Quagga Mussel Risk Analysis for Arizona

Name
Quagga mussel (*Dreissena bugensis*)

Description
Quaggas are small freshwater bivalve mollusk, reaching sizes up to 4 centimeters. The quagga mussel has a rounded angle between the ventral and dorsal surfaces. (Benson, et al) Color patterns vary widely with black, cream or white bands, but can vary to the point of having only dark or light colored shells and no stripes. They are typically found attached to objects, surfaces or each other by byssal threads originating underneath the shells.

Life History
There are five stages in the life cycle of a quagga mussel. The first three stages are microscopic (egg, veliger, post-veliger) where they remain suspended in the water column for up to four weeks and can easily pass through filters and strainers. As the shell is developed they drop out of the water column (settling stage) and attach to both hard and soft surfaces. Adults have a tendency to aggregate and form massive colonies and can live for 3 to 5 years.

Reproductive Strategy
Quaggas have separate sexes with an equal ratio of male to female and become sexually mature when the reach 8 to 10 mm in length. Quaggas can produce up to 40,000 eggs per breeding cycle, with multiple breeding cycles every year and could produce up to one million eggs in a year.

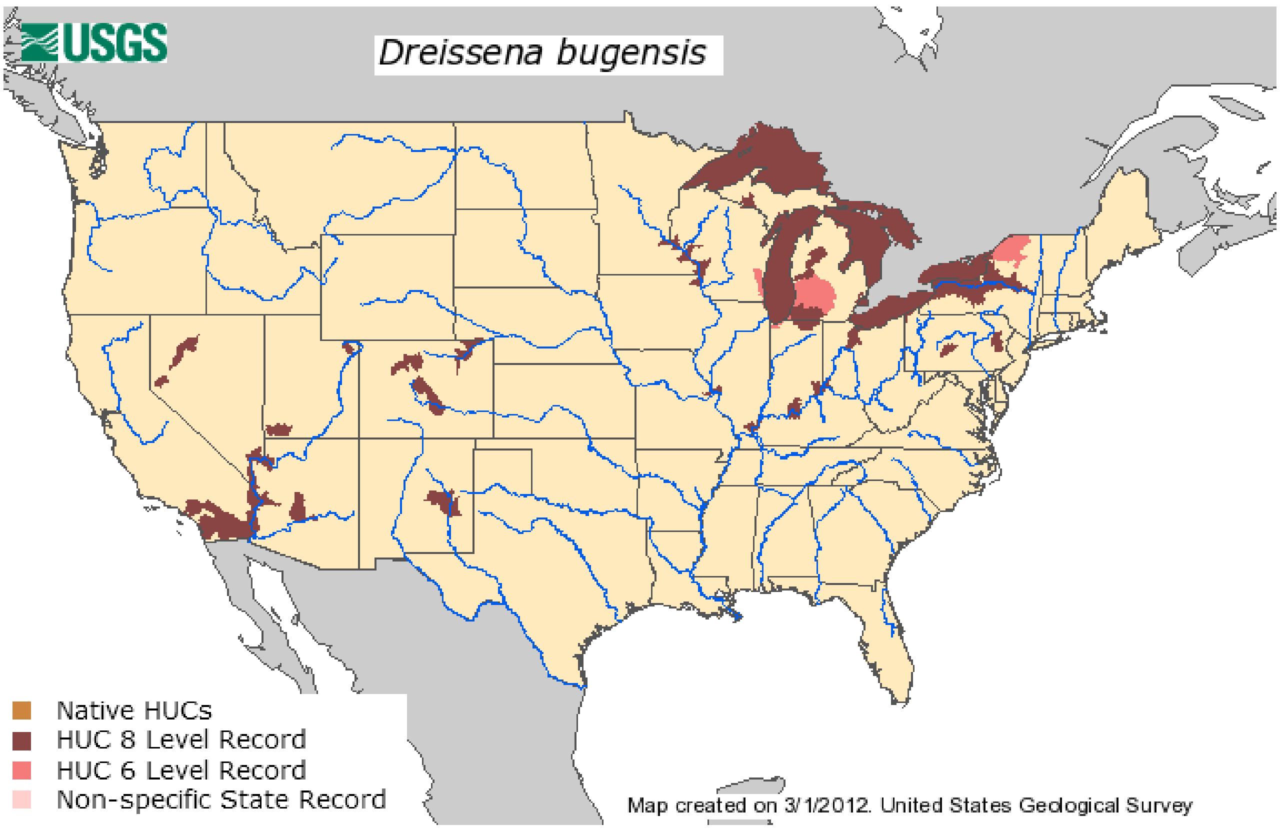
Environmental Tolerances and Restrictions
Quagga mussels can survive and reproduce in a wide range of habitats and environmental conditions. The great diversity of Arizona's habitats and water chemistries will result in different rates of invasion or establishment in some waters. However, phenotypic plasticity of the quagga will determine the ultimate extent of the invasion. It is clear that the genus *Dreissena* is highly polymorphic and has a high potential for rapid adaptation to extreme environmental conditions by the evolution of allelic frequencies and combinations, possibly leading to significant long-term impacts on North American waters (Mills et al. 1996). Based on current environmental tolerances of the quagga and using the most restrictive variable (calcium) the invasiveness (high, moderate, low, very low) of various waters in Arizona to quagga infestation is attached.

