically Endangered *Camellia* species mentioned. Moreover, these issues are of concern to the conservation of the *Camellia* flora throughout Vietnam (Tran, 2003).


Figure 13. Flowers of *Camellia piquetiana* (2010) and *Camellia dongnaiensis* (2014)

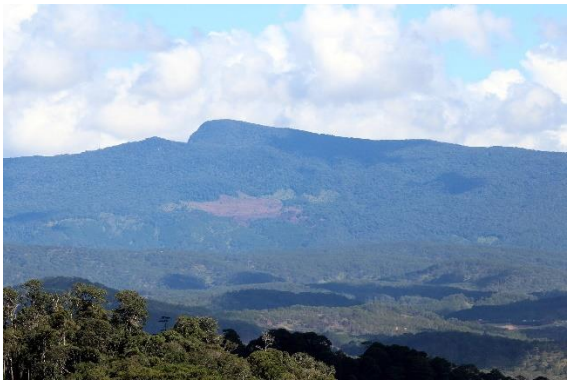

Figure 14. Flowers of *Camellia oconoriana* (2010) and *Camellia dalatensis* (2012)

Note: Image of *Camellia dalatensis* (RHS) adapted from Luong Van Dung (2012).

Human activity and settlement, including slash and burn cultivation (refer to Figure 15) have dramatically changed the nature, scale, and condition of the evergreen forests on the DP and along the HGP. These practices are the cause of ongoing habitat reduction and fragmentation in the constant drive for "new" land to cultivate food crops and support livelihoods (BirdLife International, 2022; Sobey, 2008; Sterling et al., 2006; Wikipedia, 2021a). Like many *Camellia* species in Vietnam and China, the golden-flowered *Camellia sonthaiensis* and *Camellia bidoupensis*, as well as the coral-to-dark-pink-flowered *Camellia hongiaoensis*, grow on the lower valley slopes and above creeks in moist forest (Hakoda et al., 2007; Le & Do, 2007; Orel, 2018; Tran, 1998, 2003; Tran & Le, 2005, 2013, 2015; Yang et al., 2012). These sites are often more fertile than the side and upper slopes and closer to a potential water supply, making them more attractive to indigenous farmers for cultivation. In such instances, the habitats of golden-flowered *Camellia* species and other taxa are directly put at risk due to agricultural and environmental pressures (Hauser & Norgrove, 2013).

The regular use of fire in slash and burn farming can inhibit the regenerative ability of the cultivated area and encourage the growth of Khasi pine (*Pinus kesiya* Royle ex Gordon), or other invasive plant species and weeds, e.g., giant sensitive trees (*Mimosa pigra* L.) or tree marigold (*Tithonia diversifolia* (Hemsl.) A. Gray) (BirdLife International, 2022; Fox et al., 2000; Sobey, 2008). However, due to confusion over the interpretation of the names of the various modes of traditional cultivation practices, the ultimate effects of slash and burn farming are still debated (Fox et al., 2000).

On the DP and HGP, as the population increases, the area of available arable land shrinks in relation to the population. To counteract the diminution of cultivable land, farmers encroach upon forested areas to replace the land lost (BirdLife International, 2022; Sobey, 2008; Wikipedia, 2021a). To satisfy the demand for more land farmers clear more forest. However, this "new" land is often less productive or less capable of long-term farming. The lower capability of the land is usually due to the nature of the terrain, such as potential soil degradation and topography, including rocky outcrops, steep slopes, soil erosion, mass movement, and depletion of nutrients and organic matter (Food and Agriculture Organization (FAO), 1999; Jandl & Price, 2011; Pham & Swan, 2009).



Forest clearing for planting a coffee plantation or slash and burn farming in the foothills of Bidoup Peak: Dalat Plateau, Vietnam (2012)

The impact of slash and burn farming practices: near Ban Long Mieng, Vieng Kham District, Luang Prabang Province, Laos (2017)

Figure 15. The impact of clearing and slash and burn farming in Vietnam and Laos

The images displayed in Figures 16, 17, and 18 of slash and burn cultivation practices on the HGP exemplify some of the problems associated with this unsustainable farming method, e.g., creation of light gaps, forest fragmentation, possible loss of biodiversity, land left to lie fallow exposing the soil to erosion, weed infestation, recruitment of other invasive plants and pest species, as well as depletion of nutrients and organic matter (Charman & Murphy, 1993; Jandl & Price, 2011; Sterling et al., 2006).

The images of the *Camellia hongiaoensis* site taken in 2014 and 2018 show part of the cycle of land clearing for slash and burn farming, as well as the pressing need for land by the local people for the preservation of their livelihoods. The images taken in 2018 also show that weeds invade light gaps created by clearing and burning.

In Figure 18 indigenous farmers on HGP have planted staple crops, namely plantains/bananas (*Musa* L. cultivar) and (possibly) cassava (*Manihot esculenta* Crantz) across the pass from the *Camellia hongiaoensis* site. The very steep, exposed slopes typical of plantain/banana plantations, pictured here, are subject to severe soil erosion loss of soil nutrients and organic matter in Vietnam's monsoonal climate. The lighter colored patches of exposed subsoil in the center of the image indicate the highly erosive soil along the HGP (refer to Figure 18).

