# Poyang Lake, Yangtze River Basin, China 129

James Harris

## Contents



**Abstract**

Poyang Lake is the largest freshwater lake in China. Five main tributaries drain into the lake from the south, while the lake empties through a short outlet channel into the Yangtze River. Poyang is one of the two lakes in the mid Yangtze Basin that has retained its free connection to the river. In addition, Poyang has a seasonal, reverse-flow system that occurs in most years where waters from the Yangtze River flow into Poyang Lake during part of the summer. This reverse-flow system greatly contributes to the complexity of Poyang's yearly hydrological variation. In summer, the lake's surface area exceeds 4,000 $km^2$. Falling water levels during autumn expose extensive mudflats and leave behind isolated sublakes. Dramatic hydrological variations – water levels can fall as much as 11 m between summer floods and winter lows – drive ecological processes within the system and create a wide range of habitats supporting rich biodiversity. The

J. Harris (✉)
International Crane Foundation, Baraboo, WI, USA
e-mail: harris@savingcranes.org



C. M. Finlayson et al. (eds.), *The Wetland Book*,
https://doi.org/10.1007/978-94-007-4001-3_34

seasonal changes in water levels create two separate ecological phases of Poyang Lake, supporting different sets of species and leading to near year-round productivity and rich diversity of life. Poyang is world famous for its concentrations of wintering waterbirds, including over 98% of the world population of the Siberian crane *Leucogeranus leucogeranus.* Poyang Lake has major value for flood control, with maximum storage of some 11.75 billion $m^3$, and provides valuable fish harvests. Changes in hydrology pose the greatest threat, while demand for water is growing for irrigation and industry. The Three Gorges Dam has reduced river flows during late summer and autumn. This change, combined with intensive sand dredging near the lake's outlet, has resulted in faster outflow from the lake into the Yangtze River from July to March, and reduced water storage in Poyang Lake. In addition, a dam has been proposed across Poyang Lake's outlet to stabilize water levels, which could transform the ecological character of the wetland and flood habitats used by Siberian cranes and many other waterbirds.

**Keywords**
Mid Yangtze Basin · Poyang Lake · Reverse-flow system · Sand dredging · Siberian crane

## Introduction

Poyang Lake is the largest freshwater lake in China. Five main tributaries drain into the lake from the south, while the lake empties through a short outlet channel into the Yangtze River (see Fig. 1). Poyang is one of two lakes in the mid Yangtze Basin that has retained its free connection to the river. In addition, Poyang has a seasonal, reverse-flow system that occurs in most years where waters from the Yangtze River flow into Poyang Lake during part of the summer. This reverse-flow system greatly contributes to the complexity of Poyang's yearly hydrological variation.

In summer, the lake's surface area exceeds 4,000 $km^2$ (Shankman and Liang 2003). Falling water levels during autumn expose extensive mudflats and leave behind isolated sub-lakes. Dramatic hydrological variations at Poyang – water levels can fall as much as 11 m between summer floods and winter lows – drive ecological processes within the system and create a wide range of habitats supporting rich biodiversity. The seasonal changes in water levels create two, separate ecological phases of Poyang Lake: one dominated by subtropical vegetation most productive during the hot summers and another dominated by temperate vegetation primarily growing during the cool, wet winters (Zheng 2009). Different species rely on these separate ecological phases, leading to near year-round productivity and rich diversity of life. Poyang is world famous for its concentrations of wintering waterbirds, including over 98% of the world population of the charismatic and critically endangered Siberian crane *Leucogeranus leucogeranus* (Harris and Zhuang 2010).

