— * - comment on critical habitat
Little Colo. spinedace.
* - date - 90 days -

* Oct. rept. - put end. sp. info
re. information retrieval to Documaster

Gap Crk. } Site Recs Plan
* - Interrogatories (Discovery) -
keep 'ear to ground' - types fish - squat bal. issues to be raised.

— Rice - model
— Res. operation
— Coop. - Ariz. G & F

- A.G.&F. - notify c/c S.R.P. all comment re. E. & T. sp. -

name Nongame 'dummy'
- latest update ?!

FWS 60
Thu - Grad. level.
Oct. 24 - Aut. def.
- oral rept - take home
- Problem E.
- Ethos - self - credibility
- Pathos - sympt. - audience
- Logos - ratio...

difference in ... committee
"I don't know"

reservoir
impact critical habitat

— Congress - grazing fee formula
— Com. set ≥ 300 million acre public lands - by Public Rangeland Improvement Act of 1978 expires Dec. 31, 1985
— current compromise retain current low fees but create protected riparian zones and allow designation of areas "not suitable for grazing" - vigorously fought by states ...
— survival of western ...

— Livestock Grazing
— Savory (Ariz.) System
* increase AUM
- 100% veg. cover.
"Res. Mgt."
"Holistic"

- T. & E. sp.
- location
- crit. habitat
- Exp. Pop. - Warden's statement

- Indian reservoirs
- loach minnow.
may be Endrin ... End. Sp. problem.

Basic Problem
— small, compartmentalized minds - Power in hands of those small ... - timber, grazing, mining, road builders ... fishery - wilderness values viewed as "constraints" of more "desirable" product production on Fed. lands

[Aug 1985]

travel - 138 -
motel - 102.66
food - 40 -

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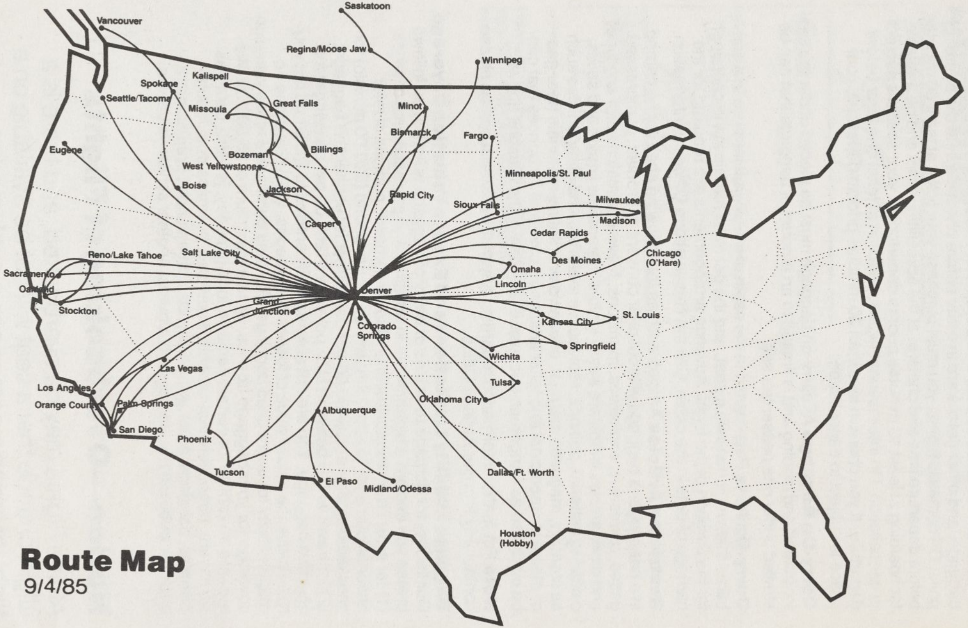

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X	TO PHOENIX	FL	57	K	6FEB	800P	OK				
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PHOENIX	DENVER	FRONTIER	268K	7FEB	710P	843P	OK
			DINNER				
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PHOENIX	DENVER	FRONTIER	36Q	1FEB	1027A	1200N	OK
DENVER	FT COLLINS	FRONTIER	924Q	1FEB	1230P	145P	OK

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DENVER	PHOENIX	FRONTIER	51Y	29JAN	447P	629P	OK
			SNACK				
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COLLEGE OF FORESTRY AND NATURAL RESOURCES

Executive Committee Meeting

A meeting of the Executive Committee of the College of Forestry and Natural Resources was held on Monday, January 27, 1986, at 10:15 a.m. in Room 100 NR Building. Present were R. Cook, D. Crews, D. Doehring, A. Dyer, B. Held, and R. Woodmansee. Dean Hughes presided.

HONOR FACULTY AND STUDENT SELECTION: Don Crews announced that the nominations for the outstanding faculty member, either assistant or associate professor, and the outstanding undergraduate student has to be in his hands by Friday, January 31, 1986. The nominees for outstanding faculty member were reviewed and selected. Each Department having a nominee for outstanding undergraduate student should get them to Don by Friday. They will be reviewed and selected at the February 3 Executive Committee meeting.

REVIEW STATUS OF GUIDES FOR PROMOTION AND TENURE: The response from faculty members to the Dean was discussed. Dean Hughes stated we did need to make sure the faculty understood that we would use the ideas in the document during the process this year. The document was carefully reviewed. The Dean will again review changes from the Department Heads. They will be discussed at the next Executive Committee Meeting and the document will then be finalized.

PROMOTION AND TENURE SCHEDULE: Each Department needs to have the documents in proper form by our next meeting. They are responsible for 8 copies needed for review. The decisions have to be made by the 10th as they need to be in the Academic Vice President's office by the 15th of February. A question was raised concerning the request for sabbatical leaves: do they follow the same process? Jay responded that those are handled by the Departments, not through the Executive Committee.

