

# Flowering Rush: A New Biocontrol Project for North America



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# *Butomus umbellatus*

- Fresh water aquatic invasive species
- Emergent & submerged growth forms
- Colonizes wetlands, slow-moving rivers, canals & irrigation ditches
- Diploid & triploid cytotypes
- Disperses through rhizome fragments & rhizome buds



# Flowering Rush Impacts

- Invading NA
  - WA, ID, MT, OR, AB, B.C. & midwestern states/provinces
- Creates dense stands & can dominate from shoreline to 20'
- Economic impacts
  - irrigation & dam management
- Ecological impacts
  - aquatic plant communities
  - increase habitat for salmonid predators?
- Recreational impacts



Mackey, Chelan CNW/CB



Marcus Österberg/SXC

# Flowering Rush Biocontrol Consortium

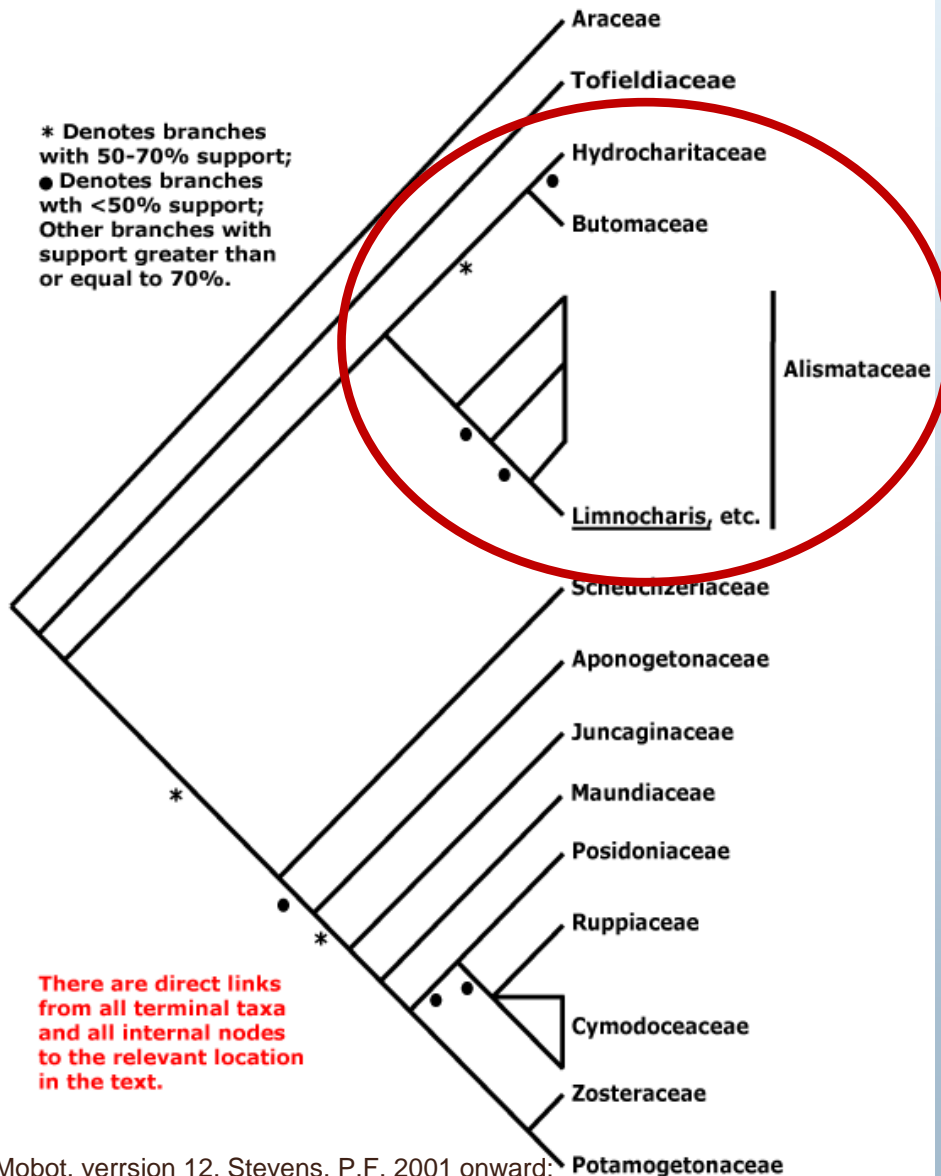
- Difficult to control
- Only species in Butomaceae
- Consortium formed in 2012
  - Partnership between CABI, WA, MT, ID, B.C., AB, MN, MS...
- Funding sources
  - Montana Noxious Weed Trust Fund
  - Washington Department of Agriculture
  - Washington Department of Ecology
  - Army Corps of Engineers
  - British Columbia - Ministry of Forest, Lands and Natural Resources Operations (FLNRO)
  - WA Department of Natural Resources, Kalispel Tribe

