Research, Information and Implementation Priorities

What aspects of plant taxonomy are most important in management of aquatic invasives?

-Accurate identification of aquatic plants (in the field)
-Accurate identification of aquatic plants (in the trade)
-Database of not only known invasive aquatic plants, but all aquatic plant genera (early detection)
-Molecular plant identity (barcoding)
-Specimen Vouchering

*Much time and money can be wasted by aquatic plant management agencies if we do not target the correct aquatic plant taxa. Methods of management should be tested on the specific taxon being targeted for management. Correct plant identity is essential to determine the appropriate management tools to use against any particular taxon.

Need to integrate identification of taxa before conducting research:

Before research (on herbicide, biocontrol, physiology, etc.) is conducted positive identification of the study taxon should be implemented using the data we now have at the molecular level.

Do not consider hybrid taxa to respond to management like their parental taxa; hybrid taxa are unique and many invasives have a hybrid origin. (See lit. cited hybrids; Fritz 1999 ; Ellstrand & Schierenbeck 2001).

Emphasize the organisms we already know have problems with proper taxonomic identification immediately (*Hydrilla*, *Myriophyllum*, Duckweeds, *Phragmites*, *Tamarix*, etc.) Include hybrids and known genotypes. (See lit. cited)

Particular taxonomic groups in which to prioritize basic taxonomic studies on invasives and their native origins.

Primary
***Hydrilla* (how many species do we have?) monograph**
***Trapa natans*?: (which species is in North America) monograph**
Azolla

Secondary
***Egeria densa, E. najas* (others).**
Lagarosiphon
Limnophila
Hydrocharis

Continue developing tools to understand genetic structure (genotypes to species)

- better molecular markers should begin to be used (microsatellites, ISSRs, AFLP's)
- much data present for terrestrial taxa, but not aquatics

Use the genotype data available (as described above)

- Unique genetic types often respond differentially to the environment around them, selection.
- Differential response to herbicides and herbivores
- life history traits, physiology, growth responses, seed set, mating systems

(See studies and reviews in lit cited)

Molecular Methods:

***In order to quickly identify plants for more efficient management.**

A. Currently most useful for known invasive taxa and early identification.
B. Prioritize types of plants for ID. (e.g., it is not as useful to have somebody sending in *Brasenia* or *Nuphar* for ID as it would be for a submersed aquatic which would be more likely to represent an invasive).
C. Molecular analysis of an aquatic plant specimen can be completed in 24 hours with today's technology.
D. Determine specific molecular markers for invasive taxa based on verified voucher specimens.
E. Multiple specimens verified using morphology should be sampled to determine accuracy of DNA data.
F. nrDNA ITS has been suggested as a good candidate for barcoding plants (Kress et al. 2005). Over 36, 000 ITS sequences in genbank.
G. Additional markers when appropriate for **intraspecific** or **hybrid** identification. Use the abundant data now available and published.
H. The level of use of the barcode or molecular marker is defined by the taxonomist.
I. Especially important for early identification!
J. Can identify plant fragments, nonindigenous genotypes, hybrids, difficult taxa (many submerged aquatics) especially when lacking reproductive parts,
K. Examples where molecular markers have been, could be or continue to be useful:
   - *Myriophyllum* (hybrids not ID'd until molecular data applied)
   - *Phragmites* (Saltonstall 2003): invasive, nonindigenous genotypes ID
   - *Vallisneria* (*spiralis*? - Texas): unknown prior to molecular analysis
   - *Glossostigma* (misidentified even by the author of the species name! Molecular data clearly distinguish the various species (current work D. Les & B. Capers)
   - *Hydrilla*: what DO we have in North America (e.g., "monoecious" vs. "dioecious" "strains"; fluridone resistant strains.
   -*Tamarix* – Hybrids ID'd poorly known genotypes
   - *Trapa* "*natans*" – is it really? *Trapa natans* in Eurasia is moresubtropical in distribution and has all but disappeared from northern Europe where it had been cultivated for centuries; yet, *T. japonica* thrives in Asia at the same latitudes as North America. How can we be sure that we don't have *T. japonica* in N.