Camellia hongiaoensis site: 800 m elevation, Hon Giao Pass (2014)

A site cleared and burnt opposite the *Camellia hongiaoensis* site: Hon Giao Pass (2014)

A view of the burnt clearing at the *Camellia hongiaoensis* site: 800 m elevation, Hon Giao Pass (2018)

A view from a different angle of the cleared and cultivated land opposite the *Camellia hongiaoensis* site, Hon Giao Pass (2018)

Figure 16. Comparison of the *Camellia hongiaoensis* site and a site opposite on Hon Giao Pass: 2014 and 2018

A view of the slope of the burnt clearing at the *Camellia hongiaoensis* site

A cut stump of *Camellia hongiaoensis*. Camellias are cut for construction, tool handles, and walking sticks

Figure 17. Weed invasion of the *Camellia hongiaoensis* site: Hon Giao Pass, elevation 800 m (2018)

Figure 18. Plantains/bananas in cultivation at the clearing on the side of Hon Giao Pass opposite the *Camellia hongiaoensis* site: Son Thai District, Khanh Hoa Province, 800 m elevation (2018)

The removal of topsoil by erosion seriously impedes the ability and rapidity of disturbed areas to regenerate (refer to Figure 19) (FAO, 1999).

A slaking pile of soil

A slaking earthen road embankment

Figure 19. Examples of soil erosivity and instability contributing to soil degradation along Provincial Road 723 linking Dalat to Nha Trang via Hon Giao Pass

Competition or disputes between farmers may lead to a shortening of fallow periods within a rotation, or even the loss of fallowed land to competitors, which in turn drives further soil degradation, reduced land capability, and the need for clearing more forest land by slash and burn farmers.

This sequence of events may threaten the habitats of the golden *Camellia* species along the HGP (Sobey, 2008; Sterling et al., 2006). Clearing forest areas by shifting cultivators in this manner fragments ecosystems, forming a patchwork of “cold, cool, warm, and hot areas of forest instability” that can lead to further land degradation, habitat disturbance, and loss of biodiversity. When this occurs, the affected areas have little prospect of returning to their former “productive,” “natural,” or “primary” states (FAO, 1999).

3.3. Energy production: renewable energy production, hydro-electric power station and dam construction

The construction of dams and hydroelectric power stations on the DP and HGP does not readily come to mind as threats to the golden-flowered *Camellia* species growing there. However, the provincial engineers constructed Dan Kia Lake in the 1940s to supply potable water to Dalat (Alotrip.com, 2014; Dalat Happy Tours, n.d.; Dankia Lake–Golden Stream, 2018). The building of the dam and its impoundment, as seen in Figure 20, submerged the type locality of *Camellia langbianensis* (Gagnep.) P. H. Ho (syn. *Dankia langbianensis* Gagnep.).

Figure 20. View to Dan Kia Lake from the summit of Rada Peak near Lat Commune, Lang Biang Reserve (2006)

However, recent fieldwork and research have resulted in the rediscovery of *Camellia langbianensis* with the location of two populations in Lam Dong Province and one in Ninh Thuan Province in 2017–2019 (Quach et al., 2021).

Another example of this potential threat to a wild *Camellia* species occurred in Dong Nai Province. The Endangered *Camellia longii* Orel and Luu (Beech et al., 2017) is only known from Cat Loc, the northern part of Cat Tien National Park, in Dong Nai Province, about 170 km from Dalat (Orel et al., 2014).

The Endangered Long's camellia grows in a secondary, evergreen, broadleaf-bamboo tropical forest in an area of less than 150 m^2 (Beech et al., 2017; Orel et al., 2014; Trung tâm Dữ liệu Thực vật Việt Nam, n.d.). Long-term agricultural activities, such as cashew (*Anacardium occidentale* L.) plantations, threaten the habitat of *Camellia longii*. In 2002 the proposed construction of Dong Nai 6 and Dong Nai 6A hydroelectric projects and their impoundments on the Dong Nai River, in southern Vietnam threatened the type-locality of this rare *Camellia* species (Beech et al. 2017; Scheidel, 2019). However, policymakers and government officials decided to cancel the planning and construction for both of these projects in 2013 rescuing *Camellia longii*, as well as the rich, biodiverse forests and wetlands of Cat Loc and parts of Cat Tien National Park. This decision also rescued the UNESCO-recognized Dong Nai

Biosphere Reserve, Bau Sau swamp, a RAMSAR site, and a Dong Nai special national relic site, from permanent inundation (Dao & Bui, 2015; Pham, 2015; Scheidel, 2019). The discovery of *Camellia longii* (refer to Figure 21) by Vu Ngoc Long, Director of the Southern Institute of Ecology, in July 2011 contributed to the eventual cancellation of the construction of both hydropower projects on the Dong Nai River (Sterling et al., 2006; Vietnam Academy of Science and Technology, 2014).

