ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

An Assessment of Aquatic Invasive Plants in the Illinois River: water hyacinth surveillance, mapping, persistence, and potential seed dispersal

Annual Progress Report

Period: 1 May 2013 – 30 April 2014

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INHS Technical Report 2014 (21)

Prepared for Illinois Department of Natural Resources, Division of Fisheries

Issue Date: 07/07/2014

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Annual Report – Final FY2014

EXECUTIVE SUMMARY

<u>Project Title</u>: An Assessment of Aquatic Invasive Plants in the Illinois River: water hyacinth surveillance, mapping, persistence, and potential seed dispersal

<u>Objectives</u>:

1. Documenting the current distribution of mature water hyacinth plants in the Illinois River/CAWS corridor and comparing with historical records and sightings.
2. Comparing seed densities and frequencies in seed banks and dispersal in areas where dense colonies of water hyacinth occur and non-occupied areas (i.e., control) in the main Illinois River channel and associated backwaters.
3. Concurrently assessing the temporal and spatial overlap between recurring stands of water hyacinth and the presence of their seeds in their underlying seed bank
4. Developing and evaluating a rapid aerial survey technique to detect and map locations of water hyacinth along the Illinois River

Water hyacinth (*Eichhornia crassipes*) is becoming a reoccurring problem in the Illinois River – Chicago Areas Waterway System (CAWS), but the current extent and potential for future intensification are largely unknown in this system. Regular reoccurrence of water hyacinth represents a significant threat to the recreation, fisheries, and wildlife resources, economy, and ecological processes of both the Great Lakes and the Illinois & Mississippi River systems. We conducted aerial surveillance flights and boat surveys of floating-leaved vegetation with visual signatures of water hyacinth from Hennepin, IL to Joliet, IL along the Illinois River five times during the summer/fall of 2013. We collected sediment cores in historically-infested sites, random sites, and at water hyacinth bed locations. We collected and assessed diets of 29 Common Carp (*Cyprinus carpio*) to determine evidence of water hyacinth seed presence. We located a single bed of water hyacinth while conducting aerial surveillance, and ground reconnaissance confirmed our discovery. We then found water hyacinth propagules present within 3 Illinois Waterway reaches (Marseilles, Dresden, and Brandon) and two disconnected water bodies (Skokie Lagoons and an unnamed pond). We found water hyacinth seed densities in the Dresden Reach ranging from 0 seeds/ft^2 to as high as 480.5 seeds/ft^2. We determined that frequency of water hyacinth seed (whole or partial) in common carp diets was 50.3% of the total carp assessed. Aerial surveillance, ground reconnaissance, seed bank assessment, and dispersal vector sampling will continue through 2014-15.

Project Title: **An Assessment of Aquatic Invasive Plants in the Illinois River: water hyacinth surveillance, mapping, persistence, and potential seed dispersal**

Introduction

Water hyacinth (*Eichhornia crassipes*) is an invasive aquatic macrophyte native to Lower Amazonia, Brazil, South America (Penfound and Earle, 1948). Water hyacinth forms dense mats on the surface of slow-moving waterways and backwaters, restricting commercial and recreation traffic, outcompeting native emergent and submerged plants, and affecting natural biogeochemical and evapotranspiration cycles (Penfound and Earle 1948, Rai and Datta Munshi 1979). Large, leathery "sail-like" leaves, with swollen petioles, allow water hyacinth to be blown through the water with ease, and a new colony can be created from a single propagule (Bock, 1969). Water hyacinth beds are easily disturbed by water current, wind, or wave action, spreading plants to new localities within the system (Burton, 2005).

Water hyacinth is becoming a reoccurring problem in the Illinois River – Chicago Areas Waterway System (CAWS), but the current extent and potential for future intensification are largely unknown in this system. Regular reoccurrence of water hyacinth represents a significant threat to the recreation, fisheries, and wildlife resources, economy, and ecological processes of both the Great Lakes and the Illinois & Mississippi River systems. Considering the scale and density to which water hyacinth mats can grow, it can be extremely problematic and costly to control. Several methods are commonly used, including biological, chemical, mechanical, and integrated control methods. Because water hyacinth has the potential to substantially degrade aquatic and wetland resources wherever it becomes established, proactive management of biomass and prevention are the best methods of control (Gopal, 1987; Villamagna and Murphy, 2010). Risk assessment, surveillance, and control of aquatic invasive plants like water hyacinth relies on a firm understanding of the factors controlling its establishment and dispersal.