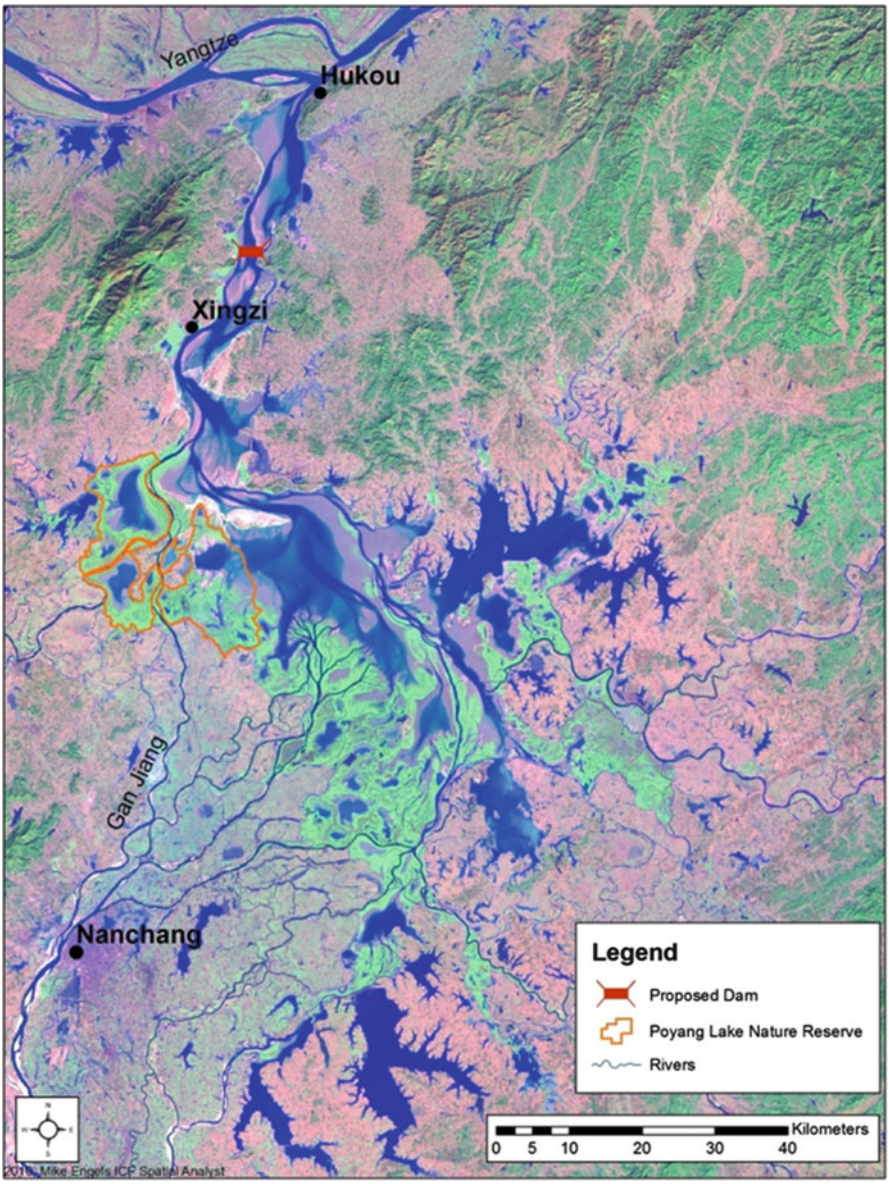


**Fig. 1** Map of Poyang Lake showing boundaries of Poyang Lake National Nature Reserve, the location for the proposed dam, and hydrological station at Xingzi (Source: © Provided courtesy of International Crane Foundation)

The lake's catchment of 162,225 km$^2$ includes ~97.2% of Jiangxi Province (Editorial Committee of Studies on Poyang Lake 1988), while 18 million people live in the counties surrounding the lake.

## Hydrology

The hydrological character of Poyang is unique among China's lakes. The flood peak caused by flooding in the lake's five tributaries usually happens between May and June. In late summer, the Yangtze flood can backflow into Poyang Lake, usually between July and October (Editorial Committee of Studies on Poyang Lake 1988; Harris and Zhuang 2010). After September, with the flood period ending, the water level in the lake gradually reduces until its lowest levels occur during December or January.

Water levels at Poyang in the low water season, as compared with the high water season, exhibit significant differences between the upper and lower reaches of Poyang. The lake surface slopes downwards from upstream areas in the south towards the north and its confluence with the Yangtze. The difference in water surface elevation between upper and lower parts of the lake can be >4 m. In spring, when the water level reaches about 15 m above sea level (Wu Song System – see Box 1 at end of chapter), however, the surface of the entire lake flattens out (i.e., the entire basin is flooded).