Figure 21. *Camellia longii* flower bud and habitat: Cat Loc, Cat Tien National Park, Lam Dong Province (2010)

3.4. Transportation and service corridors: roads

Road construction to widen and upgrade for intercity or interprovincial travel for any purpose could have harmful effects on the *Camellia* habitats on the DP and along the HGP.

On the DP and at the head of the HGP an especially gloomy warning for one *Camellia* species was sounded:

> The known population of *Camellia inusitata* faces a potentially elevated risk of extinction in the immediate and mid-term future. The building of a main road has already divided the type-population of *Camellia inusitata*, resulting in disturbance and habitat fragmentation. Traffic volumes are increasing with ever-expanding local traffic and tourist activities. Future road widening would directly threaten the population since trees occur within 15 m of the present road. Given this situation, we consider the IUCN category of Critically Endangered (CR) to be appropriate (Orel et al., 2012b, p. 352).

In northern Vietnam, Tran and Le (2013) reported another dire situation where an ecotourism project threatens a population of *Camellia petelotii* (Merr.) Sealy. The distribution of this species includes China and northern Vietnam in Tam Dao National Park at an elevation of 900 m on Rung Rinh Peak.

> In 1994, many [mature] individuals of this species were observed when we were on the way to Rung Rinh Peak. In 2005, developers constructed a new road connecting the Tam Dao 1 to Tam Dao 2. This road lies along the distribution area of this species. During the road construction, the road crews cut down and

removed many individuals of this species. In addition to the decline in numbers, the habitat of the Petelo[t] camellia has also changed a lot. Therefore, this species is now listed as in need of protection and future development in TDNP (Tran & Le, 2013, p. 126).

Recently constructed ecotourism road Tam Dao 1 to Tam Dao 2 (2007)

Ecotourism road construction through the *Camellia petelotii* site (2007)

Ecotourism facilities at the termination of the road from Tam Dao 1 to Tam Dao 2 in amidst *Camellia petelotii* site (2015)

Ecotourism facilities at the termination of the road from Tam Dao 1 to Tam Dao 2 amidst *Camellia petelotii* site (2015)

Figure 22. Some consequences of the construction of an ecotourism road from Tam Dao 1 to Tam Dao 2, Tam Dao National Park, Vinh Phuc Province, northern Vietnam

Figure 22 depicts the problems highlighted by Orel et al. (2012b) and Tran and Le (2013), such as growing local traffic and tourist activities, the proximity of *Camellia* specimens to roads, further road widening that threatens *Camellia* populations near road edges, the many mature *Camellia* trees that are chopped down, and the consequential reduction in species numbers and degradation of *Camellia* habitat.

The rapidity of implementation of this ill-conceived road corridor at this site, in such a biodiverse and species-rich region of Vietnam dramatically shows how threatened natural ecosystems are in developing regions and especially the Indo-Burma Hotspot. The longevity of the populations of golden-flowered *Camellia* species on the DP and along the HGP will depend on how well these and the other threats are managed and balanced with the needs of the indigenous farmers and villagers.

3.5. Biological resource use: gathering terrestrial plants, logging and wood harvesting

Physical harvesting and removal of plants, and overexploitation of non-timber forest products accounted for 21 violations or 6% of the law infringements reviewed in the BNBNP "Threat Assessment Report (2006-8)" (Sobey, 2008). The image in Figure 23 (LHS) gives some sign of the scale and duration of the operations that poachers undertake to illegally remove fauna and flora from protected areas. Local people collect orchids (*Orchidaceae* Juss.), cycads (*Cycadaceae* Pers.), medicinal herbs, ferns, and mushrooms routinely and regularly from the forests and other habitats of BNBNP and its environs (Short, 1994; Sobey, 2008). Traditional herbalists use fungi and plants collected from the forest for traditional medicine. Other plants are collected by villagers from the forest for food, gardening, and for sale to tourists. These uses make up a significant part of household incomes (Hoang et al., 2008).

In BNBNP, indigenous farmers, instead of harvesting "Dung Dinh" trees and fishtail palms (*Caryota mitis* Lour.) from the forest, are now planting them in their allotments for use by local healers to treat various maladies, e.g., infected limbs (Sobey, 2008; Wikipedia, 2021b).

Equipment confiscated by forest rangers from poachers apprehended in the forest near Hon Giao Pass: Bidoup-Nui Ba National Park (2014)

Hon Giao Ranger Station, situated along PR723: Bidoup-Nui Ba National Park (2013)

Figure 23. Evidence of poaching near Hon Giao Ranger Station

In southern China and northern Vietnam, "plant poaching" of *Camellia* species for therapeutic purposes, teas, and horticultural purposes is common (Short, 1994; Short, 2013; Tran, 2002, 2003; Curry, 2013; Tran & Le, 2013; 2015). In the forests of the Golden Camellia National Nature Reserve of Fangchenggang, Guangxi, southern China, three species and one variety of golden-flowered camellias grow, i.e., *Camellia euphlebia* (Merr.) ex Sealy, *Camellia nitidissima, Camellia tunghinensis* Hung T. Chang, as well as *Camellia nitidissima* var. *longistyla* (Mo et Zhong) SY Liang (see Figure 24). Over the years "plant poachers" have repeatedly invaded the reserve for yellow-flowered *Camellia* plants and plant parts. In response to these attacks, the park rangers have installed surveillance cameras and employed a pack of Chinese guard dogs to thwart the deeds of any future poachers (Curry, 2013; Short, 2013).