OTHER: Don Doehring announced that he had received information that was in error concerning the software he wanted to use on the Computers in the Learning Lab. He now believes it will work on the machines. Dr. Held also stated that his questions concerning the software his Department needed have been satisfactorily handled.

The Dean informed the Committee that Corrine will be contacting each Department to set up review meetings for the status of all 1-3 funds. The effect of an additional recision on our College was discussed.

Don Crews reminded the attendees of the information he distributed concerning Dean Jaros' request for a rewrite of the information concerning each department's graduate student programs. He needs this information by this Friday, January 31th.

The meeting was adjourned.

Respectfully submitted,

Corrine Johnson

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July 30, 1985

Dr. Robert Behnke
Department of Fishery and Wildlife Biology
Colorado State University
Fort Collins, CO 80523

Dear Bob:

In response to your letter of July 13, 1985, I am enclosing a report entitled Factors Affecting the Success of Gila Topminnow (Poeciliopsis o. occidentalis) Introductions on Four Arizona National Forest.

Sincerely yours,

Gerald Burton

Gerald Burton
Endangered Species Biologist

Enclosure

FACTORS AFFECTING THE SUCCESS OF GILA TOPMINNOW (*Poeciliopsis o. occidentalis*) INTRODUCTIONS ON FOUR ARIZONA NATIONAL FORESTS

Prepared for:

Office of Endangered Species
U.S. Fish and Wildlife Service
Post Office Box 1306
Albuquerque, New Mexico 87103

Prepared by:

James E. Brooks, Nongame Biologist
Arizona Game and Fish Department
2222 West Greenway Road
Phoenix, Arizona 85023

Acknowledgments

This study was funded through the Office of Endangered species, U.S. Fish and Wildlife Service, Albuquerque to the Arizona Game and Fish Department. Personnel involved in field work were numerous but involved primarily Phil Hines, AGF and Ken Byford, USFS. Their time and efforts are appreciated as is that of the Wildlife Managers in whose districts this study was conducted. Larry Riley assisted in statistical analysis and Ruth Patterson performed all word processing. This report was improved through reviews by Terry B. Johnson, Larry Riley, Bill Silvey, Jerry Burton, Paul C. Marsh and W. L. Minckley.

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INTRODUCTION

This report summarizes data collected under U.S. Fish & Wildlife Service (FWS) contract No. 14-16-0002-82-216 for monitoring Sonoran topminnow (Gila subspecies, *Poeciliopsis o. occidentalis*) introduction sites on U.S. Forest Service (FS) lands. Endangered Gila topminnow were introduced into selected waters on four National Forests in Arizona under the auspices of a tripartite Memorandum of Understanding (MOU) between the FWS, FS and Arizona Game & Fish Department (AGF).

Selection of introduction sites was based upon qualitative assessments of habitats utilized by naturally occurring Gila topminnow populations. The site selection criteria were developed by FS biologists to assist non-fishery related field personnel in the selection process. As such, the criteria pertained primarily to abiotic factors (i.e., physical size, flow, depth, perennial water source, temperature, elevation, flooding, stream barriers, access). One biological criterion (presence of predator/competitor) was included.

Monitoring of introductions was the responsibility of the AGF as specified in the MOU and in a Management Plan outlining this recovery effort. Monitoring included assessment of both habitat and topminnow populations, including collection and identification of Gila topminnows.

This is the first annual report detailing status of introduced Gila topminnow populations. Site selection criteria presented here will be further refined into an ecosystem approach to identify suitable introduction sites. Included is an initial set of refined site selection criteria, based upon information gained during first year of recovery, a literature review of Gila topminnow habitat, and field observations of introduced and naturally occurring topminnow populations.

METHODS

Stocking

Sixty-four sites on four Arizona National Forests were stocked with Gila topminnows from 17 May through 16 June 1982 (Table I). Gila topminnow from the Boyce Thompson Arboretum pond, Pinal County (original genetic stock from Monkey Springs, Santa Cruz County) and Dexter National Fish Hatchery, FWS, Dexter, New Mexico (transplanted from the Arboretum pond) were utilized. Twenty-four additional introductions of Gila topminnow from the Arboretum pond were conducted during 1983. These sites, stocked from 1 June through 28 June 1983 (Table II), are not included in the data analyses elsewhere in this report.

Monitoring

Fifty-eight 1982 introduction sites were monitored during June and July, 1983. An introduction was considered successful if topminnow were identified at the site and unsuccessful if none was collected or observed. Six sites were not monitored and thus are of unknown status.

Table I. Gila topminnow introduction sites stocked during 1982 (Unn = un-named).

Site	Latitude			Longitude			Date Stocked	Number Stocked	Source
Holly Spring	34	45	35	111	50	00	17 May	200	Arboretum
Sheepshead Spring	34	44	27	111	55	40	17 May	200	Arboretum
Deep Spring	34	22	10	111	39	55	17 May	200	Arboretum
Chalk Tank	34	23	20	111	42	03	18 May	1,000	Arboretum
The Lake	32	19	35	110	37	15	14 June	200	Dexter NFH
Alambre Tank	32	18	08	110	36	20	14 June	200	Dexter NFH
White Tank	32	18	02	110	34	35	14 June	200	Dexter NFH
Yellowstone	32	17	25	110	38	00	14 June	200	Dexter NFH
Canada del Oro	32	33	15	110	42	15	15 June	2,000	Arboretum
Sabino Canyon	32	20	30	110	46	50	14 June	2,000	Arboretum
Buehman Canyon	32	25	05	110	32	00	16 June	2,000	Arboretum
Bear Canyon	31	22	50	110	21	45	17 June	2,000	Arboretum
El Pilar	31	40	36	110	45	50	17 June	2,000	Arboretum
Romero Canyon	32	24	00	110	51	00	15 June	2,000	Arboretum
Mansfield	31	37	10	110	49	53	17 June	2,000	Arboretum
Johnson's Wash Spring	34	32	58	112	02	25	18 May	200	Arboretum
Government Spring	34	27	40	112	01	45	17 May	500	Arboretum
Cedar Spring	34	29	45	112	00	15	17 May	200	Arboretum
Sheep Spring	34	28	35	112	02	05	17 May	200	Arboretum
Monkey Tank	34	26	10	111	47	40	18 May	1,000	Arboretum
Montezuma Tank	34	38	05	112	01	20	18 May	2,000	Arboretum

Table I Continued.