America instead? Could be a nomenclatural issue as *T.japonica* once was placed in synonymy with *T. natans* (recognized as var. *japonica*).

Traditional Methods:

A. Continued revisions of aquatic taxa (especially in underdeveloped regions). Many groups still poorly known.
B. Centralized herbarium for storing verified material. Many taxonomic identities are quite obvious using morphology, even from immature plants or plant fragments.

Centralized Molecular Lab:

A. Lab For Identification of Aquatic Invasive Species.
B. Who would run it (Government or Academic facility).
C. Who will head up such a facility? Should be a person thoroughly familiar with the problem and well-versed in the technical (e.g., molecular) aspects.
D. Where (physically) will the facility be located?
E. Such as facility should be organized to interact directly with other groups (e.g., state and local agencies) involved in the management of invasive species.
F. Where and how will the lab get, and verify, their comparative samples? And where will they be vouchered?
G. Interaction with similar facilities would be important (University of Guelph) http://www.uoguelph.ca/foibis/barcoding.htm

Database Ideas:
To help nationwide management personnel and the general public to identify taxa (at least to within in a narrow range).

A. All aquatic genera (not only known invasives). Very important for early detection.
   -Interactive key for all genera. (i.e C.D. Cook; Aquatic Plant Book)
   -At least one species from each genus (Voucher specimen & DNA)
   -All the known invasive species
   -All aquatic taxa with phylogenetic or DNA data already available
   -Plants sold in the trade in N. A.
B. Integrate into an existing database (e.g. USDA PLANTS database; www.)
C. Interactive key (use an interface similar to Joe DiTomaso's weed key)
   -Include a simple format with easy to identify characters
   -Definition of technical characters
   -short list of taxa with a narrowing range of characters.
D. Voucher specimens included and scanned.
E. Peer Reviewed? (Set up advisory board, cite references, ask for advice from experts).
F. Accuracy of plants identified as invasive.
G. Include native aquatic taxa for comparison.
H. Include: photos, line drawings, and scanned specimens,

I. Where are taxa currently invasive, natural distribution, reproductive info., basic life history info., hybrid potential, molecular sequence data,
J. Monitoring through invasives in other countries, monitoring.

Identifying Aquatic Plants (the trade):

A. Require aquatic plant nurseries to accurately (correct nomenclature) label their material, under penalty.
B. Increase the range of laws limiting the sell of invasive aquatics (Federal level: State laws aren't sufficient).

Education;

A. Train management personnel at the college level in basic taxonomic skills.
B. This should be emphasized in university departments such as Natural Resource Management and Introductory Biology.

General Biology:

A. Incorporate prehistorical component of plant distributions - - the fossil record. If more land managers knew the history of vegetation and flora for their region they would have a better concept of exactly where it could go.
B. Understand that the flora of any spot is not permanent. Once you understand the fossil history and thus the pre-historic climate and flora, the view that the biological world must be protected at all costs from anything different will go away. And let managers focus on what should and can be done, not what they imagine should be done.
C. Acquire genetic, ecological data and other life history data on invasive species:
    - It is difficult to manage any species without first understanding its reproductive biology, basic ecology (habitat preferences/tolerances, etc.), seed germination/longevity, etc.
    - More basic life history information needs to be obtained for invasive species. E.g., identification of habitat characteristics could help managers determine which portions of their preserve would be most susceptible to establishment of a particular species.
D. Evolutionary thinking must be emphasized more completely. Make sure land managers understand natural selection; how it can be used as a management tool, and also how it can "naturally" prevent the "invasion" of both non-natives and non-local genotypes.

Funding Sources:

-link funding linked to legislation

-tie the need for proper plant identification into funding sources.
-tie the need of research of systematics of aquatic plant groups into more efficient management.
-NRI: designing research project
-USDA –should be open to this idea

GENOTYPE STUDIES

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