Methods

Study Area

The study area is located along the upper Illinois Waterway (Figure 1), including sections of the Illinois, Des Plaines, and Kankakee rivers and the Chicago Area Waterway System (CAWS). The Illinois River proper is formed at the confluence of the Des Plaines and Kankakee Rivers (Figure 1). This consists of the upper Peoria reach, Starved Rock reach, Marseilles reach, Dresden reach, and Brandon Road reach (river miles 208-291). Search areas included the main channel, connected and disconnected backwaters, sloughs, marinas, and other slack-water areas in or near the river floodplain where water hyacinth may be present. We also conducted surveys outside of the main study area, neighboring the survey route, as supplemental data.

Design

We conducted aerial surveillance flights and boat surveys of floating-leaved vegetation from Hennepin, IL to Joliet, IL along the Illinois River five times during the summer/fall of 2013. We estimated spatial extent and frequency of plant colonies (i.e., clusters or groups of plants >2 m^2) during mid-summer (June), late summer (August), early fall (September), and twice during mid-fall (October) to evaluate presence and the extent of colonies. Target plant colonies were water hyacinth, American white water lily, yellow pond-lily, American lotus, watershield, and other common floating-leaved plants.

Aerial Surveys — Before vegetation size estimates occurred, we flew over areas of known size (i.e. a football field including end zones is 1.32 acres, soccer fields) at surveillance altitudes as a calibration method to ensure accurate estimations of vegetation area. During low-altitude surveys, two observers seated on the same side of the aircraft (front and rear seating) (Cook and Jacobson, 1979), searched water surfaces for floating-leaved vegetation, and marked the locations of hyacinth beds, and plant colonies having visual signatures resembling water hyacinth with a GPS waypoint. Once a colony was found, both observers will identified vegetation to negate any discrepancy of species identity, circling multiple times to ensure accuracy. Once identified, we estimated size (in acres) of the bed. Then, we estimated extent of vegetation coverage within the estimated area, and finally we estimated species composition within the vegetation coverage. Locations of floating-leaved vegetation colonies were marked with a GPS waypoint using a standardized code. The observer located in the rear seat recorded all data on data sheets. Following low-altitude surveys, we then took aerial photographs at a fixed altitude (1,500 ft. AGL [Above Ground Level]) from the cockpit and a wing-mounted, downward looking camera. These photos will later be digitized using Geographic Information Systems software to accurately measure bed size. Locations of beds were waypointed during upstream flight from Hennepin to Joliet and aerial photographs were obtained during the return trip from Joliet to Hennepin.

Ground Surveys — Within 1 week of aerial surveys, we visited all GPS waypoints and beds by boat to verify aerial species identifications and bed size estimates (Everitt et al., 1999). We also conducted exhaustive searches of the main river channel and all connected, accessible, and disconnected backwaters, sloughs, marinas, and other slack-water areas to determine the aerial detection rate for each species of plants. Additionally, we conducted intensive ground surveys from watercraft to assess aerial detection rates and minimum detectable patch size. Boat surveys covered all of the accessible backwaters, sloughs, and the main navigation channel of the Illinois River. We assumed that detection is 100% from boat surveys. Multiple contiguous beds may be present within a single backwater site, but each site was deemed as a “bed” based on occurrence of at least a $2m^2$ patch of plants.

Seed Bank and Fish Sampling

Core and Sweep Samples — Within Dresden reach, we collected three sets of benthic core samples: 1) Random cores 2) Bed cores and 3) Historical core samples. A set of Random core samples was obtained at 30 random points during October of each year throughout the entire Dresden reach that were generated using ArcMap. We obtained 3 randomly-placed subsample cores and 3 vertical sweep net samples within 5 m of each random point. We obtained a set of Historically-infested site core samples within each backwater where water hyacinth has been historically present (i.e., marinas, basins, sloughs). We generated 10 random points using ArcMap within each Historical site and obtained 3 randomly-placed subsample cores and 3 vertical sweep net samples within 5 m of each random point and homogenize the three subsamples at each point in a Wildco sieve bucket with 35um apertures screen. Random cores will be used as a control for historical and bed sites. For Bed cores, we collected 5 core and vertical sweep net samples, estimated size of hyacinth bed, described hyacinth bed maturity, and described other plant species present within the bed. All individual subsample cores and sweeps were combined in a Wildco sieve bucket, rinsed, placed into labeled Ziploc bags. At each random point, we also collected a Secchi disk reading and water depth. We also measured the overall bed size and recorded it on standard data sheets. Seeds and aquatic vegetation were identified to species or lowest possible taxonomical unit, dried at 80°C, and weighed to the nearest 0.0001g (Hagy et al. 2011).