# Biocontrol Research Process

- 1) Planning (funding, test plant list development)
- 2) Exploration (literature & field survey)
- 3) Host-specificity testing
- 4) Shipment
- 5) Quarantine (more h-s testing)
- 6) Approval process (TAG & USDA APHIS)
- 7) Rearing
- 8) Colonization
- 9) Assessment of establishment
- 10) Evaluation of biocontrol

**Not mutually exclusive from each other**

# Draft Test Plant List



- 42 species selected for host-specificity tests
- Primarily in 3 closely related families
- FR in subclass Alismatidae
- Mobot:
  - Order: Alismatales
  - 2 families closely related: Hydrocharitaceae & Alismataceae (includes Limnocharitaceae)
- USDA PLANTS Database
  - 3 orders: Alismatales, Hydrocharitales, Najadales
  - 3 families closely related

# Draft Test Plant List

| Family           | Species                         |
|------------------|---------------------------------|
| Butomaceae       | <i>Butomus umbellatus</i>       |
| Limncharitaceae  | <i>Hydrocleys nymphoides</i>    |
| Alismataceae     | <i>Limncharis flava</i>         |
| Alismataceae     | <i>Alisma gramineum.</i>        |
| Alismataceae     | <i>Alisma plantago-aquatica</i> |
| Alismataceae     | <i>Alisma subcordatum</i>       |
| Alismataceae     | <i>Alisma triviale</i>          |
| Alismataceae     | <i>Baldellia ranunculoides</i>  |
| Alismataceae     | <i>Damasonium californicum</i>  |
| Alismataceae     | <i>Echinodorus berteroi</i>     |
| Alismataceae     | <i>Echinodorus cordifolius</i>  |
| Alismataceae     | <i>Echinodorus tenellus</i>     |
| Alismataceae     | <i>Sagittaria cuneata</i>       |
| Alismataceae     | <i>Sagittaria graminea</i>      |
| Alismataceae     | <i>Sagittaria latifolia</i>     |
| Alismataceae     | <i>Sagittaria longiloba</i>     |
| Alismataceae     | <i>Sagittaria platyphylla</i>   |
| Alismataceae     | <i>Sagittaria rigida</i>        |
| Hydrocharitaceae | <i>Blyxa aubertii</i>           |
| Hydrocharitaceae | <i>Blyxa octandra</i>           |

| Family           | Species                                    |
|------------------|--|
| Hydrocharitaceae | <i>Elodea bifoliata</i>                    |
| Hydrocharitaceae | <i>Halophila engelmannii</i>               |
| Hydrocharitaceae | <i>Hydrilla verticillata</i>               |
| Hydrocharitaceae | <i>Hydrocharis morsus-ranae</i>            |
| Hydrocharitaceae | <i>Limnobium spongia</i>                   |
| Hydrocharitaceae | <i>Ottelia alismoides</i>                  |
| Hydrocharitaceae | <i>Thalassia testudinum</i>                |
| Hydrocharitaceae | <i>Vallisneria americana</i>               |
| Potamogetonaceae | <i>Potamogeton amplifolius</i>             |
| Potamogetonaceae | <i>Potamogeton zosteriformis</i>           |
| Potamogetonaceae | <i>Potamogeton pusillus</i>                |
| Potamogetonaceae | <i>Potamogeton richardsonii</i>            |
| Potamogetonaceae | <i>Stuckenia pectinata</i>                 |
| Ceratophyllaceae | <i>Ceratophyllum demersum</i>              |
| Nymphaeaceae     | <i>Nuphar lutea</i> ssp. <i>polysepala</i> |
| Nymphaeaceae     | <i>Nymphaea odorata</i>                    |
| Polygonaceae     | <i>Polygonum amphibium</i>                 |
| Pontederiaceae   | <i>Heteranthera dubia</i>                  |
| Cyperaceae       | <i>Carex obnupta</i>                       |
| Cyperaceae       | <i>Schoenoplectus tabernaemontani</i>      |
| Cyperaceae       | <i>Schoenoplectus acutus</i>               |
| Poaceae          | <i>Glyceria borealis</i>                   |