Preferred Habitat
Quaggas prefer no direct sunlight and are found in shaded areas in lakes, rivers and streams. In infected waters quaggas are easily found on undersides of boat hulls, docks, buoys, rock crevasses and have a particular fondness for concrete. Quagga mussels can inhabit depths of up to 400 feet.

Distribution
Native Range: Dneiper River drainage of Ukraine and Ponto-Caspian Sea (Eastern Europe).

Expanded Range in United States
Great Lakes, Mississippi and Ohio Rivers, Iowa, Kentucky, Michigan, New York, Ohio, Pennsylvania, California, Arizona, Nevada, Colorado (see map below).

Quagga distribution in the United States



Current Status in Arizona
Adult populations have been found in the Colorado River from Lake Mead downstream to the Mexican border, Central Arizona Project Canal and Lake Pleasant. Quagga are suspected in the Salt River Project canals downstream from Granite Reek Dam.

Pathways
Quagga mussels use passive methods for dispersal primarily during the pelagic state. Eggs, veligers and post-veligers are distributed in lake and stream currents for up to four weeks before settling. Adults attached to logs and floating debris are also carried on currents to new areas. Overland translocation is

accomplished through the movement of water and therefore eggs and veligers in live wells and bilges in boats. Adults can be transported great distances attached to boats and other equipment.

Potential Impacts
Wildlife/Habitat
Quaggas are prodigious water filterers (up to one liter/individual/day), removing substantial amounts of phytoplankton and suspended particulates, such as bacteria, protozoan, zebra mussel veligers, other microzooplankton and silt from the water. By removing the phytoplankton, quaggas in turn decrease the food source for zooplankton, therefore altering the food web and impacting fisheries. Impacts associated with the filtration of water include increases in water transparency, decreases in mean chlorophyll a concentrations, and accumulation of pseudofeces (Claxton et al. 1998). Water clarity increases light penetration causing a proliferation of aquatic plants that can change species dominance and alter the entire ecosystem. The pseudofeces that are produced from filtering the water accumulate and create a foul environment. As the waste particles decompose, oxygen is used up, and the pH becomes very acidic and toxic byproducts are produced. In addition, quagga mussels accumulate organic pollutants within their tissues to levels more than 300,000 times greater than concentrations in the environment and these pollutants are found in their pseudofeces, which can be passed up the food chain, therefore increasing wildlife exposure to organic pollutants (Snyder et al. 1997). Quaggas are able to colonize both hard and soft substrata so there are negative impacts on native freshwater mussels and invertebrates.

Infrastructure
Dreissena species ability to rapidly colonize hard surfaces causes serious economic problems. These major biofouling organisms can clog water intake structures, such as pipes and screens, therefore reducing pumping capabilities for power, agriculture and water treatment plants, affecting industries and communities. Recreation-based industries and activities have also been impacted; docks, breakwalls, buoys, boats, and beaches have all been heavily colonized.

Economic
Dreissena species (quagga and zebra mussels) have costs millions of dollars annually to control. In the United States, Congressional researchers estimated that zebra mussels alone cost the power industry $3.1 billion in the 1993-1999 period, with their impact on industries, businesses, and communities more than $5 billion.

Human Health
Broken shells are very sharp and have caused lacerations to swimmers and anglers.