Average winter elevation of the water in Poyang Lake is 11.98 masl at the Gan River station at Wucheng near Poyang Lake National Nature Reserve (NNR), with minima fluctuating by +/− 1 m between and within years. There are over 60 sub-lakes in the system, so it is not easy to generalize about water depth – although the profile is relatively flat. Most of the sub-lakes (e.g., in Poyang Lake NNR) are very shallow in winter and can be more or less dry after being drained for fishing purposes, with just the channels having water remaining. Typically, winter depths will range from a bit more than 100 cm to less than 15 cm around the margins of the lake pans.

The mean annual runoff from Poyang into the Yangtze River is 143.6 million $m^3$. On average, the annual water exchange rate for Poyang Lake is 20.9 days (China Academy of Sciences unpublished data; Harris and Zhuang 2010). The waters thus exchange in the lake almost 18 times in one year, so that Poyang has the second fastest rate of exchange for large lakes in China. The rapid exchange helps keep the water clean within the lake, by flushing out pollutants. When the water level drops below 15 masl, the water develops a slope with water moving from south to north and the rate of flow increases to a relatively high rate. When the water level rises above 15 masl, the slope of the lake surface flattens and gravity flow weakens so that wind becomes an important factor. The higher the lake water level, the slower will be the flow rate. As a result, during high water the lake exchange period is longer than in winter (ignoring evaporation). Thus the natural process of flood and water drainage periods each year results in an overall rapid exchange of water for Poyang Lake, but at uneven rates among seasons.

## Biodiversity

Poyang supports significant diversity of aquatic plants, with the different communities responsive to soil elevation and water depth (Cui et al. 2000; Yuan and Li 2008; Barzen et al. 2009). For a wetland as dynamic as Poyang Lake, the elevations at

which particular plant communities grow, however, depends upon hydrological conditions in any one year. Submerged aquatic plants, for example, can grow in Poyang Lake at elevations as low as 8 or 9 masl during drought years or as high as 16 masl during flood years. On average, submerged aquatic plants grow at elevations from 13 to 14 masl, while the sedge zone dominates the 14–15 masl range (Barzen et al. 2009). At 15–16 masl reeds grow as do other grasses and forbs, though sedges are prevalent as well. Elevations above 16 masl tend to support upland vegetation composed mostly of grasses and shrubs.

The food resources provided by the aquatic plant diversity within the system are a major reason that hundreds of thousands of migratory birds travel to Poyang every winter (Li et al. 2005). Winter surveys at Poyang have recorded 425,000 waterbirds on average, with a peak count of 726,000 birds in 2005 (Barter et al. 2005; Li et al. 2005; Ji et al. 2007; Qian et al. 2011), making it the most important wetland for waterbirds in East Asia. In addition to the Siberian cranes, over 90% and 50% of the world's populations of the endangered oriental stork *Ciconia boyciana* and vulnerable swan goose *Anser cygnoides*, respectively, winters here. Formerly, half the world population of vulnerable white-naped cranes *Grus vipio* wintered at Poyang but the latter population has declined to roughly half the numbers present in the mid-1990s (Li et al. 2012), probably due in part to prolonged drought on the breeding grounds. In two years of winter waterfowl surveys in the middle and lower Yangtze River Basin, Poyang Lake supported more than 1% of the regional populations of 12–15 species of waterbird.

Poyang Lake provides habitat for numerous other aquatic animals dependent upon its wetlands, including the globally vulnerable finless porpoise *Neophocaena phocaenoides* and the vulnerable Chinese water deer *Hydropotes inermis inermis*. Zhang and Li (2007) report that 136 fish species have been recorded in Poyang Lake, although the critically endangered Chinese sturgeon *Acipenser sinensis* and critically endangered Chinese paddlefish *Psephurus gladius* are apparently gone from the lake.

Vegetation and hydrologic diversity at Poyang, together with the vast areas of shallow water and mudflats, offers conditions suitable for a variety of avian foraging guilds (Barzen 2008). Cranes, swan geese, and swans feed primarily on tubers of *Vallisneria* spp. and other submerged aquatic plants. Five species of geese, including the vulnerable lesser white-fronted goose *Anser erythropus*, feed in the sedge-grass zone. Large numbers of shorebirds forage for invertebrates exposed as waters recede from the muds, while spoonbills and avocets filter the water for zooplankton. Fish eaters are present, although in relatively small numbers.

