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Protected area complexes: a new approach to connectivity in Thailand

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ABSTRACT

A well-known principle of conservation biology is that larger areas can support larger wildlife populations and thereby reduce the risk of extinction. To be effective in conserving rare species, protected areas need to be sufficiently large to include at least a minimum viable population, though few, if any, are large enough to support all of the species they intend to help conserve. To address this concern, Thailand has become a leader in establishing complexes of protected areas and surrounding lands, designed to facilitate their planning and management on an ecosystem basis. The 20 protected area complexes established in Thailand to date cover both terrestrial and marine protected areas, in virtually all parts of the country. They potentially can connect protected areas through conservation corridors that include privately owned land or land managed by other government agencies (such as Forestry, Fisheries, and Military) to connect protected areas, thereby expanding their effective size. These corridors enable the movement of plants and animals between protected areas, as well as physically linking the habitats. Protected area complexes provide opportunities for adapting to climate change and enable closer collaboration between protected areas and local communities, thereby supporting rural development.

KEYWORDS: Biodiversity, climate change, conservation corridors, ecological functions, elephants, forest, protected area complexes, Thailand, tigers, trees.

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INTRODUCTION

It is well known that larger areas with a suitable habitat support larger populations/higher species numbers of plants and animals and thereby reduce the risk of extinction (MacArthur & Wilson, 1967; Williams *et al.*, 2002). Loss of biodiversity is a major factor in determining the effects of environmental changes (Hautier *et al.*, 2015; Isbell *et al.*, 2017), justifying the considerable attention being given to conserving biodiversity. To be effective in conserving rare species and ecosystems, protected areas need to be sufficiently large to include at least a minimum viable population of the plants and animals living there (Morris & Doak, 2002). But, after an assessment of population viability, Thailand's protected areas appear almost always too small to conserve wide-ranging species such as tigers, hornbills, and elephants, or rare species of large trees (Suksawang & Nootong, 2017). The point here is that for conserving biodiversity protected areas alone are not sufficient, but their conservation efficacy also depends on what happens in the surrounding lands and waters (Laurance *et al.*, 2012; Saura *et al.*, 2017). And, perhaps more important, such landscape approaches can also generate positive changes over a larger area that includes both protected areas and the non-protected surrounding areas (Miller *et al.*, 2012).

PROTECTED AREA COMPLEXES

To address these concerns and opportunities, Thailand has become one of Asia's leaders in establishing complexes of forested and marine protected areas (Fig. 1): these are designed to facilitate planning and management of ecosystems whereby the surrounding lands and waters are included in the considerations (Suksawang & Temchai, 2014). The most outstanding example is the Dong Phayayen-Khao Yai Forest Complex (area 9 in Fig. 1), which includes four National Parks and one Wildlife Sanctuary, totaling 6,154.93 km^2; this complex was included on the World Heritage List in 2005. Four others are well developed, including the Western Forest Complex (WEFCOM; area 11 in Fig. 1), which includes twelve National Parks and six

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Wildlife Sanctuaries (two of which were included jointly on the World Heritage List in 1991) covering 19,699.2 km^2 and providing the possibility for transboundary cooperation with Myanmar; the Eastern Forest Complex (EFCOM; area 10 in Fig. 1), which includes three Wildlife Sanctuaries and four National Parks covering 2,349.18 km^2 and providing the opportunity for transboundary cooperation with Cambodia; the Kaeng Krachan Forest Complex (area 12 in Fig. 1), which includes three National Parks and one Wildlife Sanctuary covering 4,782.01 km^2 and also offering the opportunity for transboundary cooperation with Myanmar; and the Phu Khieo-Nam Nao Forest Complex (area 6 in Fig. 1), which includes four National Parks and five Wildlife Sanctuaries, covering 4,816.9 km^2. A 10-year (2013–2022) ecological management plan has been proposed for these latter four, with a focus on corridor management (Emphandhu *et al.*, 2012).