Camellia tunghinensis (2013)

Figure 24. One of the golden-flowered *Camellia* species, Golden Camellia National Nature Reserve of Fangchenggang, Guangxi, southern China

Tran (2003) reported that local people in northern Vietnam collect leaves from *Camellia gilbertii* (A. Chev.) Sealy in Phu Tho Province and *Camellia quephongensis* Hakoda & Ninh in Nghe An Province for herbal teas and infusions for a variety of conditions and maladies. Tea made from the leaves of *Camellia quephongensis* is precious in Thailand. In Vietnam, tea merchants use flower buds and flowers to produce golden tea, as seen in Figure 25 (Pham, 2019).

A selection of Chinese yellow camellia tea brands (2021)

Vietnamese golden camellia tea: Kim Son brand
Note: Image adapted from M. Pham (2019)

Figure 25. Examples of Chinese and Vietnamese golden-flowered camellia teas

Again, in northern Vietnam, the endemic golden-flowered *Camellia* species of the Tam Dao Massif are threatened due to the illegal collection of whole plants and plant parts. Around Tam Dao, poaching of golden-flowered *Camellia* species extends to digging up whole plants for horticulture, cutting off leaves and branches for leaf tea, and harvesting the flower buds and flowers for the Chinese golden tea trade (Tran & Le, 2013, 2015, Tran et al., 2019). Poaching golden-flowered *Camellia* species is a lucrative industry, especially in northern Vietnam. In Vietnam, the cost of 1 kg of dry yellow *Camellia* flowers was 600 to 700 USD in 2018, while the cost of 1 kg of dry golden *Camellia* leaves was 40 to 50 USD. However, in China, the cost of 1 kg of dry golden *Camellia* flowers was 320 USD. It has been estimated that a mature 3-m-tall specimen of *Camellia euphlebia* can yield up to 3 kg of fresh, or 0.5 kg of dry, yellow *Camellia*

flowers/year. At these prices, it is no wonder that golden-flowered *Camellia* species have been exploited by poachers. However, the high prices also reveal possible opportunities for local indigenous farmers to supplement their livelihoods by cultivating and harvesting golden-flowered *Camellia* plants and products for the medicinal, tea, and commercial horticulture markets (Tran et al., 2019).

In northern Vietnam, scientists and educators have been training local people to avoid collecting and harvesting yellow-flowered *Camellia* plants, foliage, and flowers. Also, five "priority" yellow *Camellia* species were selected for in-situ and ex-situ conservation programs at Tam Dao National Park (Tran et al., 2019; Tran & Le, 2013). No doubt, the yellow-flowered *Camellia* species of the DP and HGP will suffer similar fates as those in northern Vietnam and southern China unless similar protective and conservation policies are implemented in the Central Highlands. It is believed that the golden-flowered species of the HGP would benefit greatly from initiatives such as these.

The anthropogenic degradation of primary forest and the subsequent loss of associated biodiversity is one of the most serious problems to be faced this century, e.g., more than 1.2 million km^2 of forest land were fragmented and disturbed globally (Liu et al., 2016). In Vietnam, forestlands have been drastically reduced since 1943. The total forest cover was reduced from 43% in 1943 to approximately 27% in 1990 due to extreme harvesting and utilization in service of the war effort, high levels of economic growth, industrial development, urban expansion, and agricultural expansion. However, in 2009 forest cover was reported to have risen to about 40% using a different rubric due to an upsurge in the establishment of timber tree plantations and the re-growth of disturbed, secondary forest (Asian Development Bank (ADB), 2013).

The BNBNP "Threat Assessment Report (2006-8)" documented 270 (70%) of the law infringement cases were encroachment matters, and of these 39 (11%) related to logging breaches (Sobey, 2008). Deforestation, fragmentation, and degradation of habitat continue to be major causes of habitat loss on the DP and Hon Giao Mountain (Facts and Details, 2014). Logging is a threat to the more iconic vertebrate species, such as the asian gray shrew (*Crocidura attenuata* Milne-Edwards), large bent-winged bat (*Miniopterus magnater* Sanborn), and mountain tailorbird (*Phyllergates cucullatus* var. *coronatus* Temminck) (Abramov et al., 2009; Lepage, 2003). However, logging also puts at risk the many less-familiar, unknown, and yet-to-be-discovered species of plants, invertebrates, and fungi (Tordoff et al., 2020, p. 82).