Site	Latitude			Longitude			Date Stocked	Number Stocked	Source
Ox Bow Spring	34	42	10	112	03	50	18 May	500	Arboretum
Hull Spring	34	35	25	111	57	42	18 May	500	Arboretum
Squawpeak Spring	34	30	30	111	50	35	18 May	200	Arboretum
Copper Canyon	34	36	33	111	55	00	18 May	2,000	Arboretum
Fig Spring	33	55	20	111	38	10	10 June	400	Arboretum
Unn Spring (5N 7E 24)	33	46	05	111	35	20	9 June	200	Arboretum
T. T. Spring	34	10	54	111	47	25	9 June	200	Arboretum
Unn Spring (9-1/2N 5E 24)	34	11	25	111	47	30	9 June	200	Arboretum
Frog Spring	34	08	28	111	46	50	9 June	200	Arboretum
Rock Spring	33	45	52	111	36	05	9 June	200	Arboretum
Lime Cabin Spring	34	01	10	111	47	50	10 June	400	Arboretum
Unn Spring Stream (5N 7E 32)	33	44	15	111	34	35	9 June	200	Arboretum
Unn Spring (10N 5E 34)	34	11	50	111	48	45	9 June	200	Arboretum
Blue Mtn. Spring	33	50	46	111	42	22	10 June	200	Arboretum
McCann Spring Tank	33	44	47	111	35	49	9 June	200	Arboretum
White Rock Spring	34	07	55	111	47	20	9 June	200	Arboretum
Horse Creek	34	03	35	111	40	45	10 June	400	Arboretum
Spring Fed Tank (5N 13E 31)	33	44	03	111	03	49	10 June	200	Arboretum

Table I Continued.

Site	Latitude			Longitude			Date Stocked	Number Stocked	Source
Artesian Well	33	44	08	111	00	27	10 June	200	Arboretum
Artesian Well #3	33	52	52	111	15	10	8 June	200	Arboretum
Artesian Well #4	33	52	50	111	15	05	8 June	200	Arboretum
Corner Artesian	33	50	50	111	15	25	8 June	200	Arboretum
Kayler Spring	33	56	35	111	18	05	4 June	200	Arboretum
Unn Spring Tank #498	33	48	40	111	18	30	8 June	200	Arboretum
Reed Spring	33	59	20	111	19	42	4 June	200	Arboretum
Buckhorn Spring	33	39	33	111	13	13	4 June	200	Arboretum
Packard Spring	33	51	30	111	21	00	8 June	200	Arboretum
Mesquite Flat Spring	33	49	03	111	19	03	8 June	200	Arboretum
Tucker Box	33	46	05	111	02	35	10 June	600	Arboretum
Cottonwood Creek	33	37	50	111	08	15	3 June	800	Arboretum
Unn Spring Dr. (4N 11E 2)	33	42	49	111	12	23	3 June	200	Arboretum
Indian Spring	33	35	17	111	16	45	11 June	500	Arboretum
Little Mud Spring	33	35	38	110	48	07	3 June	1,000	Arboretum
Grapevine Spring	33	37	15	110	46	30	3 June	200	Arboretum
Happy Camp Spring	33	18	34	111	08	24	3 June	400	Arboretum
Chalky Butte Well Tank	33	33	31	110	38	28	3 June	1,000	Arboretum
Little Nob Well	33	33	24	110	38	53	3 June	1,000	Arboretum
Walnut Spring	33	53	51	111	31	18	4 June	1,000	Arboretum
Mesquite Tank	33	32	31	111	22	50	3 June	1,000	Arboretum

Table I Continued.

Site	Latitude	Longitude	Date Stocked	Number Stocked	Source
Unn Tank (6N 9E 21)	33 51 20	111 26 45	4 June	600	Arboretum
Mud Spring	33 44 55	111 29 20	9 June	200	Arboretum
Unn Spring (6N 9E 21)	33 51 20	111 26 58	4 June	200	Arboretum
Unn Spring Fed Tank (6N 9E 21)	33 51 20	111 26 35	4 June	300	Arboretum

Table II. Gila topminnow introduction sites stocked during 1983 (Unn = un-named).

Site	Latitude			Longitude			Date Stocked	Number Stocked	Source
Middle Mesa Tank	34	19	34	112	12	39	1 June	1,000	Arboretum
White Tank	34	18	21	112	13	03	1 June	1,000	Arboretum
Unn Spring (11N 1E 2)	34	18	51	112	12	53	1 June	200	Arboretum
Lower Mine Spring	34	29	03	111	51	07	1 June	200	Arboretum
Unn Spring Pond (15N 3E 16)	34	41	22	112	02	09	1 June	200	Arboretum
Copper Canyon[1]	34	32	08	111	54	38	1 June	100	Arboretum
Pilot Tank	33	18	25	111	10	53	1 June	1,000	Arboretum
Mesquite Tank	33	24	30	111	11	45	1 June	1,000	Arboretum
Rock Springs	33	36	50	110	36	30	1 June	200	Arboretum
Indian Spring	34	14	00	112	27	50	1 June	200	Arboretum
Bain Spring	34	14	39	112	30	12	1 June	500	Arboretum
Campbell Flat Spring	34	10	58	112	30	58	1 June	200	Arboretum
Charlebois Spring	33	27	05	111	20	32	2 June	200	Arboretum
Rock Tank Spring	33	54	45	111	54	45	2 June	200	Arboretum
Mud Spring Tank	34	11	13	111	51	48	2 June	1,000	Arboretum
Unn Spring Dr. (9-1/2N 5E 32)	34	09	45	111	52	15	2 June	500	Arboretum

[1]Restocked from 1982.