Waterbirds move widely across different parts of the lake, responding not only to abundance of food (likely determined by summer water conditions) but also to availability of food that is determined by winter conditions such as water depth, vegetation patterns, human disturbance, and weather including the effects of wind. Thus any individual part of the lake does not consistently support populations of bird species of concern. During parts of some winters, for example, few if any cranes are present within Poyang Lake NNR as they move to other parts of Poyang's large basin.

## Conservation Status

A total of 14 wetland nature reserves have been established at Poyang Lake, with a combined total area of over 200,000 ha or 50% of the lake basin (Wildlife Protection and Nature Reserve Management Department 2010). Of these, two are National Nature Reserves: Poyang Lake NNR (22,400 ha) and Nanjishan NNR (33,300 ha). Poyang Lake NNR was designated a Ramsar Site in 1992 and is on the site list for the Alliance for Zero Extinction (www.zeroextinction.org) because of its importance for the survival of the Siberian crane. Two of the reserves are provincial level: Duchang (41,100 ha) and Poyang (40,900 ha). The other reserves are municipal or county level reserves and have minimal staff or other resources.

Within Poyang Lake NNR are nine sub-lakes that separate from the main lake in winter and provide habitat for some of the greatest concentrations of waterbirds in the lake basin. The reserve has gained use rights to five of these lakes, thus having a greater degree of control over their aquatic resources and water management. Reserve control of sub-lakes is still constrained by contracts with outsiders for rights to fish and raise crabs. The protection status afforded the rest of the reserve and almost all other lands within the other nature reserves is limited to bird protection while resource rights belong to others.

After the 1998 floods, large numbers of people were moved out of the lowest areas of Poyang Lake to reduce flood risk and to restore a larger capacity for flood water storage. Many of these lowlands have been gradually resettled.

## Ecosystem Services

Poyang Lake, due to its great extent, has major value for flood control. When water levels go from 8.33 masl (the 1998 lowest level within the outlet channel) to 16 masl, the storage is 11.75 billion $m^3$, equal to 50% of the Three Gorges Reservoir's adjusted storage capacity – a benefit provided without water infrastructure. This amount (11.75 billion $m^3$) mainly absorbs and controls the flood from Poyang's five tributaries and reduces the pressure from flooding on Poyang Lake and Jiangxi Province. During late summer flooding of the Yangtze, Poyang may absorb water from the Yangtze as well, buffering downstream communities.

Ecosystem services provided by the lake also include maintenance of water quality (see above) as well as important water supply and fishery production services. The lake supplies water to surrounding human communities, for urban, industrial, and agricultural purposes, and is an important navigation route, linking the city of Nanchang to the Yangtze River, other provinces, and eventually the sea. The lake provides valuable fish harvests, with an average annual catch of 198 kg/$km^2$ in the 1990s (Zhang and Li 2007). Portions of the lake support sand dredging, fish farming, and crab farming, but some of these practices may not be sustainable.

## Future Challenges

Changes in hydrology pose the greatest threat to Poyang Lake's ecosystems and their biodiversity, but this is by no means the only threat facing the lake. As of 2001, 9,603 dams had been built on the five tributaries, with a total water storage capacity of 27.9 billion $m^3$ (Liu et al. 2009). Demand for water, for irrigation and industry, is growing. The Three Gorges Dam, although well upstream on the Yangtze, has reduced river flows during late summer and autumn, resulting in faster outflow from the lake into the Yangtze River from July to March, and reduced water storage in Poyang Lake (Guo et al. 2012). Numerous additional dams in the upper Yangtze Basin are in operation, under construction, or in the approval process that will further affect seasonal flows. Following the ban on sand dredging in the main channel of the Yangtze in 2000, a large part of this activity moved into Poyang Lake, where it has been particularly concentrated at the outlet channel. Aside from disturbance to substantial parts of the lake bottom and increasing turbidity, a deepening of the outlet channel could affect the rate of outflow to the Yangtze River (de Leeuw et al. 2010).