# Literature Review

- 22 species recorded to develop on *Butomus*:
  - 8 Coleoptera, 5 Lepidoptera, 4 Diptera, 1 Hemiptera, 4 fungal pathogens
- 6 species recorded as monophagous on *Butomus*:
  - *Bagous nodulosus* (Col.: Curculionidae)
  - *Bagous validus* (Col.: Curculionidae)
  - *Donacia tomentosa* (Col.: Chrysomelidae)
  - *Phytoliriomyza ornata* (Dipt.: Agromyzidae)
  - *Hydrellia concolor* (Dipt.: Ephydriidae)
  - *Glyptotendipes viridis* (Dipt.: Chironomidae)



# Field Surveys: Challenges

- Flowering rush is relatively rare in Europe & grows in sensitive, often protected habitats
- The two *Bagous* species are on red lists & the *Donacia* species are listed as threatened & endangered
  - necessitates permission in most cases to visit habitats and survey plant



# Field Surveys: Herbivores Found

- Sites visited in 2013-2014: Germany, Czech Republic, Slovak Republic, Poland, Hungary, Switzerland

|                                |                |             |
|--------------------------------|----------------|-------------|
| <i>Bagous nodulosus</i>        | weevil         | monophagous |
| <i>Donacia tomentosa</i>       | leaf beetle    | monophagous |
| <i>Phytoliriomyza ornata</i>   | agromyzid fly  | monophagous |
| <i>Hydrellia concolor?</i>     | ephydrid fly   | monophagous |
| <i>Glyptotendipes viridis?</i> | Chironomid fly | monophagous |
| <i>Plusia festucae</i>         | noctuid moth   | polyphagous |
| Unknown moth                   |                |             |

ID of some insects still needs confirmation



# *Bagous nodulosus*

- Typical adult feeding damage facilitates confirming presence at field sites
- Found at many field sites in Germany, Hungary, Slovak Republic & Poland
- Established rearing with successful development from egg to adult
- Testing different rearing strategies to increase numbers



# *Bagous nodulosus* : Lifecycle & Damage

- Oviposition in May-July (timing appears site related)
- Larval develop in leaves & rhizomes between June-August
- Pupation in July/August
- Damage both through larval & adult feeding
- Overwintering as adult
- Specimens sent for molecular analysis



# *Bagous nodulosus*: Host-specificity Test

- Sequential no-choice adult feeding & oviposition test
- No oviposition on nontarget species
- Some adult feeding on nontarget species

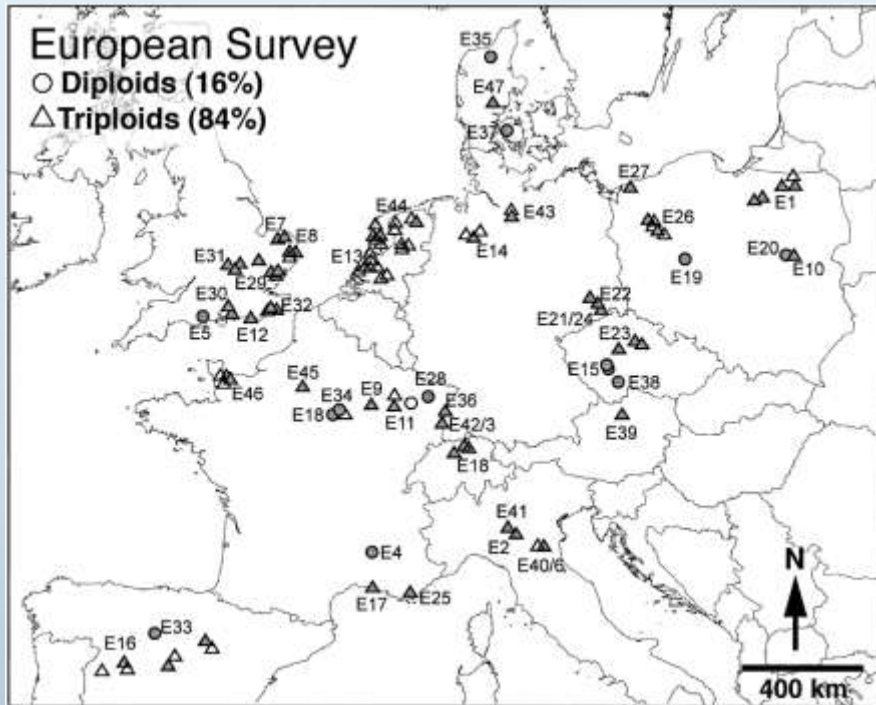
| Test plant species               | # replicates setup | # replicates valid | # eggs |
|----------------------------------|--------------------|--------------------|--------|
| <i>Alisma plantago-aquatica</i>  | 5                  | 3                  | 0      |
| <i>Elodea canadensis</i>         | 7                  | 4                  | 0      |
| <i>Elodea densa</i>              | 6                  | 5                  | 0      |
| <i>Hydrilla verticillata</i>     | 8                  | 5                  | 0      |
| <i>Miriophyllum spicatum</i>     | 5                  | 3                  | 0      |
| <i>Polygonum amphibium</i>       | 5                  | 3                  | 0      |
| <i>Schoenoplectus americanus</i> | 2                  | 1                  | 0      |
| <i>Sagittaria graminea</i>       | 6                  | 3                  | 0      |
| <i>Sagittaria latifolia</i>      | 5                  | 3                  | 0      |
| <i>Sagittaria platyphylla</i>    | 7                  | 6                  | 0      |
| <i>Butomus umbellatus</i>        | 399                |                    | 529    |