Table II Continued.

Site	Latitude	Longitude	Date Stocked	Number Stocked	Source
Bronco Canyon Spring Tank	33 55 45	111 51 15	24 August	1,000	Arboretum
Unn Spring (7N 10E 4 and 5)	33 59 00	111 20 45	3 June	200	Arboretum
Upper Horrel Spring	33 31 27	111 05 15	3 June	200	Arboretum
Thicket Spring	34 11 46	111 48 18	3 June	1,000	Arboretum
2 Mile Spring	34 05 17	111 44 13	3 June	200	Arboretum
Dutchman's Grave Spring	34 06 56	111 38 32	3 June	1,000	Arboretum
Bench Well	34 11 14	112 13 23	28 June	100	Arboretum

Qualitative assessments were made for cover availability (4 categories), substrate (5 categories) and habitat types (5 categories) at each introduction site (Table III). Substrate was classified according to Herrington & Dunham (1967) with additions of concrete (trough) and metal (stock waterer) substrate types. Dissolved oxygen, pH, temperature and conductivity were measured at 50 sites. Drainage area and elevation for each site were from USGS topographical maps. Topminnow population size was visually estimated for successful introductions.

Discriminant Analysis

Linear discriminant analysis was used to identify factors contributing to the success of an introduction. A stepwise analysis was used that incorporated variables one at a time on the basis of their discriminating power (Klecka, 1975). This method formulates a reduced set of variables that explains most variance as well or better than the full set. A classification table was constructed to identify the suitability or unsuitability of a potential introduction site. The program used habitat parameters of 50 sites to develop the discriminant function, which was then used to classify those sites as successful or unsuccessful.

RESULTS

Thirty-one (48.4%) sites monitored in June-July 1983 were classified as successful (Fig. 1). Unsuccessful sites numbered twenty-seven (42.2%) and six (9.4%) were not monitored (unknown).

Unevaluated sites included Romero Canyon and Mansfield Tank (Coronado National Forest) and McCann Spring Tank and Mesquite Flat Spring (Tonto National Forest). One site, Copper Canyon (Prescott National Forest), was surveyed and restocked during 1983 in a stream section with perennial flow since the initial plant was in a reach that proved not to be perennial. Kayler Spring (Tonto National Forest) was also surveyed but no topminnow were collected for taxonomic verification. Kayler maintained a population of *Gambusia affinis* at the time of the original topminnow stocking, and it is possible that observed fish were the former species. Mesquite Spring Stream (Tonto National Forest) was not surveyed due to site misidentification. It was thought unsuccessful, but a recent survey by Pollock (1984) indicated that it held topminnow. Mesquite Spring Stream is included in the total number of successful sites but not in 1983 habitat analyses.

Habitat

Five basic habitat types describe the introduction sites: 1) spring fed or overland flow fed pond, 2) spring fed trough, 3) artesian well fed habitat (marsh/pond), 4) spring stream and 5) stream (spring and runoff fed). Seven introduction sites were