In the last six years four severe droughts and one severe flood have occurred. These extremes of weather appear to be compounding the impacts of dams and other human activities. During unusually low water periods, people encroach on the lake edges, construct dikes to separate fish ponds, and otherwise reduce the size of the natural wetland. Water quality has deteriorated, due to urban and industrial development within the neighboring counties. Lakes elsewhere in the mid Yangtze have seen major changes in vegetation as water quality declined, resulting in reduced food availability for tuber feeders including the Siberian cranes (Fox et al. 2010; Zhang et al. 2010). Poyang appears vital to their survival.

Over past decades, Jiangxi Provincial Government has sought to construct a dam across all or part of Poyang Lake to stabilize water levels. Recent hydrological changes have added wetland restoration to the objectives of projects designed to manage water. The current proposal calls for sluice gates to be built across the outlet of Poyang Lake; these gates would remain open and allow water to flow freely during high water periods but hold the water back from autumn through spring. In particular, the structure would prevent the rapid drop of lake levels in early autumn when water is needed for rice irrigation.

Yet many experts question whether the dam's negative impacts on ecosystem services of the wetland have been adequately evaluated and whether alternative strategies have been fairly compared. Raising winter water levels substantially from historic norms could transform the ecological character of the wetland and flood habitats used by Siberian cranes and many other waterbirds, pushing the birds to outer parts of the wetland where human disturbance is high (Barzen et al. 2009).

Other threats to waterbirds and their food supply include poaching, primarily by nets and poisons, and stocking of crabs into sub-lakes, consuming most or all submerged vegetation. The crab species are native to China but not naturally occurring in Poyang Lake.

**Table 1** Water elevations measured in three datums used at Poyang Lake (Wu Song, National Vertical Elevation 1985, and Huang Hai) and their conversion factors to the Wu Song system. A water elevation of 12 m above sea level (Wu Song) approximates the average low water elevation at Poyang Lake (11.98 m Wu Song) as measured at Wucheng for the combined months of December, January, and February 1955–2006

| Conversion table of analysis water levels for the three elevation datums (m) | | | | |
|---|---|---|---|---|
| | Water level | Water level | Water level | Conversion |
| Wu Song | 11.98[a] | 14.00 | 16.00 | |
| National 85 | 10.14 | 12.16 | 14.16 | National 85 elevation = Wu Song elevation – 1.84 m |
| Huang Hai | 9.72 | 11.74 | 13.74 | Huang Hai elevation = Wu Song elevation – 2.26 m |

[a]Historic Mean Low Water Level. Based on water elevation from Water Gauge Data of Gan and Xiu Rivers averaged for the months of December, January, and February 1955–2006

**Box 1: Different Elevation Scales in Use in China**

Three vertical elevation datums are commonly found in data obtained at Poyang Lake: Wu Song, Huang Hai, and National Vertical Datum 1985. Huang Hai elevation systems were used as the basis for reporting elevations on topographic maps whereas water levels were often recorded in Wu Song or National Vertical Datum 1985 elevation systems. In this account, any given elevation is measured in the Wu Song datum (Xu et al. 2007). "Wu Song" is named after a seaport near Shanghai (Table 1).

## References

Barter M, Lei G, Cao L. Waterbird survey of the middle and lower Yangtze River floodplain in February 2005. Beijing: World Wildlife Fund-China and Chinese Forestry Publishing House; 2005.

Barzen J. Phase 1 report: How development projects may impact wintering waterbirds at Poyang Lake. Unpublished report submitted to Hydro-ecology Institute of the Yangtze Water Resources Commission. Baraboo: International Crane Foundation; 2008.

Barzen J, Engels M, Burnham J, Harris J, Wu G. Potential impacts of a water control structure on the abundance and distribution of wintering waterbirds at Poyang Lake. Unpublished report submitted to Hydro-ecology Institute of the Yangtze Water Resources Commission. Baraboo: International Crane Foundation; 2009.