Table 1 outlines the respective rates of forest loss (tree cover) throughout Vietnam and in Lam Dong and Khanh Hoa provinces for 2000–2010 and 2010–2018. Vietnam, as a whole, and the two provinces show loss of forest for these years. However, there was a marginal reduction in forest loss in Lam Dong in 2010–2018 compared to 2000–2010 and an increase in tree cover in Khanh Hoa in 2000–2010, but this was dramatically canceled out by a loss of forest in 2010–2018. This situation poses great challenges in the twenty-first century for policymakers, forestry, and protected area administrators alike (BirdLife International, 2022; Mongabay, n.d.; Sobey, 2008). Slash and burn

cultivation practices have ultimately led to degraded plant environments such as scrubland and grasslands, known locally in Vietnam as *tranh* (Facts and Details, 2014).

Table 1. Forest loss in Vietnam 2000–2018

Aspect of Forest Loss	Vietnam	Lam Dong Province	Khanh Hoa Province
Total Primary Forest Loss 2000–2018 (km^2)	6,258	826	291
Average annual rate of forest loss 2001–2018 (km^2/year)	45	48	31
Loss (%)	9	11	15
Forest Loss 2000–2010 (km^2)	2577	425	+14
Forest Loss 2010–2018 (km^2)	3681	401	305

Source: Adapted from Mongabay (n.d.).

Sobey (2008) stated that the main reasons for intrusion into forestlands in BNBNP, on the DP, and along the HGP, are population growth and the scarcity of arable land for farming (Pham & Swan, 2009; Wikipedia, 2021a). Also, logging on the HGP, in all its forms and consequences, poses real threats to the survival of golden *Camellia* species in situ. *Camellia* species wood is highly prized for domestic ware, handcrafts, tool handles, wooden weapons, and walking sticks due to the color, weight, and durability of the wood (Aizawa, 2009; Delage, 2019). *Camellia* species can be threatened by selective logging or by the extraction of neighboring trees (Beech et al., 2017; Delage, 2019). Forests are degraded and fragmented for the expansion of land area for use by slash and burn farmers to support individuals, families, and village groups by illegal or selective logging and timber collecting, e.g., bamboo and *Camellia* species for construction, poles, and supports, fuelwood for cooking or charcoal burning (see Figure 13), as well as ethnomedicinal uses (Beech et al. 2017; BirdLife International, 2022; Facts and Details, 2014; Jandl & Price, 2011; Trehane, 2012; Uhart, 1953; Wikipedia, 2021a).

Figure 26. Bundles of charbonnets strapped to baskets of charcoal: Black Rock Dam, near Nha Trang (2004)

Figure 26 shows carrying yokes used for the transportation of baskets full of charcoal with bundles of charbonnets strapped to the tops of the baskets. Charcoal burning is vital for the livelihoods of many indigenous peoples on the DP and HGP. It is also another activity that increases the fire pressure on the region and may threaten *Camellia* habitats on the DP and HGP (BirdLife International, 2022; Chidumayo & Gumbo, 2013; Goldammer & Mutch, 2001; Thanh Mai, 2012; Uhart, 1953; Wikipedia, 2021a).

3.6. Natural system modifications: fire and fire suppression

The forested area of northern Lam Dong Province is very mountainous, making it virtually unusable for farming, which partly accounts for the majority of Vietnam's remaining 5,000 km^2 of primary forest being found in the Central Highlands (ADB, 2013). Approximately 70% of Lam Dong Province and 35% of Khanh Hoa Province are covered in forest (Giang, 2021; OffRoadVietnam, n.d.). The degree of forestation coupled with about 60% of Lam Dong Province being mountainous, i.e., with steep, V-shaped valleys, 200–300 m deep, and elevations above 1,000 m (Lamdong Foreign Affairs Department, 2020), and approximately 90% of Khanh Hoa Province being mountainous, makes this part of Vietnam subject to severe fires (My Hau, 2015). The center of the Lang Biang Biosphere Reserve is Lang Biang Peak (2,167 m); with Hon Nga Range (1,998 m), Cong Troi (2,272 m), and Chu Yang Yu (2,040 m) in the Chu Yang Cao (2,006 m) Range to the west; Elephant Mountain (1,085 m) with Pinhatt Peak to the south and the Bidoup Range (Bidoup Peak 2,287 m) to the southeast, with the two adjacent mountain ranges of Gia Rich (1,923 m) and Hon Giao (2,062 m) to the east (Lamdong Foreign Affairs Department, 2020; Southern Institute of Ecology, 2017). With over 1,900 species of vascular plants, including 96 species of plants endemic to the national park, and 62 plant species included in the IUCN Red List, BNBNP has a wealth of biodiversity. With approximately 91% of its 560 km^2 covered in forest, BNBNP is viewed as the heart of the Lang Biang Biosphere Reserve (BNBNP, n.d.; Hiking Vietnam, 2019; Tang, 2015; UNESCO, 2015). These densely forested mountainous areas make fire management and firefighting extremely difficult.