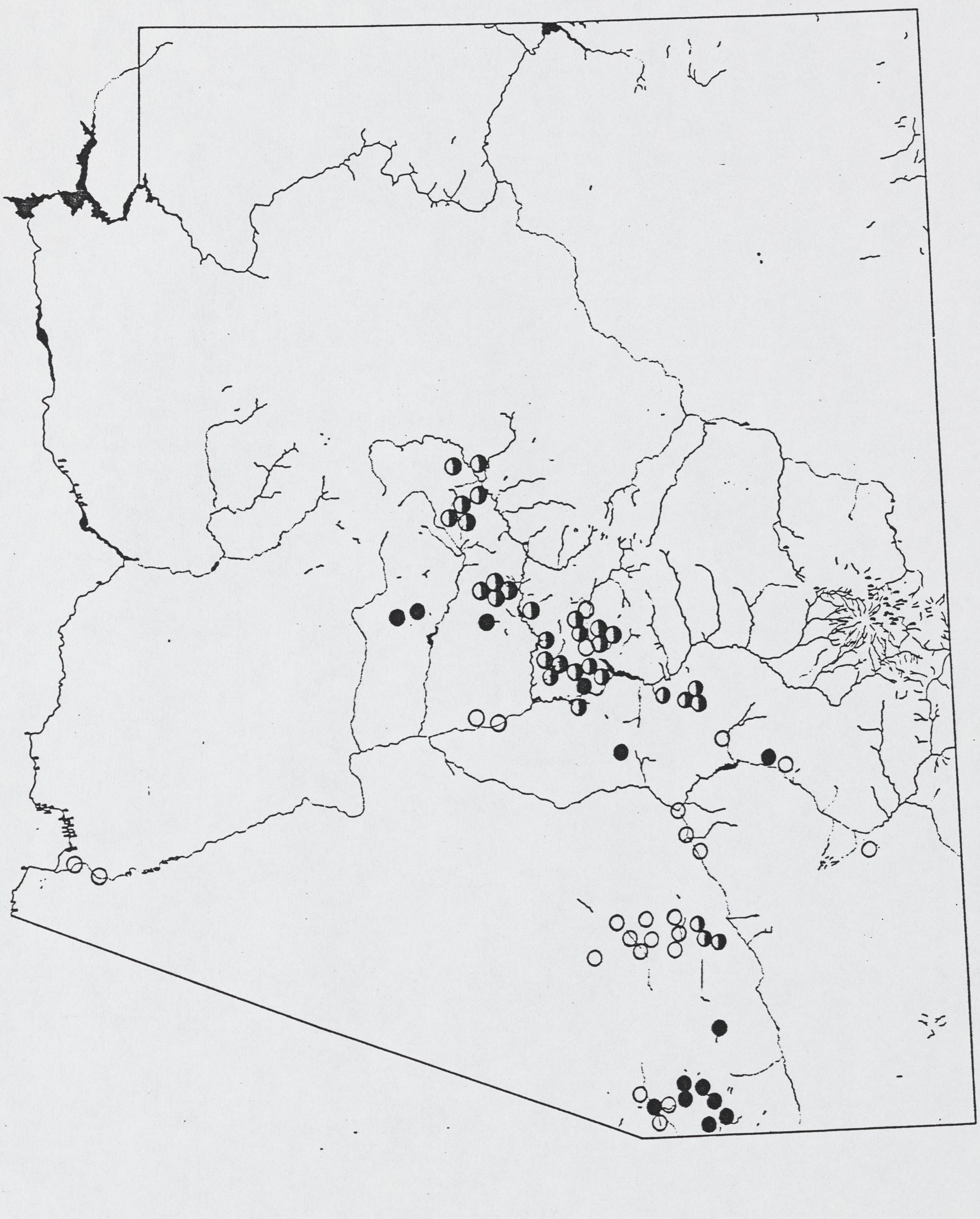

Fig. 1. Historic (open circles), existing (solid circles) and 1982 (half circles) Gila topminnow populations in Arizona.

not included due to desiccation at the time of monitoring (Table III). Success of introductions into each habitat type is shown in Table IV.

Spring streams, the most common habitat stocked, represented 26.0% of the total number of sites analyzed (Fig. 2). Of these sites, 65.0% were successful introductions. Seventeen spring fed or runoff fed tanks were stocked and twelve (70.6%) were successful. Nine streams and three artesian well fed sites had success rates of 22.2% (2 sites) and 100%, respectively.

Cover

Introduction success differed between the four general cover types present at the 50 successful stocking sites (Table V). Of the 32 sites classified as aquatic plant habitat types, 23 (71.8%) were successful. Success rates decreased for each of the less common cover types, from 50.0% (1 of 2 sites) for terrestrial vegetation to 44.4% (4 of 9 sites) for the abiotic cover type to 14.3% (2 of 7 sites) for sites with no cover available.

Substrate

Substrate types dominating the 50 introduction sites were silt, sand, gravel, bedrock, concrete (stock watering trough) and metal (above ground stock tank). Introduction success varied according to substrate type (Table VI). Success rate was highest for sites with a silt substrate (65.2%). Sites with sand, bedrock and gravel were similarly successful with rates of 61.5%, 60.0% and 50%, respectively. The two sites with concrete or metal substrate both failed.

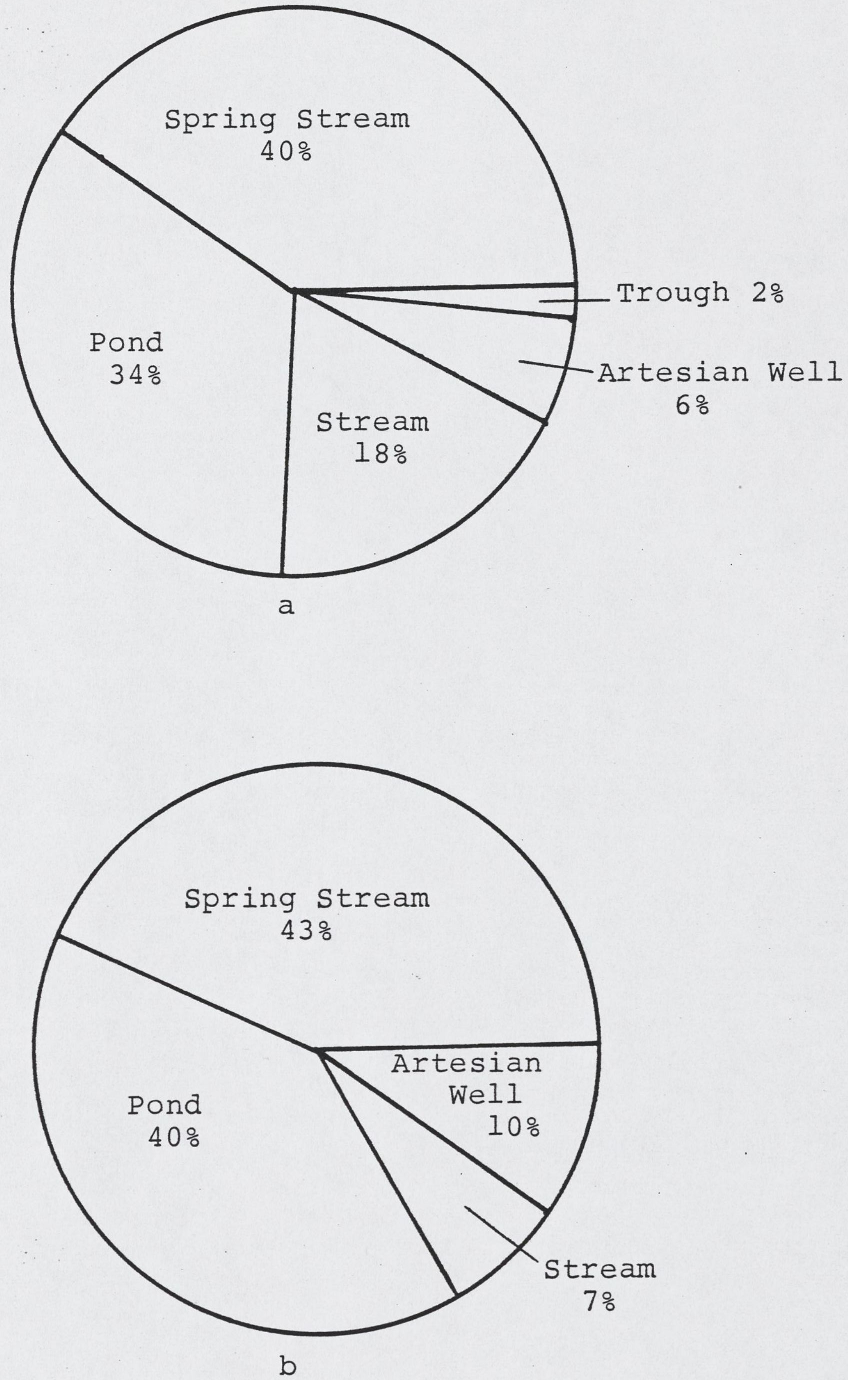

Fig. 2. Relative composition (a, n = 50) and success rate (b, n = 30) for sites stocked with Gila topminnow in 1982.