Fish Sampling — We collected common carp (*Cyprinus carpio*) throughout the Dresden reach of the Illinois River two times (September and October). We used AC and DC boat-mounted electroshocking techniques to obtain 36 common carp. Emphasis was placed on electroshocking hyacinth beds, and fish shocked directly from a water hyacinth bed were labeled accordingly.

Fish were also collected from the Illinois Natural History Survey-Illinois River Biological Station's Long-term electrofishing (LTEF) fixed sites throughout the Dresden reach. Immediately after capture, fish were placed on ice until they were weighed, measured, and the entire digestive tract (anus – mouth) removed and preserved with 10% formalin in a laboratory (<3 hours; Garcia-Berthou 2001) (Institutional Animal Care and Use Committee Protocol #12049; Wild Fish Population Studies). Later in a laboratory, all contents including seeds, invertebrates, and vegetation were removed from the digestive tract, identified to species or lowest possible taxonomical unit, dried at 70°C, and weighed to the nearest 0.0001g (Colle et al. 1978).

Results

Distribution of Hyacinth beds

Anecdotal evidence from the Illinois Department of Natural Resources (IDNR) and Illinois Natural History Survey (INHS) suggested the presence of water hyacinth within the Dresden reach of the Illinois Waterway within the previous 3-4 years, with specific sightings in Big Basin, the Big Basin Marina, and downstream portion of the Treat Island side channel (hereafter termed 'Historical sites'). During October 2013, we found individual water hyacinth plants floating throughout the entire Dresden reach. We located one water hyacinth bed located in a barge slip just upriver of the I-55 Bridge (41°25.807', -88°11.038') on the Des Plaines River (Figure 2). The bed was approximately 0.12 acres (480 m^2) in size and we noticed free-floating water hyacinth plants floating away from this bed, out of the barge slip, and downriver to the Dresden Lock and Dam. Free floating water hyacinth was observed in the main river channel, on shorelines, and in many backwaters, bays, and marinas. No free floating water hyacinth was observed upriver of the bed location, except for three individual, immature plants found upriver of the Brandon Road Lock and Dam. Several immature plants were also located below the Dresden Island Lock and Dam, near Seneca, IL. Water hyacinth plants were very small and presumed to be immature in nature, as there were no visible flowering plants, and no plants observed had exceeded 8" in height. We also located a bed of water hyacinth growing in Skokie Lagoons, a backwater side channel system of the Skokie River near Glencoe, IL. Ground surveillance revealed that both immature and mature, flowering water hyacinth plants were prevalent within the Skokie Lagoon system.

Seeds from sediment cores

Random sediment cores were taken at 29 sites throughout the Dresden reach to assess water hyacinth seed distribution. Water hyacinth seeds were found in 8 of 29 (27.5%) of random cores in densities of 4–88 hyacinth seeds/core (Figure 2). We estimated a mean of 87.4 seeds/ft^2 (SE = 50.0) in the Dresden reach (Table 1). Seed densities in seed bank cores from historically-infested sites were 13.2 seeds/ft^2 (SE = 22.9) in Big Basin Marina, 68.6 seeds/ft2 in Treat Island South (SE = 28.4), and 480.5 seeds/ft^2 (SE = 158.5) in Big Basin proper (Table 1). There were detectable spatial trends in the distributions of water hyacinth seeds within historical basins (e.g., concentrations occurred at the mouth of the DuPage river in Big Basin) (Figure 3). No water hyacinth seeds were recovered from sediment cores taken in the barge slip beneath the water hyacinth bed (Table 1). The water hyacinth bed at Skokie Lagoons yielded a mean of 63.4 seeds/ft^2 (Table 1).

Seeds in Common Carp stomachs

Electrofishing techniques were used to collect 36 common carp during fall 2013, and 29 during spring of 2014. Contents of the digestive tracts of 29 common carp from the fall sampling period have been assessed for the presence of water hyacinth seeds. We have calculated that 40% of the 29 total carp processed had whole water hyacinth seed present, and 10.3% had water hyacinth seed evidence (i.e., seed casing or seed fragments) present within the digestive tract, totaling 50.3% of all carp processed (Table 2). We calculated that 28.6% (2/7) collected within a water hyacinth bed had whole water hyacinth seeds present in the digestive tract and an additional 14.3% (1/7) had partial or broken water hyacinth seeds (Table 2). We calculated that 41% (9/22) of carp collected at other locations within the Dresden Reach contained whole water hyacinth seeds and 9.1% (2/22) contained partial or nonviable water hyacinth seed (Table 2). Sample processing of remaining digestive tracts is ongoing.