Another 12 forested areas with national parks and wildlife sanctuaries are also managed as complexes, based on habitat suitability, physical characteristics of forest area coverage, and potential or actual connections among several protected areas. Some of these complexes have the potential to be further linked to protected areas in neighbouring countries. From north to south these include Lum Num Pai-Salawin (with a transboundary potential with Myanmar; area 1 in Fig. 1), Doi Phuka-Mae Yom (with transboundary potential with Lao PDR); Phanom Dangrak-Pha Tam (with transboundary potential with Lao PDR and Cambodia; area 3 in Fig. 1); and Hala-Bala (with transboundary potential with Malaysia; area 17 in Fig. 1). Several of them have been supported by the work of the Mekong River Commission (Moinuddin *et al.*, 2012).

The protected area complex approach is also being applied to marine protected areas, with four complexes identified to date: the Mu Koh-Pipi-Andaman Sea (area 18 in Fig. 1) and Mu Koh Ang Thong-Gulf of Thailand marine complexes (area 19 in Fig.1). Marine protected areas may require innovative management approaches and close collaboration with the Fisheries Department; their management takes advantage of their substantial tourism potential and seeks to provide multiple benefits to the local fishing communities. Connectivity is especially relevant in marine ecosystems, with mangroves providing a particularly productive part of marine complexes (Friess *et al.*, 2016) as they provide the start of many food chains. Marine national parks that are connected to mangrove habitats support increased biomass of herbivorous marine species as well as higher species richness, with additional benefits to coral reefs through increased feeding of fish on the algae that damage corals (Olds *et al.*, 2012). An important conclusion from this work (Olds *et al.*, 2012) is that ecosystem resilience is enhanced by managing coral reefs, mangroves, and other habitats as a functional unit, providing both improved resource management and insights into restoration activities. Isolated coral reefs tend to be much less diverse and productive than those connected to mangroves, indicating the importance of protected area complexes in marine habitats (Mumby, 2006).

Basing protected area management on complexes has multiple advantages: the larger area covered enables wide-ranging species to move more freely or form a larger breeding population, and to reach at least minimum viable population sizes; the larger areas, often on a north-south axis on land, can provide more opportunities for adapting to climate change; and complexes enable closer collaboration between the protected areas and the local communities and thereby support rural development.

Protected area complexes also provide a basis for reaching out to other agencies that control land or ocean that is important for conservation. For example, the military can make significant contributions to protected area complexes, since army and navy bases in Thailand are often located near protected areas or even adjacent to them. Since these bases are well protected, they offer additional habitat to many species of plants and animals and, therefore, effectively form part of the protected area complex even if formal collaboration is still under negotiation. One outstanding example is the Kuiburi National Forest, which is owned by the Royal Forest Department, but is under the control of the Royal Thai Army. It is effectively part of the Kaeng Krachan Forest Complex, providing the key corridor for elephants, tigers, and other species moving between Kuiburi National Park and Kaeng Krachan National Park.

The managers of the complexes are developing their own comprehensive management plans that include appropriate monitoring measures as well as a responsive management structure that ensures

effective coordination among the individual sites for dealing with potential problems and taking advantage of the potential benefits. Such coordination is especially important when complexes include both National Parks and Wildlife Sanctuaries that have different lines of reporting and different accessibility for the public.

THE ROLE OF CONSERVATION CORRIDORS

Corridors are already part of protected area management in Thailand, judging from detailed research carried out in many parts of the country and presented in a detailed report that provides numerous maps based on satellite imagery (Suksawang & Temchai, 2014). Conservation corridors can connect protected areas, expanding their effective size, but they require agreements to be negotiated with the owners of the land that provides the necessary links between protected areas (Brodie *et al.*, 2016). These corridors enable the movement of plants and animals between protected areas, as well as physically linking the habitats. Research has shown that habitat patches connected by corridors retain more native plant species than do isolated patches, thereby enhancing their effectiveness in conserving species in the long term (Damschen *et al.*, 2006).