In Vietnam, forest wildfires ravage several km^2 of forestlands annually (Le et al., 2014). In BNBNP, the management plan focuses on nine core operational strategies, with fire ranked as the second priority. The BNBNP "Threat Assessment Report (2006–8)" supplies information on law enforcement matters within the national park (Sobey, 2008). Of the 385 infringement cases reported, 14 (4%) related to fire issues within the national park. This number seems small; however, fire management in and around BNBNP is a high priority for the park administrators and forestry rangers who patrol the park and implement fire minimization strategies as part of their duties (Sobey, 2008). As elsewhere, forest fires are a real threat to the plant communities in BNBNP, and the threats are becoming ever greater due to climate change (ADB, 2013; Dang et al., 2018; Jandl & Price, 2011; Sterling et al., 2006; Tordoff et al., 2020). The occurrence and development of forest biomes are driven by environmental conditions, especially climate. Under climate change conditions in Vietnam, and especially the Central Highlands and the Hoang Lien Son Range in northern Vietnam, the tree-line is

ascending, so long as the edaphic and rainfall conditions are suitable for tree growth. This ascent is largely due to the effects of global warming on ambient climatic conditions enabling tree species to grow at higher elevations. With this marginal increase in forested areas in the future, an equal push for encroachment into forestlands is likely to follow (Jandl & Price, 2011).

Forest fires and other natural disasters in parts of Vietnam, including areas of Khanh Hoa and Lam Dong provinces, are becoming more prevalent (Jandl & Price, 2011). The reasons for this include failure of the monsoonal rains, more frequent and severe electrical storms and lightning, prolonged droughts, and extremely hot, dry weather associated with climate change (ADB, 2013; Dang et al., 2018; Le et al., 2014; Tordoff, 2020). Sobey (2008) reported that pine forests are threatened by fire if there are several seasons without fire, allowing pine needles to accumulate. An increase in the fire load of pine forests in this way puts them at significant risk of wildfires (BirdLife International, 2022; Goldammer & Mutch, 2001). These are "hot" fires that can damage and kill trees, destroy undergrowth, as well as ravage wildlife habitats. Hazard reduction and controlled burns are recommended for the management of fires in these situations (Goldammer & Mutch, 2001; Sobey, 2008).

Human activity capable of initiating forest fires is widespread on the DP and HGP. Therefore, any population of wild *Camellia* species could be put at risk. The main human causes of wildfires on the DP and HGP include burning and setting fire to "clean up plant waste" on agricultural land, i.e., slash and burn cultivating, the use of fire for hunting, and the use of smoke to collect honey. Other anthropogenic reasons for fires igniting in forests include harvesting timber and wood for charcoal burning, cooking, smoking, and carelessness. Indigenous farmers' use of fire to settle trade conflicts or land disputes between neighbors can lead to burning forested areas as revenge, or to dissuade, deter, or abuse neighbors, rivals, or intruders (BirdLife International, 2022; Goldammer & Mutch, 2001; Le et al., 2014; Wikipedia, 2021a).

In most state forests, "661 Protection Forest Contracts" are granted to compensate people for loss of traditional use and to ease poverty within the community. This scheme is used for almost all categories of state forest except Special Use Forest (SUF) core zones. Even in the SUFs, certain "reserves or parks will provide 'nominal' payments for SUF core zones according to the standard forest office compartment or block system, even if strict 'no-use' is in force." (Sobey, 2008, pp. 7-8) From the perspective of forest administrators, the contracts in these cases are specifically for fire management and control. The "661 Protection Forest Contracts" override all forest treatment and uses in state forests for all non-timber forest products. If "661 Protection Forest Contracts" were not granted, it is likely that the local people would resort to other means to earn an income, e.g., selectively fell trees for agarwood *Aquilaria crassna* Pierre (Barden et al., 2000; Facts and Details, 2014; Sterling et al., 2006; Tan et al., 2019; Wikipedia, 2021c) or clear additional forest to plant coffee and maize (*Zea mays* L.) to fill the "light gaps" created in the push for more land (Ganz & Moore, 2002; Sobey, 2008). Therefore, these practices may place the existing forests,

and any golden-flowered *Camellia* species found in them, at risk whether they are in a national park or not.

Currently, an alignment of the causative factors leading to catastrophic fires over a season, or even a few seasons, could devastate the national park, DP, HGP, and their yellow-flowered *Camellia* populations, as well as other endangered taxa. Fire management action plans and aggressive control strategies have not been fully developed or implemented for the protection of the inhabitants of the plateau or the fauna and flora. Agricultural fires can spread into forested areas in exceptionally dry years, particularly in El Niño seasons (Facts and Details, 2014). The slash and burn land tenure system on the DP and HGP may prove extremely problematic due to forest clearing and later burning during the dry season unless more sustainable agricultural practices are adopted by the local indigenous peoples (ADB, 2013; Ganz, 2002; Ganz & Moore, 2002; Sobey, 2008; Tordoff et al., 2020).

In Vietnam, the government has allocated areas of forests to organizations, families, and individual farmers, to enhance forest management and protection practices for long-term sustainable forest maintenance. Kusters (2021, paras. 1, 7) stated that this strategy has the potential to improve the outcomes for communities using and selling timber and non-timber products from their forest allocations. It also acknowledges the community's contributions to the sustainable management and the protection of their forest parcels, the strategy has not only contributed to improved fire prevention and management but has also enhanced the livelihoods and living conditions of farm families, particularly those in mountain forests. The implementation of community-based forest management programs has partially satisfied the farmers' subsistence requirements for forest products, including fuelwood, timber, bamboo for construction, foodstuffs, traditional medicines, and fodder for livestock (Ganz & Moore, 2002; Ha, 2002; Wikipedia, 2021a).