Table III. Status and habitat determinations for each introduction site stocked with Gila topminnow in 1982.

Site	Latilong 0 ' "	Drainage Area km² (mi²)	Elevation m (ft)	Habitat Type[1]	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. °C	Cond. umho/cm	Status[4]	Population Size
Holly Spring	34 45 33 111 50 00	0.02 (0.007)	1080 (3530)	4	1	1	No	0.8	7.3	15.5	625	0	0
Sheepshead Spring	34 44 27 111 55 40	0	1058 (3460)	4	1	2	No	5.9	7.8	17.0	590	1	5000
Deep Spring	34 22 10 111 39 55											Dry	
Chalk Tank	34 23 20 111 42 03											Dry	
The Lake	32 19 35 110 37 15	0.10 (0.04)	1223 (4000)	1	1	2	No	9.5	7.7	22.5	112	1	50
Alambre Tank	32 18 08 110 36 20	0.10 (0.04)	1284 (4200)	1	1	1	No	10.8	8.0	22.0	190	1	5000
White Tank	32 18 02 110 34 35	0.18 (0.07)	1321 (4320)	1	4	2	No	8.9	9.0	26.0	118	0	
Yellowstone	32 17 25 110 38 00	0.08 (0.03)	1223 (4000)	1	4	1	No	8.1	9.2	20.1	192	1	
Canada del Oro	32 33 15 110 42 15	15.67 (6.05)	1223 (4000)	5	3	3	No	8.8	7.1	13.5	105	0	
Sabino Canyon	32 20 30 110 46 50	15.72 (6.07)	979 (3200)	5	3	2	Gila intermedia	7.8	7.1	21.5	75	0	
Buehman Can.	32 25 05 110 32 00	15.51 (5.99)	954 (3120)	5	3	2	Agosia chrysogaster	5.8	7.3	21.0	370	0	

Table III Continued.

Site	Latilong ° ' "	Drainage Area km² (mi²)	Elevation m (ft)	Habitat Type[1]	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. °C	Cond. umho/cm	Status[4]	Population Size
Bear Canyon	31 22 50 110 21 45	11.53 (4.45)	1682 (5500)	5	3	2	Agosia chrysogaster	8.9	7.5	19.0	450	0	
El Pilar	31 40 36 110 45 50	1.68 (0.65)	1492 (4880)	5	1	1	No	10.8	7.5	21.3	480	0	
Romero Canyon	32 24 00 110 51 00	0.05 (0.02)	1835 (6000)	5	3	3	No					Unk.	
Mansfield	31 37 10 110 49 53	0.60 (0.23)	1590 (5200)	1	4	1	No					Unk.	
Johnson's Wash Spr.	34 32 58 112 02 25	0	1465 (4790)	4	1	1	No	4.0	7.6	26.0	575	1	3000
Government Spring	34 27 40 112 01 45	0.98 (0.38)	1300 (4250)	4	1	5	No	7.9	7.9	23.0	450	1	500
Cedar Spring	34 29 45 112 00 15	0.85 (0.33)	1358 (4440)	4	1	1	No	5.1	7.7	26.0	625	0	
Sheep Spring	34 28 35 112 02 05	0.21 (0.08)	1312 (4290)	4	1	1	No	8.6	7.9	27.0	400	1	1500
Monkey Tank	34 26 10 111 47 40											Dry	
Montezuma Tank	34 38 05 112 01 20	0	1220 (3990)	1	1	1	No	12.6	9.7	33.0	880	0	
Ox Bow Spring	34 42 10 112 03 50	0.10 (0.04)	1315 (4300)	1	1	1	No	7.2	7.7	26.0	710	1	100
Hull Spring	34 35 25 111 57 42	0	1110 (3630)	1	1	1	No	9.7	8.2	22.0	475	1	5000

Table III Continued.

Site	Latilong ° ' "	Drainage Area km^2 (mi^2)	Elevation m (ft)	Habitat Type[1]	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. ^0C	Cond. umho/cm	Status[4]	Population Size
Squawpeak Spr.	34 30 30 111 50 35	0	982 (3210)	1	1	1	No	9.2	7.7	24.0	1090	0	
Copper Canyon	34 36 33 111 55 00	1.48 (0.57)	1162 (3800)	5	3	2	No					Unk. Restocked 1983	
Fig Spring	33 55 20 111 38 10	0	587 (1920)	4	2	1	No	6.0	7.3	27.0	350	0	
Unn Spring 5N 7E 24	33 46 05 111 35 20	0.60 (0.23)	832 (2720)	4	2	1	No	8.8	7.8	27.0	425	1	5000
T. T. Spring	34 10 54 111 47 25	0.16 (0.06)	878 (2870)	4	1	2	No	8.5	7.8	23.0	425	1	5000
Unn Spring 9-1/2N 5E 24	34 11 25 111 47 30	0	869 (2840)	4	1	2	No	7.6	8.1	21.5	375	1 Restocked 1983	1
Frog Spring	34 08 28 111 46 50	0.16 (0.06)	853 (2790)	4	1	5	No	5.0	7.9	29.5	500	1	25
Rock Spring	33 45 52 111 36 05	0.88 (0.34)	755 (2470)	4	1	5	No	7.5	7.8	23.5	900	1	50
Lime Cabin Spring	34 01 10 111 47 50		789 (2580)	5	4	5	No	8.2	8.4	18.0	510	0	
Unn Spring Stream 5N 8E 32	33 44 15 111 34 35	0.6 (0.23)	801 (2620)									[5]	
Unn Spring 10N 5E 34	34 11 50 111 48 45	0.21 (0.08)	942 (3080)	4	1	5	No	7.1	7.9	19.0	550	1	15

Table III Continued.