Aerial surveillance

We conducted five aerial surveys of the upper Illinois River during summer–fall 2013. We mapped floating leaved aquatic vegetation with visual characteristics resembling water hyacinth and estimated species composition and size of the plant colony. Plant colony species composition error rate describes the percent of aerial observations of species composition that differed from groundtruthed species compositions. A negative error rate means estimates are greater from the plane than was actually present on the water, whereas a positive error rate means that estimates from the air were lower than measured by boat surveys. For example, we found a 100% error rate when conducting water hyacinth surveillance meaning that percent species composition estimates of water hyacinth beds (n = 1) were incorrect 100% of the time (note we only encountered one water hyacinth bed during aerial surveys). This is not to say that we saw water hyacinth when it was not there or missed it when it was, but instead that we called a plant bed "100% water hyacinth" from the air when, based on a follow up subsequent boat survey, we discovered it was really 90% hyacinth, 10% creeping water primrose. However, in this example, we correctly identified that water hyacinth was present and the dominant form of vegetation cover in the bed, but misclassified 10% of the vegetation coverage; thus, the effect size of our error rate was actually quite small.

We located 24 floating-leaved plant colonies in the Dresden reach during 5 flights. Plant colony species composition error rates (%) showed high variation. We estimated a 7.7% error rate for creeping water primrose (*Ludwigia peploides*), whereas for water hyacinth we estimated a 100% error rate (Table 3). We estimated a 50% plant colony species composition error rate for White water lily (*Nymphaea alba*) and for American lotus (*Nelumbo lutea*) we estimated a plant colony species composition error rate of 38.5%. Species identification error rate for creeping water primrose (0.76%) (SE = .77, n = 13), water hyacinth (-1.20%) (SE = 2.2, n = 5), white water lily (-5%) (SE = 5, n = 2) and American lotus (0.46%) (SE = .81, n = 13) were all relatively low, meaning that our overall accuracy was quite high and we had few species misidentifications of significant size (Table 3). We estimated size of 24 colonies in the Dresden reach ranging from 0.1 acres to 4 acres. We both overestimated, underestimated, and were correct on bed sizes when compared to ground measurements (Table 4). A size error rate was calculated using the difference of air estimates and ground measurements. On average, we overestimated colony size by 223%, but when three outlying colony estimations are removed, size error rates dropped to 71.4% (Table 4).

Discussion

Illinois endured an unusually late spring in 2013 with below normal temperatures and above normal rainfall (Angel, 2013). The late spring was exacerbated by historic flooding along the Illinois River. As such, growth of aquatic vegetation along much of the upper Illinois River was likely delayed. Once water hyacinth was found, it appeared as if dispersal from the "parent bed" by floating plant propagules was excessive. Water hyacinth beds are easily disturbed by water current, wind, or wave action, and individual or clusters of plants often spread to new locations within the system (Burton, 2005). Large, leathery "sail-like" leaves with swollen petioles allow wind-driven dispersal of water hyacinth, and new colonies can be created from a single propagule (Bock, 1969). Dispersal of these propagules from the only water hyacinth bed (i.e., one barge slip) appeared to be aided by the wake and movement of barge and tug traffic in close proximity to the bed. Water hyacinth plants were found during October 2013 in all anecdotal locations made aware to us by the IDNR and INHS staff. Individual plants were found both upriver and downriver of lock and dam systems (Dresden and Brandon Rd. L&D), suggesting that water hyacinth plants are likely capable of passing through/around these structures by current, and perhaps recreational and commercial water traffic.

Water hyacinth is capable of asexual reproduction via parent/daughter plants connected by stolons and large root masses, and sexual reproduction via flowering stalks and seed production. Each mature plant has one to three flowering spikes capable of producing up to 6,000 seeds (Matthews, 1967). No water hyacinth seeds were located in the seed bank upriver of Treat Island South side-channel. The highest density of water hyacinth seeds was located at the mouth of the DuPage River, on the Western shore of Big Basin (Figure 3), suggesting two potential scenarios: 1) water hyacinth plants/seeds are flowing down the Des Plaines River and collecting in the slack water of Big Basin or 2) water hyacinth plants/seed are flowing down the DuPage River and are being deposited into Big Basin. More flight and ground time will be allocated in 2014 to investigating the DuPage River system for water hyacinth. Seeds have been shown to retain viability for greater than 28 years (Sullivan and Wood, 2012). With seed densities as high as 480.5 seeds/ft^2 (Table 1) present within the Dresden reach, cause for concern of future water hyacinth intensification is warranted.