Benefits
As quagga mussel density increases water clarification will also increase through biosdeposition of the suspended material. Quagga could also supply a high protein and high calcium food source for certain fish and wildlife (redear sunfish, *Lepomis microlophus* and razorback sucker, *Xyrauchen texanus*) and waterfowl.

Recommendation
Through Arizona Game and Fish Department Directors Order {A.R.S. §17-255.01(B)}, list quagga mussel (*Dreissena bugensis*) as an aquatic invasive species in Arizona, with subsequent affected waters listing and mandatory conditions for movement.

References

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Mills, E. L., G. Rosenberg, A. P. Spidle, M. Ludyanskiy, Y. Pligin, and B. May. 1996. A review of the biology and ecology of the quagga mussel (*Dreissena bugensis*), a second species of freshwater Dreissenid introduced to North America. Amer. Zool. 36:271-286.

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Benson, A.J., D. Raikow, J. Larson, and A. Fusaro. 2012. *Dreissena bugensis.*
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Arizona Waters

High Risk Based on Calcium Requirements for Dreissena
High >28 mg/l Ca

Site	Region	pH su	Cond umhos	Ca-total mg/l	Range	Number of samples
Agua Fria River	VI	8.43	610	65.5	63-68	2
Alamo Lake	IV	8.24	701	29.0	23 - 35	2
Alvord Lake	VI	8.19	1692	58.4	33 -115	4
Apache Lake	VI	8.19	1780	51.6	46 - 58	20
Arlington Wildlife Area Pond	VI	8.96	3025	96.0		1
Ash Creek	V		320	54.1		1
Babacamori River	V	7.48	448	55.6		1
Bartlett Lake	VI	8.71	646	41.2	30-46	4
Big Casa Blanca Canyon	V			28.9	27-31	2
Big Springs	II	8.50	350	39.3		1
Black Butte Well	VI	7.60		328.0		1
Boulder Creek	III	7.52	1123	105.6	18-212	5
BPH Artesian Lab Well	II	7.54	322	49.2		1
Brown's Fish Farm	V			44.9		1
Bubbling Ponds Hatchery	II	7.83	383	46.0	42-51	4
Buckeye Hills Catchment	VI			29.1		1
Canyon Lake	VI	8.13	1716	51.0	46-56	9
CAP Canal	III,IV,V,VI			73.9	70-78	2
Cave Creek	VI	8.48	0	48.0	40-73	5
Chaparral Lake	VI	8.57	550	41.8	42	1
Chase Creek	V	3.66	1400	96.5	56-138	8
Chevelon Creek	I	8.37	226	26.9	17-33	9
Cholla Lake	I	8.44	2554	130.8	90-217	16
Clear Creek Reservoir	I	7.89	1076	34.9	31-37	3
Cocio Wash	V	7.70	105	40.0		1
Colorado River	II,III,IV	8.27	1337	64.6	25-110	16
Coors Lake	III	7.48	375	31.5		1
Copper Creek	III	3.75		520.0		1
Desert West	VI	9.12	1151	34.7	25-45	8
Dripping Springs	V	8.08	748	87.3	84-99	3
East Clear Creek @ Kinder Xing	II	6.30		37.7		1
Encanto Park Lake	VI	8.43	961	46.3		1
Fain Lake	III	8.02	364	39.3	36-42	2
Fossil Creek	II	7.77	631	72.0	48-99	5
Gila River	IV,V,VI	7.95	2756	111.8	55-343	12
Gila River Pond	IV	7.78	5560	253.0		1
Gold Gulch @ Wier	V	8.95	1850	352.0		1
Granite Basin Lake	III	7.27	375	41.0		1
Green Valley Lake	V	8.70	762	46.4		1
Horseshoe Lake	VI	7.96	618	46.2	42-50	3
Hunter's Hole	IV			180.4	78-322	6

Jacques Marsh	I	8.69	606	33.0		1
Kearny Lake	V	8.06	4449	156.2	82-258	12
Lake Pleasant	VI	8.03	796	62.4	33-96	56