Fire management strategies in BDBNP avoid the use of large trees, even if they produce fruit for wildlife, in roadside restoration programs to maximize the effectiveness of roads as firebreaks. In places, the road corridors are much wider than necessary, and here there is room for planting larger trees away from the road verge and small trees, shrubs, and grasses nearer the roadways (Sobey, 2008).

Throughout the fire season, forest rangers conduct 24-hour patrols to rapidly detect and extinguish fires to limit their impact and size, as well as to minimize loss of life, property, and damage to forest ecosystems. The rangers also supply forest fire information to local government bodies and forest owners and monitor forest fire warnings via the national early fire warning system to inform forest owners and firefighters when fires break out. The Forest Management Department encourages forest owners to develop fire management plans as well as measures to monitor and reduce forest fuel loads (Ha, 2002).

The community-based interventions provided by the local people, forest administrators and managers are designed to safeguard the forests from wildfires and in

so doing protects the golden-flowered *Camellia* habitats. This should provide more stable and sustainable land-tenure systems for both the forests and the local people on the DP and along the HGP (Ganz & Moore, 2002).

3.7. Invasive and other problematic species and climate change

Plants that are under environmental stress are often infested by piercing and sucking insects, arachnid pests, aphids (Aphididae), mealybugs (Pseudococcidae), scales (Coccoidea), and mites (Tetranychidae). Environmental pressures and climatic abnormalities may also be induced by climate change, and this too can contribute to plant susceptibility to pests and disease infections (Jandl & Price, 2011).

Varying degrees of stress imposed by the environment on the habitat of *Camellia* species, and other rare and endangered plants on the DP and HGP, affect plant phenology, e.g., disrupt pollination, cause premature flowering, cause fruit drop, decrease fruit set, impede seed maturation, and reduce seed viability (Emery & Offord, 2019). These effects diminish fecundity and the survival rate of plant species. Plant interactions in a community are diverse and intricate. Although the study of these interrelationships is in its infancy, it is believed that the interactions between plants may be of vital importance to the survival of a particular taxon growing in a certain location (Raven et al., 1982). Environmental stresses on the golden-flowered *Camellia* species along the HGP may result from land degradation, habitat disturbance, and fragmentation because of selective logging and slash and burn farming.

The images of *Camellia longii* and *Camellia hongiaoensis* in Figure 27 taken in 2010 and 2014, respectively, suggest that both these populations may be under environmental stress (Jandl & Price, 2011; Louda & Collinge, 1992; Summerill & Steinke, 1997; University of Illinois Extension, 2005). As the effects of climate change continue and intensify, researchers have postulated that animal and plant species will attempt to follow the changes in habitat conditions either latitudinally or altitudinally in response to environmental shifts. Migration and/or adaptation may be possible for plants and animals, e.g., if a species' natural habitat is the wet evergreen forests of Hon Giao Mountain on the DP, the species may be able to accompany the adapting forest as it redistributes to a higher altitude. However, if a species is a member of the montane cloud forest plant community at elevations of about 2,000 m on the same mountain, there is less opportunity for the species to accompny the shift in habitat. At these higher elevations, there are fewer niches that forest communities can occupy and resettle in as the summit of Hon Giao Peak is 2,062 m. Perhaps the forest community could colonize farther north at similar elevations. However, there are limited opportunities for habitats to shift at these altitudes between the DP and Hoang Lien Son Mountain Range in northwest Vietnam. The overall rate of change in climatic conditions within the region, especially the "protected areas," and the nature of the habitat types are the prime determinants of how Vietnam's biodiversity will fare under the ever-changing environmental regimes currently experienced on the DP and along the HGP (Rhind, 2012).

Insect-damaged flower bud and leaves of *Camellia longii*: Cat Loc (2010)

A mealybug-infested leaf of *Camellia longii* (abaxial view): Cat Loc (2010)

Ants "farming" mealybugs on spent flowers and immature fruit of *Camellia hongiaoensis*: Hon Giao Pass (2014)

Ants tending mealybugs on *Camellia hongiaoensis* fruit: Hon Giao Pass (2014)

Figure 27. Symptoms of two *Camellia* species under environmental stress

3.8. Geological events: landslides and soil erosion

The HGP dives down from the DP, and steeply twists and twines from Hon Giao, at an elevation of 1,645 m, to the East Sea. The pass is lined by moist forests, precipitous valleys, with vast, exposed, rocky faces, water gushers and waterfalls. Due to the extremely steep gradients of the pass, and the associated torrential, wet season rains experienced along the pass, it is often cut by washouts, rock falls or landslides, making travel and road repairs exceedingly difficult at these times.

