SUMMARY OF DOCTORAL THESIS

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Title: A study on the invasion of alien plants species in Nong Bong Khai Non-hunting Area, Ramsar site, Chiang Rai, Thailand
（タイ、チェンライ、ノン・ボン・カイ禁漁区ラムサール湿地における外来植物種の侵入に関する研究）

Wetlands are ecosystems that are important to human, animal and plant. It consists of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters (Ramsar convention Secretariat, 2013). In 1998, Thailand participated to the 110th Ramsar Convention and registered 15 Ramsar sites, 69 wetlands of international importance, and 47 wetlands of national importance. Currently, Nong Bong Khai wetland is the one of Ramsar site where is threaten by the increase of alien plant species. It seemed that the causes of the increase of alien plant species may be nutrient rich environment affected by changes of land use/land cover. And water level fluctuation from low precipitation also may affect lake vegetation. Then this study aims to (1) Describe background of the increase of alien plants species by analyzing land use/land cover and water quality in lake. And apply unmanned aerial vehicle (UAV) for non-submerged aquatic vegetation mapping to study their distribution especially *Eichhornia crassipes*. (2) Describe impacts of water level fluctuation caused by less precipitation on the distribution of the non-submerged aquatic vegetation community and the expansion of *Eichhornia crassipes* by applying non-submerged aquatic vegetation and distribution maps based on images from UAV.

The study is in Nong Bong Khai Non-hunting Area in Chiang Rai, Northern part of Thailand. It is approximately 5 km apart from the Mekong River. The lake area is registered as the Ramsar site No. 1,101 of wetland of international index on 5th July 2001. The average annual temperature is 24.4 °C. The average rainfall is 1,600-1,800 mm. The lake covers the area around 434 ha. This area has a beautiful scenery and also be an important habitat for local water birds and migratory water birds which migrate to live in this area in winter (November-February). The lake is surrounded by hills and private areas such as agricultural area, residence and degraded forest.

A land use/land cover map in 2009, 2012, 2016 and 2018 which produced by satellite images showed changes in the watershed of the Nong Bong Khai Non-hunting Area. The area of field crop continuously increased from 2009 to 2018 by 92.07% while the area of deciduous forest and rangeland continuously decreased by 53.23% and 47.86% respectively. In field crops area, there was an increase in pineapple field and cassava field by 344.48% and 100.25% respectively. The increase in field crop area affected the amount of fertilizers used in agricultural areas, especially in a pineapple field and a cassava field where the highest usage of fertilizers per year rose to 813.43 and 100.19 tons respectively. After rain, soil erosion led to higher levels of fertilizer contamination in the lake which was a cause of high nutrient especially, phosphorous and nitrogen.

The 30 m altitude orthophoto together with 2-10 m single-shot photo gave an adequate resolution to generate the vegetation map. This was similar to that of Andrea (2019), who found that photos at 25 m together with 5 m could identify plant communities and plant species. The vegetation maps of 2019 based on the 30-m data, which were gathered in four study zones, showed that *Eichhornia crassipes* was presented in all of the study zones. The proportion of dominant plant species showed that the covering area of *Eichhornia crassipes* was mostly greater than other native species. Yongyut's (2006)'s study,

Eichhornia crassipes were not prominently found but they might increase as a result of land use and water quality changes, was similar with interview of officers of Nong Bong Khai Non-Hunting Area which reported that a few *Eichhornia crassipes* were found between the years of 2001 and 2010. The distribution map based on the 90-m orthoimage, which was gathered over the entire lake, showed a large coverage area of *Eichhornia crassipes* by almost 600,000 m2 (13.82% of total lake area). Water quality data in years 2008, 2011, 2017 and 2019 showed that phosphorous and nitrogen were over standard in 2019 while DO was below the standard. The results of water quality test showed that the nutrients in the water, which mostly came from the agricultural areas, resulted in an increase in the *Eichhornia crassipes*. And their increase resulted in reducing of oxygen in the water.

In September 2018 to December 2020, the water levels in Nong Bong Khai Lake fluctuated due to changes in rainfall. Refer to Actual rainfall and water level data, the highest water level was at 1 m in September 2018 and the lowest was at 0.2 m in March and April 2020. Thai Meteorological Department (2020) reported that the occurrence of El Niño in the first half of 2019 caused low actual rainfall. Although El Niño phenomenon did not occur in the second half of 2019, the actual rainfall still low which because of Positive Indian Ocean Dipole. Data of plant species index and water level during 3 surveys (March 2019, September 2019 and March 2020) showed that water level and the number of plant species in March 2019 and September 2020 did not obviously different. But during the lowest water level (0.2 m) in March 2020, high numbers of alien plant species (18 species) were found which was the highest amount in 3 times of survey. The terrestrial plant species also increased because of the increase of terrestrial area. High water levels have a strong negative effect on *Mimosa pigra* (Asyraf and Micheal, 2011). Indeed, Yongyut (2006) stated that a few *Mimosa pigra* was found in 2006 because the water in the lake was maintained at a high level and it could not invade into the lake area.

The vegetation maps based on the 30-m data showed the higher increase of *Mimosa pigra* in March 2020. Refer to the water level data and the 90-m distribution map of *Eichhornia crassipes* in September 2018, March 2019, September 2019 and March 2020, the covering area of *Eichhornia crassipes* was increasing continually during consecutively decline of the water level. Exception was in March 2020, the covering area of *Eichhornia crassipes* decreased due to a heavy hailstorm, which was an irregular natural event, in December 2019. This hailstorm destroyed many plants in the wetlands. An increase of *Eichhornia crassipes* during a decrease of water level shows how well they adapt to the unfavorable environment. They can survive for several months with no water and only moist sediments (Center et al., 2002).

Refer to water quality data in September 2018, March 2019, September 2019 and March 2020, an average water temperature was between 22.57°C and 30.58°C and the pH was between 6.07 and 7.98. The range of these two parameters was suitable for growing *Eichhornia crassipes*. In addition, high levels of phosphorus and nitrogen were detected in dry season (March) 2019 and 2020. Phosphorous and nitrogen are essential for growth of aquatic plants. However, excessive composition of nutrients can over-encourage aquatic plant growth (Paul and James, 2003; Prita et al., 2017). The results from water quality test showed that from March 2019 to March 2020, the water was polluted which was indicated by substandard DO values. The large *Eichhornia crassipes* mats blocked the sunlight and obstructing oxygen exchange which that degraded water quality, altered and reduced the biodiversity (Center et al., 2002; Brendock, 2003). To restore the water quality and maintain the biodiversity, a machine should be applied for get rid of all *Eichhornia crassipes* and *Mimosa pigra* out of the lake. At the same time, for sustainable wetland, vegetation buffer zones should be built all around the lake to reduce the level of fertilizer contamination caused from soil erosion.