We estimated that 50.3% of common carp diets assessed from the Dresden reach contained evidence of water hyacinth seed (Table 2). We found seeds in the digestive tracts of common carp collected from directly beneath water hyacinth, as well as from carp collected away from the water hyacinth bed. Common carp (*Cyprinus carpio*) frequently ingest seeds when foraging (Balon, 1995; Hossain et al., 2001) and are known to increase germination post-digestion (Pollux et al., 2006) is particularly important when considering that the upper Illinois River has large populations of common carp, which are capable of moving up to 238 km annually in large rivers (Jones and Stuart, 2009). Pending verified viability of water hyacinth seeds in the Illinois River, water hyacinth seed dispersal by fish has the potential to amplify the infestation of water hyacinth throughout the upper and lower reaches of the Illinois River.

Aerial surveillance for water hyacinth proved to be successful. The initial water hyacinth sighting was from the airplane, and was identified correctly. Our correct identification suggests that surveillance for this plant from the air is a practical endeavor. Estimations of plant colony species composition were moderately successful, but can likely be improved. Species identification was very accurate, yielding only $\leq$5% error for all species estimated (Table 3). Aerial size estimation error rates were high when all beds were included (223%), but when outlier beds were removed, error rates dropped significantly (71%). Emphasis in upcoming surveillance flights will be placed on lowering error rates of all estimations taken and developing standardized procedures.

Literature Cited

Angel, J. 2013. Temperatures and precipitation by month in 2013. Illinois State Water Survey. 4 January 2012 < http://climateillinois.wordpress.com/2013/05/03/temperatures-and-precipitation-by-month-in-2013/>. Accessed 8 May 2013.

Balon, E. K. 1995. Origin and domestication of the wild carp, *Cyprinus carpio*: from Roman gourmets to the swimming flowers. Aquaculture 129(1): 3-48.

Bock, J.H. 1969. Productivity of the water hyacinth *Eichhornia crassipes* (Mart.) Solms. Ecology 50(3): 460-464.

Burton, J. 2005. Water hyacinth *Eichhornia crassipes*. NSW Department of Primary Industries.

Colle, D.E., J.V. Shireman, and R.W. Rottman. 1978. Food selection by grass carp fingerlings in a vegetated pond. Journal of the American Fisheries Society 107 (1): 149-152.

Cook, R.D. and J.O. Jacobson. 1979. A design for estimating visibility bias in aerial surveys. Biometrics 35(4): 735-742.

Everitt, J.H., C. Yang, D.E. Escobar, C.F. Webster, R.I. Lonard, and M.R. Davis. 1999. Using remote sensing and spatial information technologies to detect and map two aquatic macrophytes. Journal of Aquatic Plant Management 37: 71-80.

Garcia-Berthou, E. 2001. Size-and depth-depth dependent variation in habitat and diet of the common carp (*Cyprinus carpio*). Aquatic Sciences 63: 466-476.

Gopal, B. 1987. Water hyacinth. 471 pp. Elsevier Science Publishers. Amsterdam, Netherlands. 1987.

Hagy, H.M., J.N. Straub, and R.M. Kaminski. 2011. Estimation and correction of seed recovery bias from moist-soil cores. Journal of Wildlife Management 75(4): 959-966.

Hossain, M. A., U. Focken, and K. Becker. 2001. Evaluation of an unconventional legume seed *Sesbania aculeate*, as a dietary protein source for common carp, *Cyprinus carpio* L. Aquaculture 198(1): 129-140.

Jones, M.J., and I.G. Stuart. 2009. Lateral movement of common carp (*Cyprinus carpio* L.) in a large lowland river and floodplain. Ecology of Freshwater Fish 18:72-82.

Matthews, L.J. 1967. Seedling establishment of water hyacinth. Pest Articles and News Summaries, section C, Weed Control 13(1): 7-8.

Penfound, W.T. and T.T. Earle. 1948. The Biology of the Water Hyacinth. Ecological Monographs 18(4): 447-472.

Pollux, B.J.A, M. De Jong, A. Steegh, N.J. Ouborg, J.M. Van Groenendael, and M. Klaassen. 2006. The effect of seed morphology on the potential dispersal of aquatic macrophytes by the common carp (*Cyprinus carpio*). Freshwater Biology 51: 2063-2071.