Site	Latilong ° ' "	Drainage Area km² (mi²)	Elevation m (ft)	Habitat[1] Type	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. °C	Cond. umho/cm	Status[4]	Population Size
Blue Mtn. Spring	33 50 46 111 42 22	0.16 (0.06)	838 (2740)	4	4	5	No	5.0	7.2	19.0	500	0	
McCann Spring Tank	33 44 47 111 35 49	0	798 (2610)									Unk.	
White Rock Spring	34 07 55 111 47 20	0	862 (2820)	1	1	7	No	4.0	7.1	20.0	600	0	
Horse Creek	34 03 35 111 40 45	6.11 (2.36)	679 (2220)	5	3	2	A.chrsogaster, Notropis lutrensis, Lepomis cyanellus	7.1	8.2	29.0	700	1	50
Spring Fed Tank 5N 13E 31	33 44 03 111 03 49											Dry	
Artesian Well	33 44 08 111 00 27											Dry	
Artesian Well #3	33 52 52 111 15 10	0	807 (2640)	3	1	1	No	5.0	6.9	27.0	620	1	500
Artesian Well #4	33 52 50 111 15 05	0	807 (2640)	3	1	1	No	15+	10.0	28.0	360	1	200
Corner Artesian	33 50 50 111 15 25	0	749 (2450)	3	1	1	No					1	2000
Kayler Spring	33 56 35 111 18 05	0.57 (0.22)	749 (2450)	4	2	2	A.chrsogaster, Gambusia affinis	8.2	8.0	23.0	500	Unk.	

Table III Continued.

Site	Lat/long ° ' "	Drainage Area km^2 (mi^2)	Elevation m (ft)	Habitat Type[1]	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. °C	Cond. umho/cm	Status[4]	Population Size
Unn Spring Tank #498	33 48 40 111 18 30	0.03 (0.01)	789 (2450)	1	1	2	No	15+	10.0	28.2	640	1	10000
Reed Spring	33 59 20 111 19 42	0.36 (0.14)	869 (2840)	4	3	5	No	9.2	7.5	19.5	650	1	10
Buckhorn	33 39 33 111 13 13	0.78 (0.30)	801 (2620)	4	4	5	No	3.8	7.4	20.5	560	0	
Packard Spring	33 51 30 111 21 00	0.03 (0.01)	1003 (3280)	4	4	1	No	8.6	8.0	19.0	275	0	
Mesquite Flat Spring	33 49 03 111 19 03	0	856 (2800)	2	4	6	No					Unk.	
Tucker Box	33 46 05 111 02 35	4.51 (1.74)	979 (3200)	5	3	5	No	10.1	8.7	24.8	260	0	
Cottonwood Creek	33 37 50 111 08 15	2.02 (0.78)	893 (2920)	5	3	2	No	8.9	7.1	20.0	600	1	100
Unn Spring Dr. 4N 11E 2	33 42 49 111 12 23	0.78 (0.30)	673 (2200)	4	1	3	No	6.1	7.5	19.5	540	1	50
Indian Spring	33 35 17 111 16 45	0.31 (0.12)	673 (2200)	4	3	5	No	8.3	8.1	19.0	225	1	100
Little Mud Spring	33 35 38 110 48 07	0.21 (0.08)	1174 (3840)	1	1	1	No	9.6	6.4	19.0	680	1	3000
Grapevine Spring	33 37 15 110 46 30	0.47 (0.18)	917 (3000)	4	1	2	No	7.2	7.3	24.0	850	0	

Table III Continued.

Site	Latilong ° ' "	Drainage Area km² (mi²)	Elevation m (ft)	Habitat Type[1]	Cover[2]	Substrate[3]	Other Fishes	DO mg/l	pH	Temp. °C	Cond. umho/cm	Status[4]	Population Size
Happy Camp Spring	33 18 34 111 08 24											Dry	
Chalky Butte Well Tank	33 33 31 110 38 28	0	1257 (4110)	1	1	1	No	0.7	7.3	29.0	625	1	5000
Little Nob Well	33 33 24 110 38 53	0.16 (0.06)	1275 (4170)	1	1	1	No	6.5	9.1	26.5	600	1	5000
Walnut Spring	33 53 51 111 31 18	0	1122 (3670)	1	4	1	No	9.6	6.5	21.5	425	1	5000
Mesquite Tank	33 32 31 111 22 50	0.21 (0.08)	612 (2000)	1	1	2	No	12.3	9.8	26.5	250	1	20000
Unn Tank 6N 9E 21	33 51 20 111 26 45											Dry	
Mud Spring	33 44 55 111 29 20	0	599 (1960)	1	1	1	No	1.6	7.6	24.0	1000	1	50
Unn Spring 6N 9E 21	33 51 20 111 26 58	0	1028 (3360	2	1	6	No	6.2	7.7	13.0	560	0	
Unn Spring Fed Tank 6N 9E 21	33 51 20 111 26 35	0	1055 (3450)	1	1	1	No	15+	9.2	26.5	170	0	

Table III Continued.

[1]Habitat Type: 1 - Tank/pond
2 - Trough
3 - Artesian well/pond
4 - Spring Stream
5 - Stream

[2]Cover: 1 - Aquatic plants
2 - Terrestrial Vegetation Overhang/submerged
3 - Undercut bank, instream boulders, pools
4 - None

[3]Substrate: 1 - Silt
2 - Sand
3 - Gravel
4 - Rubble
5 - Bedrock
6 - Concrete
7 - Metal

[4]Status: 0 - Unsuccessful
1 - Successful

[5]Pollock (1984)

Table IV. Success of introductions by habitat type.