# *Phytoliriomyza ornata*

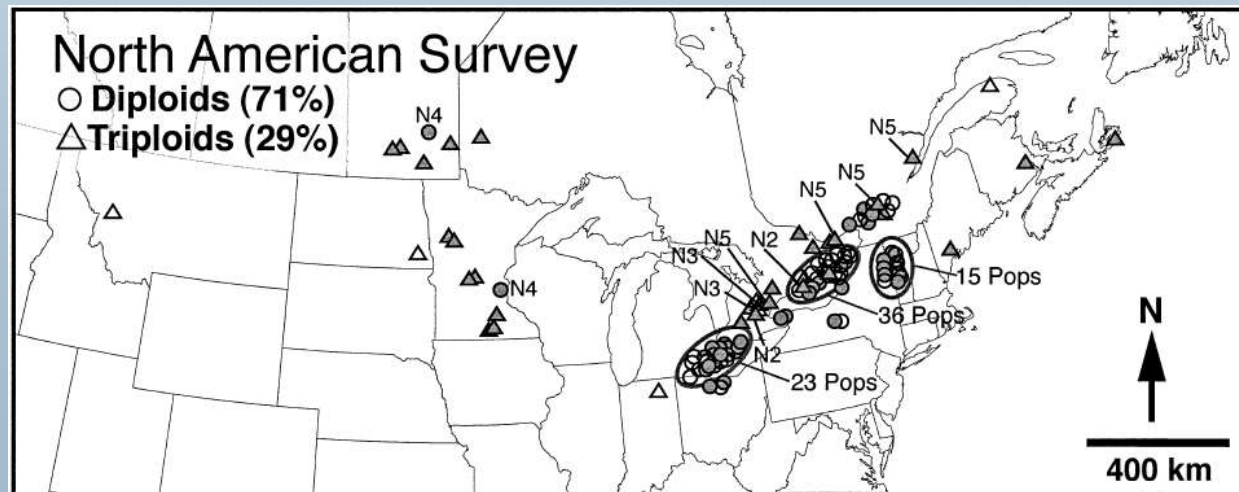
- Found at nearly all sites
- Larvae mine in leaves & flowering stems
- Pupation in July/August
- Less damaging than *Bagous nodulosus*
- Additional plants collected from Switzerland & Germany in 2014



# Flowering Rush: Molecular Analysis



- Original work conducted by Kliber and Eckert (2005)
- Diploids more common in eastern NA & triploid more common in western NA
- Ploidy type may influence biocontrol research



- Collecting samples for molecular analysis to confirm

# Future Work

- Continue obtaining test plant material for host-specificity testing
- Continue field surveys, rearing protocols, host-specificity tests in EU
- Finalize FR molecular analysis
- Research FR impact
- Pursue additional funding



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Shelton Navie



# Thank You

## Contact information:

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# Draft Test Plant List

- **42 test plant species selected**
- Category 1: genetic types of target weed species in North America
  - test at least most common genotype for both cytotypes
- Category 2: NA species in same genus
  - does not apply
- Category 3: NA species in other genera in same family
  - does not apply