Rai, D. N., and J. Datta Munshi. 1979. The influence of thick floating vegetation (Water hyacinth: *Eichhornia crassipes*) on the physio-chemical environment of a fresh water wetland. Hydrobiologia 62(1): 65-69.

Sullivan, P.R., and R. Wood. 2012. Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) seed longevity and implications for management. Eighteenth Australasian Weeds Conference: 37-40.

Villamagna, A.M., and B.R. Murphy. 2010. Ecological and socio-economic impacts of invasive water hyacinth (*Eichhornia crassipes*): a review. Freshwater Biology 55: 282-298.

FIGURES

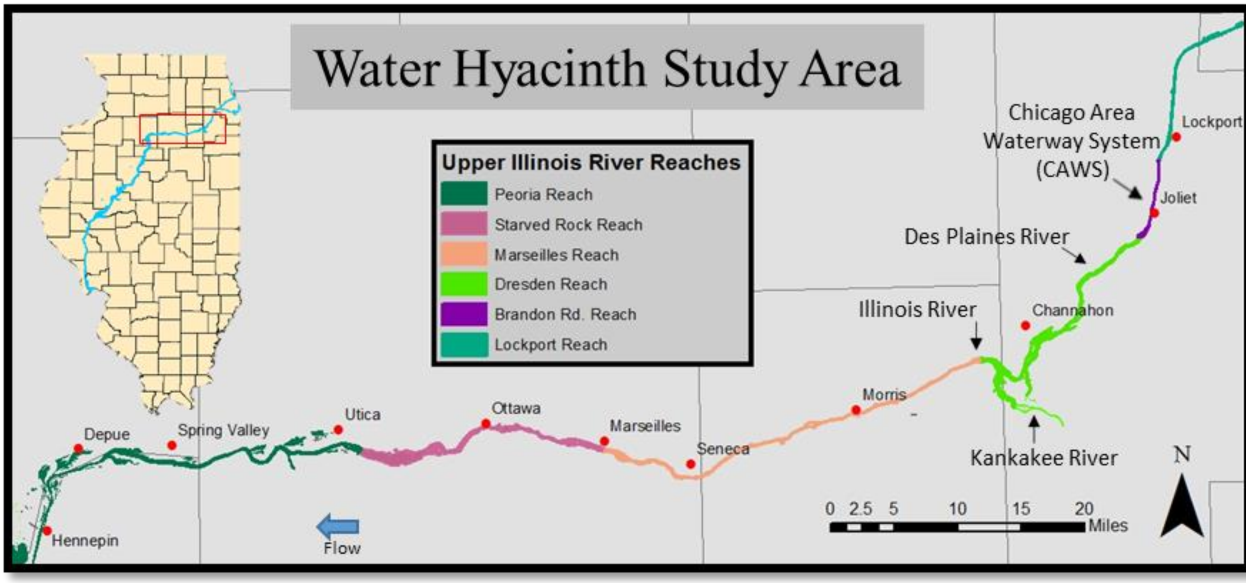

Figure 1. The upper Illinois River, Chicago Area Waterway System, associated tributaries common names of river reaches between dams, cities adjacent to the river, and flow direction.