As described by Hess & Fischer (2001) and Worboys *et al.* (2016), corridors serve six ecological functions, including habitat, conduit, filter, barrier, source, and sink. Implementing conservation corridors as part of protected area complexes draws on the fields of conservation biology, wildlife management, landscape ecology, and landscape planning. Experience from the corridors can also contribute to these fields. Research in WEFCOM has provided conclusive evidence that tigers, which are well protected in Huay Kha Khaeng Wildlife Sanctuary, are expanding their population and disperse northward to Mae Wong and Klong Lan National Parks, where they have become well established (Duangchantrasiri *et al.*, 2015). Many other species have repopulated these national parks from Huay Kha Khaeng, indicating its importance as a source of wildlife that can expand to other areas through conservation corridors. Detailed recommendations on complex management have been provided by Emphandu *et al.* (2012) and are being implemented as a high priority.

Other types of corridors can link protected areas that are virtually adjacent, such as Khao Yai and Tap Lan National Parks, separated only by Highway 304. Given that these are part of the Khao Yai-Dong Phayayen World Heritage Site, detailed plans have been prepared for both tunnels and wide bridges designed to enable species to move between two sites that have been identified by feasibility studies. These will require continuous monitoring to ensure that they are meeting their objective of promoting gene flow between the protected areas.

CHALLENGES OF PROTECTED AREA COMPLEXES

While recognizing the benefits of complexes, the Department of National Parks, Wildlife and Plant Conservation (DNP) is also considering any potential negative ecological impacts from them. For example, without proper management, the connecting corridors could facilitate the spread of disease, invasive alien species, forest fires, and other natural hazards. Connectivity may also pose some visitor management challenges, requiring innovative ways to ensure that admission fees are paid for the appropriate sites, and ensuring that visitors that have paid for admission to a National Park, for example, do not then consider that they necessarily have the right to enter an adjacent Wildlife Sanctuary that limits public visitation.

Many of the national or provincial highways pre-date the establishment of the protected area through which they travel, or cut through the new protected area complexes that are now becoming a major design principle for Thailand's protected area system. It is seldom realistic to close such roads, especially when they are major transport routes such as Route 323 that cuts through Khao Laem National Park in western Thailand and reaches the border with Myanmar. For these roads, DNP is seeking to minimize their negative impacts on the protected areas and ideally find ways to build corridors that would enable wildlife to migrate over or under the highways. Such an ideal is essential to the integrity of the Western Forest Complex as Route 323 is widened and becomes a main trade artery linking Myanmar and Thailand.

Another problem can come from successful wildlife management leading to increasing populations of species that may compete with local villagers. As

one example, some villages in the Huay Kha Khaeng buffer zone in Nakhon Sawan Province have suffered increasing losses from tiger predation on livestock. As sites in WEFCOM become more successful in conserving tigers, the population of these large predators will inevitably increase and some of the marginal tigers (often young males) can be expected to move outside of the protected areas and become a problem to the local people, and to DNP (Seidensticker *et al.*, 1999). Solutions to this problem are now being implemented, such as identifying the sources of the conflicts and their historical dimensions, exploring cultural ways of interacting with predators, and developing ways of mitigating conflics (Pooley *et al.*, 2016).

Wild elephants may pose the biggest problem, even though they are culturally important in Thailand. As humans have sought to expand the land under cultivation, often in large mono-specific plantations of species grown for export (such as pineapples, rubber, and oil palms), the traditional habitats of elephants have been disrupted (Leimgruber *et al.*, 2003). Their migration routes now take them through plantations or across roads, sometimes leading to fatal accidents for both elephants and people. This conflict also has economic implications, given the importance of elephants for their cultural roles, their contributions to tourism, their role in maintaining some ecosystem functions in forests (Bandara, 2004), and the importance of maintaining the source of elephants for captive use in forestry or tourism (Tipprasert, 2002). However, new approaches to addressing this conflict are being developed throughout the distribution range of Asian elephants (Woodroffe *et al.*, 2005; Perera, 2009), especially through developing corridors such as those in EFCOM and combining protected areas into complexes that are sufficiently large to provide adequate habitat to elephants, as in WEFCOM (Suksawang & Temchai, 2014).