# Draft Test Plant List

- Category 4: T&E species in same family as target weed divided by subgenus, genus & subfamily
  - does not apply but several species in closely related families (e.g. *Sagittaria* species), availability unclear
- Category 5: NA species in other families in same order that have some phylogenetic, morphological or biochemical similarities
  - 18 species
- Category 6: NA species in other orders that have some morphological/biochemical similarities
  - similarities unclear but approximately 15 species

# Draft Test Plant List

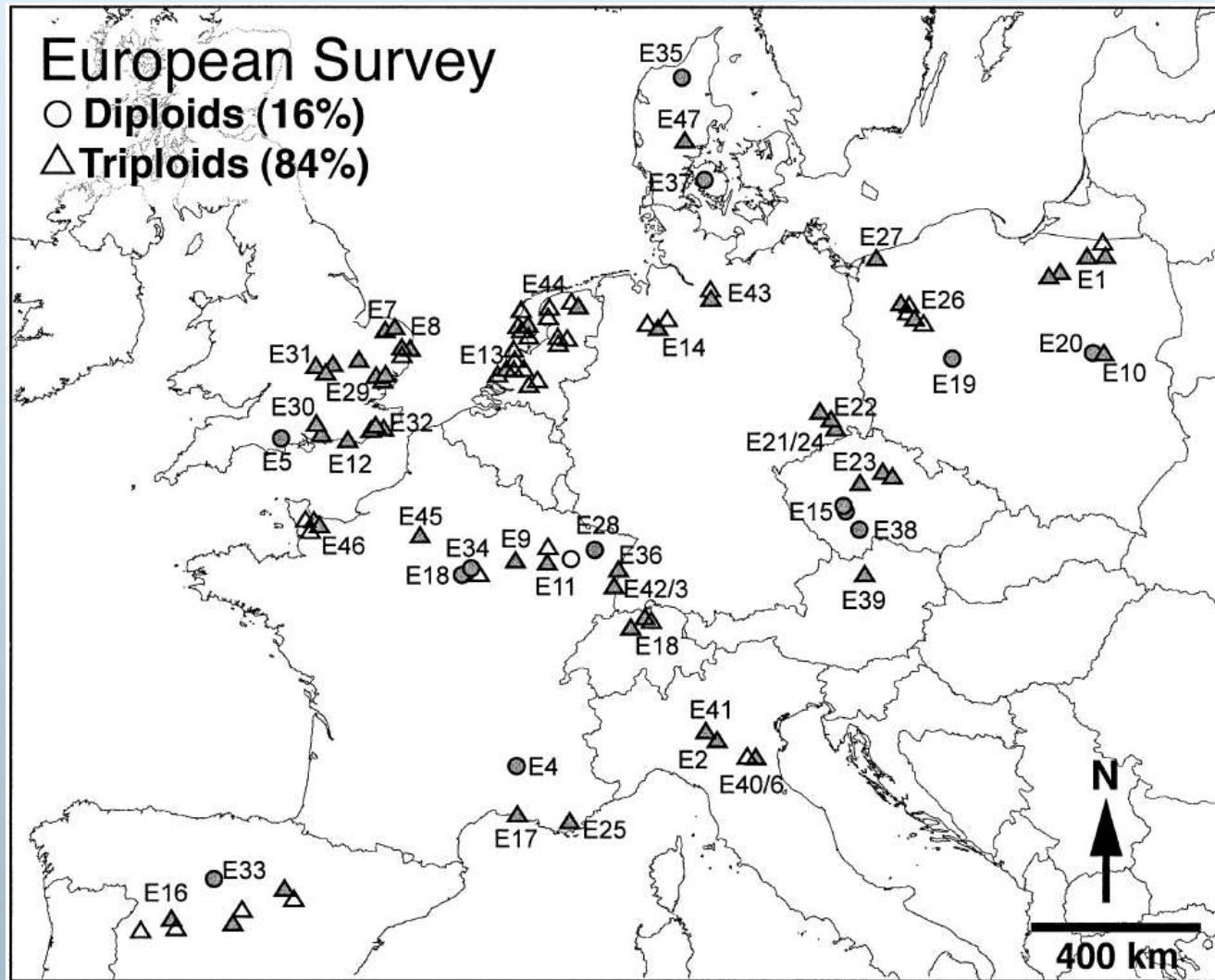
- Category 7: Any plant on which potential biocontrol agent or its close relatives (w/i same genus) have been previously found
  - not applicable for potential BCA
  - polyphagous *Bagous* sp. (including *Polygonum*, *Carex*, *Glyceria*) species in other genera in same family
  - 3 species
- Category 8: Plants in same habitat
  - not usually a category
  - 6 species