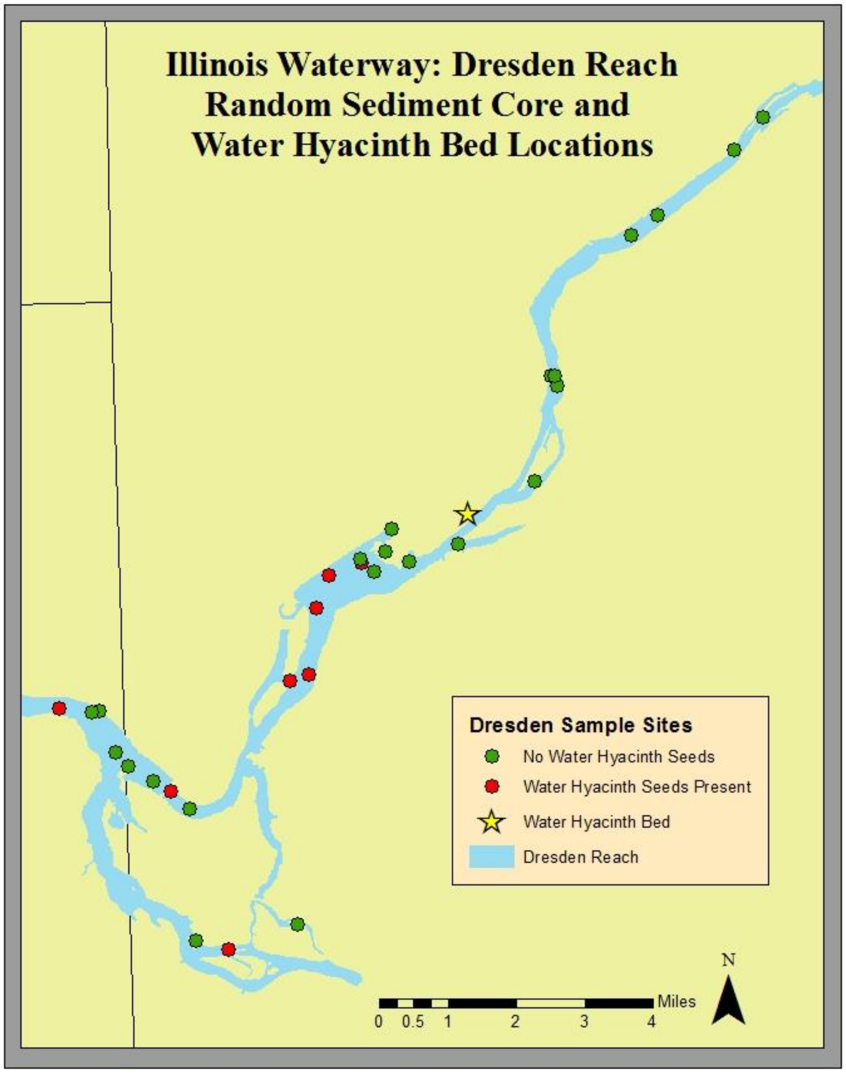

Figure 2. The Dresden reach of the Illinois Waterway and the sites at which random core samples were taken (red indicates that water hyacinth seed was present within the core sample and green dot color indicates no water hyacinth seed present) and the location of the single hyacinth bed located in the Dresden reach.