PROTECTED AREA COMPLEXES AND CLIMATE CHANGE

In the future, some important economic benefits from protected area complexes may come from climate change mitigation and adaptation. For example, mature forests continue to store more carbon as they get older (Luyssaert *et al.*, 2008; Pan *et al.*, 2011; Stephenson *et al.*, 2014); this adds strong support for conserving the old-growth forests that form the core of many of Thailand's terrestrial protected areas. Perhaps more important, some forested protected area complexes with a long north-south axis, such as those along the western boundary with Myanmar and along the Petchabun Range (see Fig. 1), likely provide increased capacity to adapt to climate change if the north-south climate gradient only moves, enabling species and ecosystems to disperse north or south as changes in temperature and rainfall affect the habitats of these species. Maintaining healthy ecosystems in the protected areas will also help enable the rural villages to adapt to these changes.

Climate change is already affecting species and ecosystems, though with current knowledge it is impossible to predict with a high degree of confidence exactly how the various species will adapt to the changing conditions that are coming. Experience to date suggests that information from many sources will be required to identify which species and ecosystems are most vulnerable, and totally new kinds of ecosystems may also be expected (Young, 2014). Protected area managers in Thailand may well need to intervene, including by assisting some species to move to areas that might otherwise be impossible to reach because of inappropriate intervening habitats (Christie & Knowles, 2015). This adds to the justification for more effective linking of protected areas in complexes through collaboration with landowners in the surrounding lands (Suksawang & Temchai, 2014).

CONCLUSIONS

Protected area complexes typically spread across two or more provinces, so they require at least the support and coordination from the government of each province in the complex. Therefore, the ecosystem management principles that link the protected areas in complexes will include other compatible land uses wherever possible. To this are added the political boundaries of provinces that clearly identify which protected areas occur where in each province. Such an understanding provides an explicit basis for expanding provincial-level support for the protected areas and encourages cooperation among provinces that share a protected area complex.

Regional highways that pass through or between Wildlife Sanctuaries or National Parks post clear signs