Diploids produce thousands of viable seeds and also reproduce by clonal bulbils formed on rhizomes and inflorescences

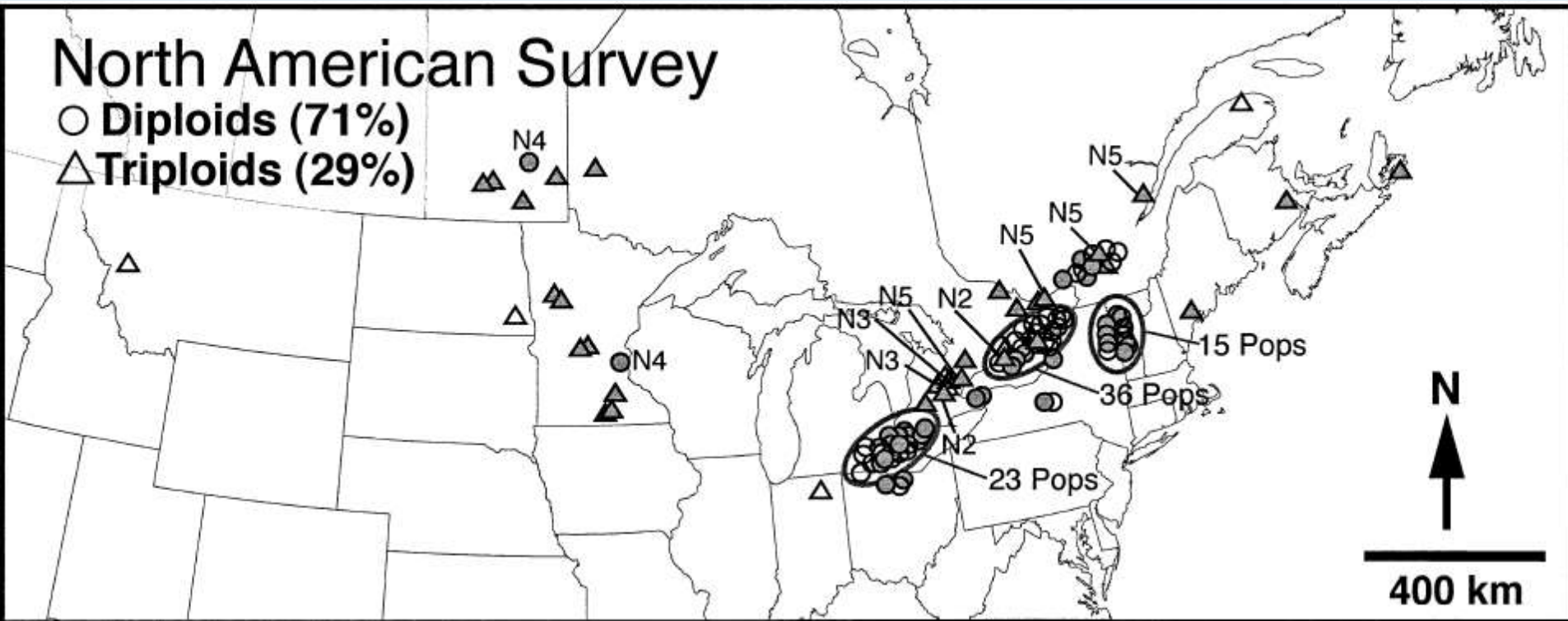
Triploids are sterile, hardly produce bulbils and mainly propagate by rhizome fragmentation