Arizona Waters

High Risk Based on Calcium Requirements for Dreissena

High >28 mg/l Ca

Lakeside Lake	V	7.70	445	27.8	24-31	2
Little Colorado River	I,II	8.08	1082	95.7	31-330	6
Lyman Lake	V	8.61	343	36.1	31-40	3
Lynx Creek	III	7.33	336	60.5	31-95	3
Lynx Lake	III	7.94	362	46.3	32-62	15
Martinez Lake	IV	7.48	1200	89.0		1
Mineral Creek	VI	8.20	965	90.9	66-120	7
Montezuma Tinaja	II	8.10	1350	124.0		1
Mormon Lake	II	8.00	257	28.6		1
Nelson Lake	I	8.51	326	31.2	25-34	6
Nutrioso Creek @ Correjo Xing	I	8.17	293	31.7	15-46	6
Oak Creek	II	8.29	277	38.7	37-44	5
Page Springs Hatchery	II	7.53	330	39.0	35-41	5
Painted Rock Borrow Pit	IV	8.06	5200	253.0		1
Paria River @ Utah Hwy 89	II			127.2		1
Paria River @ Lee's Ferry	II			47.1	36-58	2
Parker Canyon Lake	V	8.36	193	28.1	28	2
Patagonia Lake	V	8.32	700	89.0	89	1
Peck's Lake	II	8.82	550	37.3	27-46	5
Pena Blanca Wash	V		484	62.9	63	2
Phoenix 91 Avenue WWTP	VI	7.09	1337	71.2		1
Phoenix Zoo	VI			48.9	49	2
Pinal County Fairgrounds	V	7.99	2313	268.5	246-291	2
Pinery Canyon	V	8.07	1023	145.9	80-179	3
Pintail Lake	I	9.98	950	38.0		1
Pinto Creek	VI			219.2	99-339	2
Road Tank	II	7.96	775	30.4		1
Rock Creek	VI			60.7		1
Rocky Gulch	V	2.34	9760	117.6	22-213	2
Roosevelt Lake	VI	8.23	1497	55.7	31-218	52
Roper Lake	V	8.29	3324	33.7	11-75	16
Rudd Creek	I	8.08	347	37.4	17-79	6
Safford Park Lake	V	8.50	666	52.2		1
Saguaro Lake	VI	8.09	1419	48.0	44-54	16
Salt River	VI	8.02	1973	141.7	52-438	6
San Francisco River	V	8.52	465	55.1	35-86	5
San Pedro River	V	7.59	685	83.3	53-123	15
Silverbell Lake	V	8.73	1326	49.1	34-63	4
SRP Canal	VI	8.10	1216	49.8	46-53	3
Trout Creek Canyon wall	III			35.8		1
Trout Creek Pool	III	8.50		34.5		1
Verde River	III, VI	8.07	498	45.0	37-52	6
Water Ranch	VI	8.39	2762	107.6	91	2
Watson Lake	III	8.91	300	25.9	19-39	3

West Clear Creek	II	7.79	380	38.6	30-43	3

Arizona Waters

Moderate Risk Based on Calcium Requirements for Dreissena

Moderate 20-28 mg/l

Site	Region	pH su	Cond umhos	Ca-total mg/l	Range	Number of samples
Auger Creek	I	7.87	255	25.1	21-27	3
Benton Creek	I	7.67	193	20.1	15-24	3
Biscuit Tank	VI	8.05	425	23.5		1
Black Canyon Lake	I	8.26	164	23.3	9 - 36	15
Cluff Pond	VI	8.75	224	26.3	25-28	2
Concho Lake	I	9.11	228	20.1	17-26	7
Granite Creek	III	8.50	404	26.4		1
Kennedy Lake	VI	9.02	554	16.6	11-27	3
Kiwanis Lake	VI	8.63		22.5	20-25	2
Long Lake	II	8.58	211	19.8	18-26	4
Lower Lake Mary	II	8.46	105	11.7	11-28	2
Luna Lake	I	8.56	235	23.9	16-28	9
McKay Reservoir	I	9.40	117	17.9	11-25	2
Rainbow Lake	I	8.89	255	22.4	14-34	9
Show Low Creek	I	8.13	195	19.1	12-29	9
South Fork Little Colorado River	I	8.15	90	20.2		1
Stoneman Lake	II	9.78	283	20.6	15-26	3
Woodland Lake	I	8.71	217	22.8	18-29	7