Mountain slopes and valleys in Vietnam are prone to landslides due to the dominant monsoonal climate, gradient of the topography, soil hydrology, geology, ecology, and pedology. The susceptibility of the HGP to landslides can be worsened by "deforestation, increased exposure to soil erosion, insufficient protection/prevention measures during road construction, road construction or agricultural activities" (ThinkHazard!, 2020, p. 7). Road construction and maintenance, establishment and repetitive harvesting of plantation forests, slash and burn agriculture and the ongoing disturbance of the natural forests are common causes of landslides along the HGP (Gia, 2020).

As mentioned previously *Camellia* habitats along the HGP often occur on the lower valley slopes and above streams. This suggests that the habitats of *Camellia* species along the pass can be jeopardized by soil erosion and sedimentation, mass movement and soil degradation. The construction of small diversion weirs, water impoundments, and watercourse deviations can threaten *Camellia* populations, if mitigation systems are poorly designed or inadequately implemented. Failure of these structures may result from natural causes, such as extreme monsoonal events or climate change phenomena; or infrastructure projects, including road widening programs, ecotourism developments, fire prevention schemes, land subsidence or landslide mitigation barriers and runoff, or sediment control management technologies (Jandl & Price, 2011; Gia, 2020). Constructions do not have to be large or extensive; they only need to have a negative effect on the hydrology of the habitat that interferes with the lifecycle of a species and so prevents its reproduction and ultimate survival (Dang et al., 2018).

4. CONCLUSION

The habitats of the three golden-flowered *Camellia* species found growing along the HGP are Critically Endangered due to anthropogenic causes, namely population growth, logging, fragmentation and degradation of habitat, poaching, fire worsened by climate change, and extreme soil hydrology events (Dang et al., 2018).

It is rewarding to participate in the collection, publication, and research into the Theaceae, and especially the *Camellia* species, of Vietnam. Documentation of a country's flora is critical to understanding habitats and ecosystems and to conservation of plant communities. Survey teams and staff from the Vietnam National University of Science, Hanoi; Southern Institute of Ecology, Ho Chi Minh City; Dalat University, Dalat; and BNBNP, Dalat are actively searching for, discovering, and publishing a plethora of species new to science. To date, the researchers have published species of *Adinandra*, *Camellia*, and *Polyspora* from the forests of northern, central, and southern Vietnam.

In Vietnam's north and the Central Highlands, work continues propagating plants for the establishment of botanical gardens and collections of *Camellia* species, as well as other Theaceae, to promote ex-situ conservation projects throughout the country. Work is continuing in Tam Dao National Park, Vinh Phuc Province, managing a *Camellia* species garden and a collection of *Camellia amplexicaulis* (Pit.) Cohen-Stuart. Around Dalat, Dalat University is propagating endemic *Camellia* species for planting in gardens and amassing an expansive collection for future use and research. About 35 km from Dalat, in BNBNP, a botanical garden has been developed incorporating a *Camellia* species section (Winn, 2012). The species garden includes local species, species from other countries, and a selection of *Camellia* cultivars bred for ornamental purposes. These projects are not only designed to promote broader interest in, further study, and wider awareness of this remarkable genus of plants, but also to encourage ecotourism throughout the region.

The major threats to golden-flowered *Camellia* species along the HGP are real, acknowledged scientifically and officially, and systematically documented. Strategies

for in-situ and ex-situ protection and conservation projects are available for consideration, funding, and implementation. Others, implemented previously, are subjects of review, revision, or rejection. Collaborative, co-management programs and policies for forest governance appear to be the most effective and practical, especially when most of the current farming methods used by the indigenous farmers on the highlands and HGP are unsustainable and contribute significantly to forest decline (Pham & Le, 2016). This situation needs to change for sustainable progress to be made.

However, there is not a single solution to such a complex and multifaceted problem as this. The incongruities of human needs and those of the ecoregions, and the species that grow within them, have been the topic of debate and the subject of concern and even outrage throughout the last century. Many of the policies presented to date have inherent limitations and drawbacks, and it appears that the conservation of forest communities and their component species requires a holistic approach that can be adopted by all stakeholders for the good of all. The question remains, how should the competing, and often conflicting requirements of the indigenous peoples, forest lands of the DP and HGP, agri-industries, national parks, protected areas and reserves, tourism, and ecotourism businesses be sustainably administered, and by whom? Management of the region's scarce resources for the benefit of all participants is largely determined by the will to protect and promote the importance of the environmental abiotic and biotic factors upon which we all depend. This includes the rare and stunning golden-flowered *Camellia* species of HGP.

Figure 28. Roadside sign at top of Hon Giao Pass near the ranger station (2006)

At the top of HGP, stands a sign urging visitors to "*leave nothing but footprints; take nothing but photographs; kill nothing but your time*" (refer to Figure 28). The credo of BNBNP expressed there and in its information brochure is admirable and hopefully proves to be attainable in the future. The author hopes that a wider application of the published tenets for the conservation of ecosystems is achieved across the DP,

Lang Biang Biosphere Reserve, the forested valleys along HGP, and throughout Vietnam.

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