Diploids more common in eastern US;  
triploids more common in western US

Currently targeting mostly the triploids;  
rhizome feeders would be best

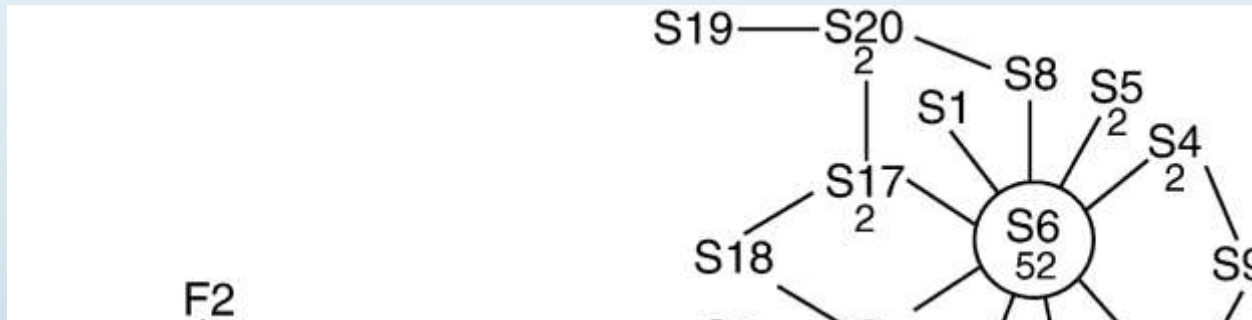


Kliber and Eckert (2005)



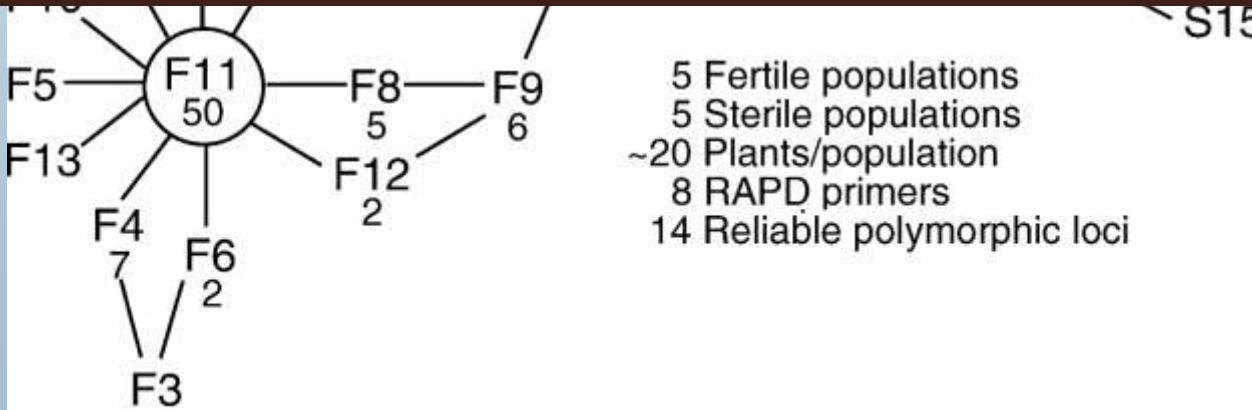
Kliber and Eckert (2005)

But see Poovey et al. 2012!



F2

Ideally obtain both dominant genotypes of each cytotype for host-specificity tests and impact studies with potential biocontrol agents



- 5 Fertile populations
- 5 Sterile populations
- ~20 Plants/population
- 8 RAPD primers
- 14 Reliable polymorphic loci



# *Hydrellia concolor*?

- Found at nearly all sites
- ID not confirmed yet
- Larval development mainly in leaves
- Damage not very obvious



# Funding

- Phase I – Biocontrol Project
  - literature search
  - field surveys
  - begin prioritizing potential biocontrol agent species
- Funding in 2013 (\$67,500)
  - Montana Noxious Weed Trust Fund (\$25,000)
  - Washington Department of Ecology (\$20,000)
  - Washington Department of Agriculture (\$20,000)
  - British Columbia, Ministry of Forest, Lands and Natural Resources Operations (FLNRO)

# Funding

- Phase II
  - determine biology
  - develop rearing techniques
  - begin host-specificity testing
- Funding in 2014: \$47,500
  - WA Department of Agriculture (\$20,000)
  - MT Noxious Weed Trust Fund (\$25,000), not confirmed
  - B.C. Ministry of Forest, Lands and Environment (\$2500)
- Shortfall of at least \$20,000, ideally \$80,000 total
  - Irrigation districts? State agencies? Utilities? Lake Associations?

# Plans for 2014

- Obtain test plant material
- Return to sites visited in 2013 and collect more *B. nodulosus* adults
- Extend surveys to Hungary and Serbia
- Improve rearing of *B. nodulosus* and try to establish rearing of *B. validus*
- Continue collecting data on biology and phenology of *B. nodulosus*
- Conduct first host-specificity tests with *B. nodulosus*
- Obtain information on impact of the two fly species



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