Arizona Waters

Low Risk Based on Calcium Requirements for Dreissena

Low 12-20 mg/l

Site	Region	pH su	Cond umhos	Ca-total mg/l	Range	Number of samples
BASF	VI		525	16.9		1
Billy Creek	I	8.06	169	15.7	15-16	3
Boneyard Bog	I	8.16	166	13.6	12-16	12
Cambell Blue	I	8.56	208	14.7	11-19	2
Canyon Creek Hatchery	VI	7.23	116	14.3	14	2
Carnero Lake	I	9.27	147	12.5	10-16	4
Colter Creek	I	7.73	134	13.4	13-16	3
Concho Creek above Concho Lake	I	8.43	190	15.2		1
Coyote Creek	I	8.26	108	13.5	8-19	2
Cresent Lake	I	9.14	123	11.6	10-13	17
Dankworth Pond	V	7.80	2087	19.1	19	2
Marshall Lake	II	9.50	115	12.7	12-13	2
Milk Creek	I	8.00	132	14.1		1
Mud Springs	II	7.68	1748	16.6	7-22	4
North Canyon Creek	II	8.50	320	0.1		1
Paddy Creek @ Nutrioso confluence	I	8.00	157	17.7	15-23	3
Pena Blanca Lake	V	7.31	163	19.0	17-21	5
Pinetop Hatchery	I	7.30	167	16.4		1
Porter Creek	I	8.31	138	12.3	9-15	3
Russel Tank	II	9.15	144	13.8	12-16	2
Scotts Reservoir	I	8.30	110	11.1	8-14	2
Show Low Lake	I	7.51	115	12.9	12-14	3
Smith Spring Pond	V	7.35	4968	18.9		1
Walnut Creek	I	8.21	209	19.3	18-20	3
Wolf Creek	III	8.25	110	14.7		1

Arizona Waters

Low Risk Based on Calcium Requirements for Dreissena
Verylow <12 mg/l

Site	Region	pH su	Cond umhos	Ca-total mg/l	Range	Number of samples
Ashurst Lake	II	8.30	74	5.5	3-10	3
Big Lake	I	7.30	97	11.1	10-13	9
Blue Ridge Reservoir	II	9.91	91	9.6		1
Bunch Reservoir	I	7.66	90	9.2	8-10	3
Burro Creek	III	7.98	72	7.1	6-8	3
Castle Creek	VI	7.71	170	8.5	5-12	2
Coconino Reservoir	II	8.70	0	2.4		1
Coleman Creek	I	8.00	72	8.9	6-12	2
Grant Creek	I	7.69	80	6.8	4-9	2
Hall Creek	I	7.29	58	4.7	3-6	2
Hart Creek @ Vincent Ranch	I	7.60	43	4.7		1
Hassayampa Creek @ Senator Mine	III	7.20	103	7.7	7-9	2
Hassayampa Lake	III	7.58	158	9.2		1
Horesthief Basin	VI	6.88	82	8.2	7-10	2
JD Dam Lake	II	8.28	66	7.1	4-9	5
Kinickinnick Lake	II	7.80	66	3.8	2-8	3
KP Creek	I	7.87	106	7.8	8	2
Lee Valley Lake	I	7.95	41	4.0	3-7	13
Montezuma Tank	II	9.70	880	7.8		1
North Canyon Creek	II	8.50	320	0.1		1
Perkins Tank	II	7.22	100	9.2		1
River Reservoir	I	8.46	74	7.6	7-8	3
Rose Canyon Lake	IV	6.90	71	10.1		1
Ruker Canyon Lake	IV	7.45	65	5.8		1
Sabino Creek	IV	7.51	101	10.2		1
Santa Fe Lake	II	8.26	60	5.6		1
Silver Creek	I	8.23	141	11.4	11-12	15
Soldiers	II	7.87	68	8.7		1
Tonto Creek Hatchery	VI	7.19	76	10.0	9-11	2
Tunnel Reservoir	I	7.40	87	9.1	7-11	3
West Fork Little Colorado River	I	7.67	51	5.1	4-6	4
White Horse Lake	II	8.04	71	8.8	7-10	2
Willow Creek	I	8.05	52	6.2	4-8	3
Willow Springs Creek below Dam	I	7.05	26	2.4	2-3	3
Willow Springs Lake	I	7.83	34	3.4	3-4	4
Woods Canyon Lake	I	7.26	28	3.8	2-6	17
Woods Canyon Creek below Dam	I	7.39	65	9.7	7-15	3