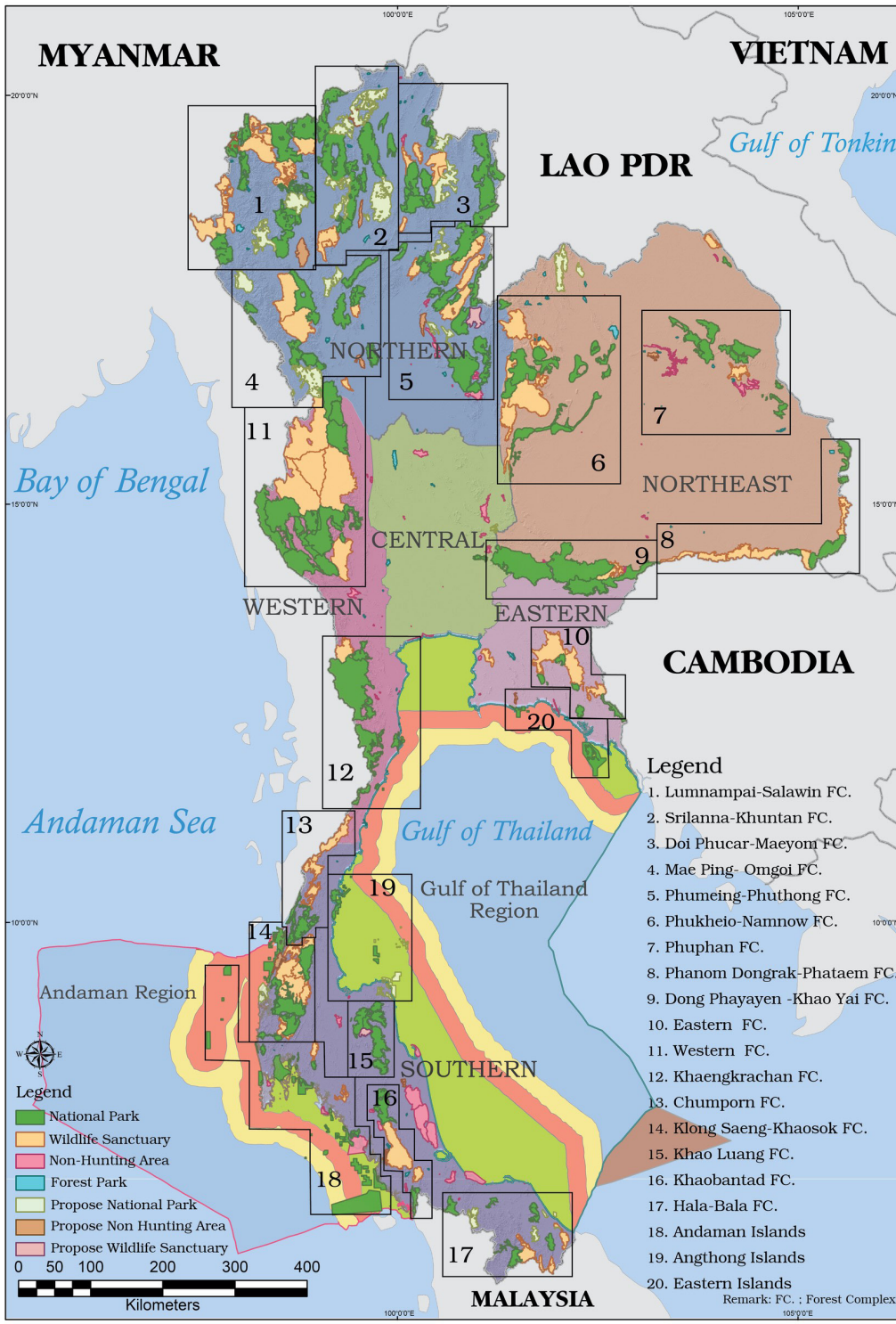

Figure 1. Map of Thailand's Conservation Complexes.

that indicate when they are entering the protected area and when they are leaving it. Signs also warn drivers when they are approaching areas where wildlife often crosses the highways. Even better, such major highways should include an engineering solution to the problem of collisions between wildlife and vehicles. These can take the form of constructed wildlife corridors, including such elements as overpasses or tunnels that are designed to be attractive to species such as elephants, deer, wild cattle, and tigers. In suitable habitats, overpasses should be designed to include trees of sufficient stature to enable gibbons and other arboreal species to cross the highway. Such overpasses have been shown to be effective in providing connectivity (Corlatti *et al.*, 2009), and a considerable amount of work has been done by DNP on such means of maintaining habitat connectivity and reducing the risks of harm to both wildlife and vehicles (Suksawang and Temchai, 2014). The comprehensive designs proposed in the Dong Phayayen-Khao Yai Forest Complex to mitigate the negative impacts of Highway 304 on this World Heritage Site are a good example of what can be done at the planning level, though full implementation is still awaited.

As DNP builds its experience with protected area complexes, a sophisticated geographic information system (GIS) will be an essential tool to coordinate the activities of the various elements of the complex and enhance communications among the sitemanagers. GIS can help ensure that the superintendents of protected areas within the complexes are well informed about issues that affect all of them, including tourism, potential applications of research, climate impacts, poaching, encroachment, risks of fire, and proposals for new developments such as dams, roads, and villages.

In conclusion, the management of protected area complexes is a foundation of the approach that DNP is taking toward improving the management effectiveness of protected areas. Thailand's experience can also inform the design of protected area systems in other countries.

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BIOGRAPHICAL SKETCH

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