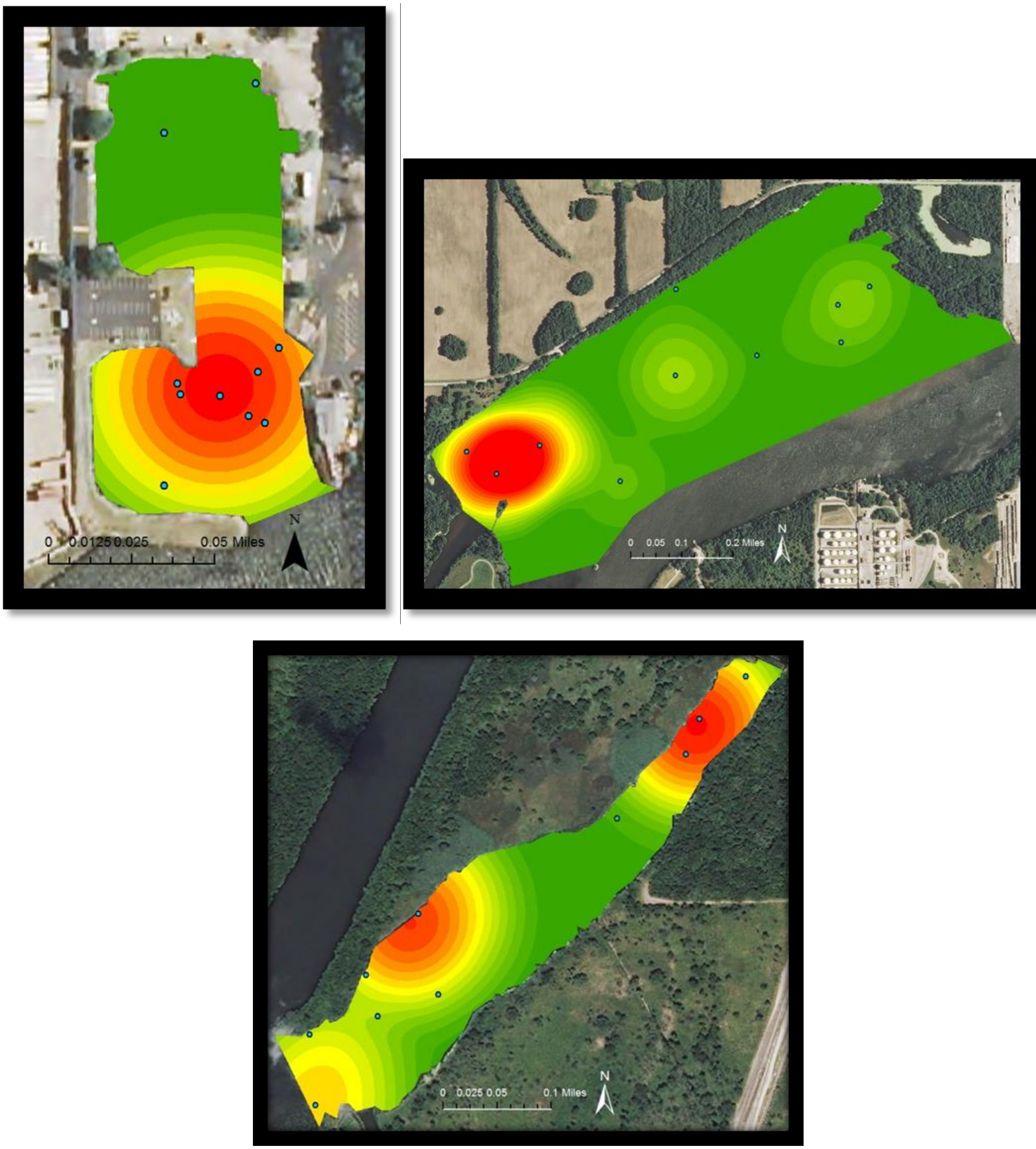

Figure 3. Relative water hyacinth seed density of Historically-infested sites (Big Basin Marina [upper left], Big Basin proper [upper right] and Treat Island South [lower]) with blue dots represent core sites (red coloration indicates highest water hyacinth seed density and green indicates lowest water hyacinth seed density).

TABLES

Core Site Type	Site Names	Mean Water Hyacinth Seeds/Sq. Ft.	SD	SEM
Historically Infested	*Big Basin*	480.5	501.2	158.5
	Treat Island South	68.6	89.9	28.4
	Big Basin Marina	13.2	22.9	7.6
Random	*Dresden Reach*	87.4	264.5	50.0
Water Hyacinth Bed	*Skokie Lagoons*	63.4	-	-
	Barge Slip	0.0	-	-

Table 1. Mean seed density (seeds/ft^2), standard deviation (SD), and standard error of the mean (SEM) of water hyacinth seeds within respective areas in the Illinois Waterway – Dresden reach during summer–fall 2013.

Carp Collection Location	Whole Seeds	Seed Evidence	Total Seed Presence
Water Hyacinth Bed Carp	28.6%	14.3%	42.9%
Non-Water Hyacinth Bed Carp	41.0%	9.1%	50.1%
Total Carp	40%	10.3%	50.3%

Table 2. Frequency (in percent) of whole water hyacinth seeds, evidence of water hyacinth seeds (<51% of a whole seed; seed casing) and total seed presence within 29 common carp digestive tracts collected from the Illinois Waterway – Dresden reach during fall 2013.

Aerial Error Rate Type	*Ludwigia peploides*	*Nymphaea alba*	*Eichhornia crassipes*	*Nelumbo lutea*
Plant Colony Species Composition	7.7%	50.0%	100.0%	38.5%
Species	0.76%	-5%	-1.20%	0.46%

Table 3. Percent error of plant colony species composition of aerially mapped floating-leaved aquatic vegetation. A negative error rate correlates to estimating a higher percent of that species from the plane than was actually present on the water. A positive error rate means that estimates from the air were lower than was actually present. Plant colony species composition error rate is the actual percentage difference (i.e., the effect size) of aerial species composition estimates from ground truth species compositions.

Dresden Reach Waypoints	Air Size Estimation (Acres)	Percent Error
259	0.1	0%
262-1	2	-15%
262-2	4	-8%
262-3	1	62%
262-4	0.5	110%
262-5	0.5	0%
263-1	0.1	0%
263-2	0.2	180%
263-3	0.2	1172%
263-4	0.2	1510%
263-5	0.2	1172%
263-6	0.1	0%
264-1	0.5	27%
264-2	0.1	0%
264-3	0.5	61%
264-4	0.5	33%
264-5	1	54%
265	0.5	322%
266	2	447%
267	0.1	0%
268	1.5	-42%
269	0.4	249%
270	0.5	-16%
271	0.2	35%
Mean % Error		**223%**
Mean % Error excluding Outliers		**71%**

Table 4. Aerial size estimation (%) of floating-leaved aquatic vegetation colonies (waypoints) in the Dresden reach. A positive percent error correlates to an underestimation in size, and a negative percent error correlates to an overestimation. Mean percent error is given for all colonies. Aerial size estimations (acres) are given for each colony. Highlighted values are outliers, and a mean percent error excluding these values is given.