Cui X, Zhong Y, Li W, Chen J. The effect of catastrophic flood on biomass and density of three dominant aquatic plant species in the Poyang Lake. Acta Hydrobiol Sinica. 2000;24(4):322–5.

de Leeuw J, Shankman D, Wu G, de Boer WF, Burnham J, He Q, Yesou H, Xiao J. Strategic assessment of the magnitude and impacts of sand mining in Poyang Lake, China. Reg Environ Chang. 2010;10:95–102.

Editorial Committee of Studies on Poyang Lake. Studies of Poyang Lake. Shanghai: Shanghai Scientific and Technical Publishers; 1988.

Fox A, Cao L, Zhang Y, Barter M, Zhao MJ, Meng FJ, Wang SL. Declines in the tuber-feeding waterbird guild at Shengjin Lake National Nature Reserve, China – a barometer of submerged macrophyte collapse. Aquatic Conserv Mar Freshw Ecosyst. 2010. doi:10.1002/aqc.1154. Wiley Online Library (wileyonlinelibrary.com), 10 pp.

Guo H, Hu Q, Zhang Q, Feng S. Effects of the Three Gorges Dam on Yangtze River flow and river interaction with Poyang Lake, China: 2003–2008. J Hydrol. 2012;416–417:19–27. doi:10.1016/j.jhydrol.2011.11.027.

Harris J, Zhuang H. An ecosystem approach to resolving conflicts among ecological and economic priorities for Poyang Lake wetlands. Baraboo/Gland: International Crane Foundation/IUCN; 2010.

Ji W, Zen N, Wang Y, Gong P, Xu B, Bao S. Analysis of the waterbirds community survey of Poyang Lake in winter. Ann GIS. 2007;13(1/2):51–64.

Li F, Ji W, Zeng N, Wu J, Wu X, Yi W, Huang Z, Shou F, Barzen J, Harris J. Aerial survey of Siberian cranes in the Poyang Lake Basin. In: Wang Q, Li F, editors. Crane Research in China. Yunnan: Crane and Waterbird Specialists Group of Chinese Ornithological Society, International Crane Foundation, Yunnan Educational Publishing House; 2005. p. 58–65.

Li F, Wu J, Harris J, Burnham J. Number and distribution of cranes wintering at Poyang Lake, China during 2011–2012. Chin Birds. 2012;3(3):180–90.

Liu J, Zhang Q, Xu C, Zhang Z. Characteristics of runoff variation of Poyang Lake watershed in the past 50 years. Trop Geogr. 2009;29(3):213–8.

Qian F, Yu C, Jiang H. Ground and aerial survey of wintering waterbirds in Poyang Lake basin. In: Prentice C, editor. Conservation of Flyway Wetlands in East and West/Central Asia. Proceedings of the Project Completion Workshop of the UNEP/GEF Siberian Crane Wetland Project, 14–15 October 2009, Harbin, China. Baraboo: International Crane Foundation; 2011. Paper #8, 9pp.

Shankman D, Liang QL. Landscape changes and increasing flood frequency in China's Poyang Lake region. Prof Geogr. 2003;55(4):434–45.

Wildlife Protection and Nature Reserve Management Department. 1999 annual report on nature reserves under the forestry system in China. Internal Report. Beijing: State Forestry Administration; 2010.

Xu J, Jiang B, Yao C. Overview on Wu Song Elevation System in main tributaries in lower and middle reaches of Yangtze River. Yangtze River. 2007;38(10):85–8.

Yuan L, Li W. Effects of water depths and substrate types on the distribution in winter buds of *Vallisneria spinulosa* in Poyang Lake. J Yangtze Univ (Nature Science Edit). 2008;5(1):55–8.

Zhang T, Li Z. Fish resources and fishery utilization of Poyang Lake. J Lake Sci. 2007;19(4):434–44.

Zhang Y, Cao L, Barter M, Fox AD, Zhao M, Meng F, Shi H, Jiang Y, Zhu W. Changing distribution and abundance of Swan Goose *Anser cygnoides* in the Yangtze River floodplain: the likely loss of a very important wintering site. Bird Conserv Int. 2010;21:36–48.

Zheng Y. Prediction of the distribution of C3 and C4 plant species from a GIS-based model: a case study in Poyang Lake, China [MSc thesis]. Enschede: ITC; 2009.