Habitat Type	N	Successful Sites	% Success	% Success of Total N
Pond	17	12	70.6	24.0
Trough	1	0	0	0
Artesian Well	3	3	100.0	6.0
Spring Stream	20	13	65.0	26.0
Stream	9	2	22.2	4.0
Total	50	30	60.0	60.0

Table V. Success of introductions by cover type.

Cover Type	N	Successful Sites	% Success	% Success of Total N
Aquatic Plants	32	23	71.8	46.0
Terr. Veg.	2	1	50.0	2.0
Abiotic	9	4	44.4	8.0
None	7	2	14.3	2.0
Total	50	30	60.0	60.0

Table VI. Success of introductions by substrate type.

Substrate Type	N	Successful Sites	% Success	% Success of Total N
Silt	23	15	65.2	30.0
Sand	13	8	61.5	16.0
Gravel	2	1	50.0	2.0
Bedrock	10	6	60.0	12.0
Concrete	1	0	0	0
Metal	1	0	0	0
Total	50	30	60.0	60.0

Drainage Area

Drainage area for successful introduction sites had a mean of 0.8 ± 0.5 km^2 and ranged from trace (< 0.1 km^2) to 6.1 km^2 (Table VII). Unsuccessful sites averaged 5.3 ± 1.8 km^2 and ranged from trace to 17.5 km^2. Thirteen successful and four unsuccessful sites had a drainage area of 0 (artesian wells, windmill fed ponds, perched springs) and were not included in computer analyses. Mean drainage areas were significantly different ($P < .001$, Student's t-test) for successful and unsuccessful introduction sites.

Elevation

Successful introduction sites had a lower mean elevation than unsuccessful sites (Table VII). Elevational mean (range) was 971 ± 45 m (599-1465) and 1071 ± 60 m (587-1682), respectively. These mean elevations differ significantly ($P < .001$).

Dissolved Oxygen (D.O.)

Dissolved oxygen did not vary significantly between successful and unsuccessful introduction sites ($P < .200$, Table VII). Sites holding Gila topminnow had a mean D.O. of 8.4 ± 0.6 ppm (range 6.4 to 10.0). Mean D.O. at unsuccessful introduction sites was 7.0 ± 0.5 ppm (range 0.8 to 10.8 ppm).

pH

Hydrogen ion concentrations (pH) in successful and unsuccessful introduction sites did not appear to differ significantly (Table VII). The pH at successful sites ranged from 6.4 to 10.0. Recorded pH values for unsuccessful sites ranged from 7.1 to 9.2.

Temperature

Water temperature differed significantly ($P < .001$) and was higher at successful introduction sites than unsuccessful sites (Table VII). Mean water temperature at successful sites was 24.1 $\pm$ 0.7 ^{0}C (range 17.0 to 33.0 ^{0}C). The mean at unsuccessful sites was 21.0 $\pm$ 0.9 ^{0}C (13.0-27.0 ^{0}C).

Conductivity

Electrical conductance showed the least amount of difference ($P < .50$) between successful and unsuccessful introduction sites (Table VII). Mean conductivity for successful introduction sites was 514 $\pm$ 39 umho/cm (112.0-1000.0). Unsuccessful sites ranged from 75.0-1090.0 umho/cm with a mean of 465 $\pm$ 58.

Discriminant Analysis

A single discriminant function accounted for variance between successful and unsuccessful sites (Cannonical Correllation = 0.73). The stepwise procedure selected four variables (drainage area, elevation, cover type, D.O.) which adequately discriminated between successful and unsuccessful

Table VII. Habitat variable summary for successful and unsuccessful Gila topminnow introduction sites. Values are the mean ± one standard error with range values in parenthesis and probability of difference derived from a student's t-test.

Variable	Successful (N = 31)	Unsuccessful (N = 19)	Significance Level
Drainage (sq km)	0.8 ± 0.5 [a] (tr.[d] - 6.1)	5.3 ± 1.8 [b] (tr. - 17.5)	P < .001
Elevation (m)	971 ± 45 (599 - 1465)	1071 ± 60 (587 - 1682)	P < .001
D.O. (ppm)	8.4 ± 0.6 (0.7 - 15.0)	7.0 ± 0.5 (0.8 - 10.8)	NS
pH	8.0 ± 0.2 [c] (6.4 - 10.0)	7.7 ± 0.1 (7.1 - 9.2)	NS
Temp. (^{0}C)	24.1 ± 0.7 (17.0 - 33.0)	21.0 ± 0.9 (13.0 - 27.0)	P < .001
Cond. (umho/cm)	514 ± 39 (112 - 1000)	465 ± 60 (75 - 1090)	NS

[a] 13 missing values (sites w/ o drainage area)
[b] 4 missing values (sites w/ o drainage area)
[c] 1 missing value (pH not recorded), log mean not computed
[d] Trace, < 0.1

sites. A plot of the discriminant scores (Fig. 3) shows that the two groups (successful and unsuccessful) could be separated based upon the four criteria. The following classification functions were derived to aid in the selection of future sites.

Successful = -15.4765 - .0979 (Drainage) + .0173 (Elevation) + 2.6106 (Cover type) + 1.1243 (D.O.)

Unsuccessful = -22.2359 + .0629 (Drainage) + .0236 (Elevation) + 4.06 (Cover type) + .69 (D.O.)

The first number in each function is a constant and the following numbers are derived coefficients for the respective variables. The classification functions are evaluated for each site to predict success based upon its scores on those functions. The function that generated the highest score classified the site.

The classification functions were then used to classify the original set of introduction sites (Table VIII). Overall, 80% of all sites were correctly classified by discriminant analysis.

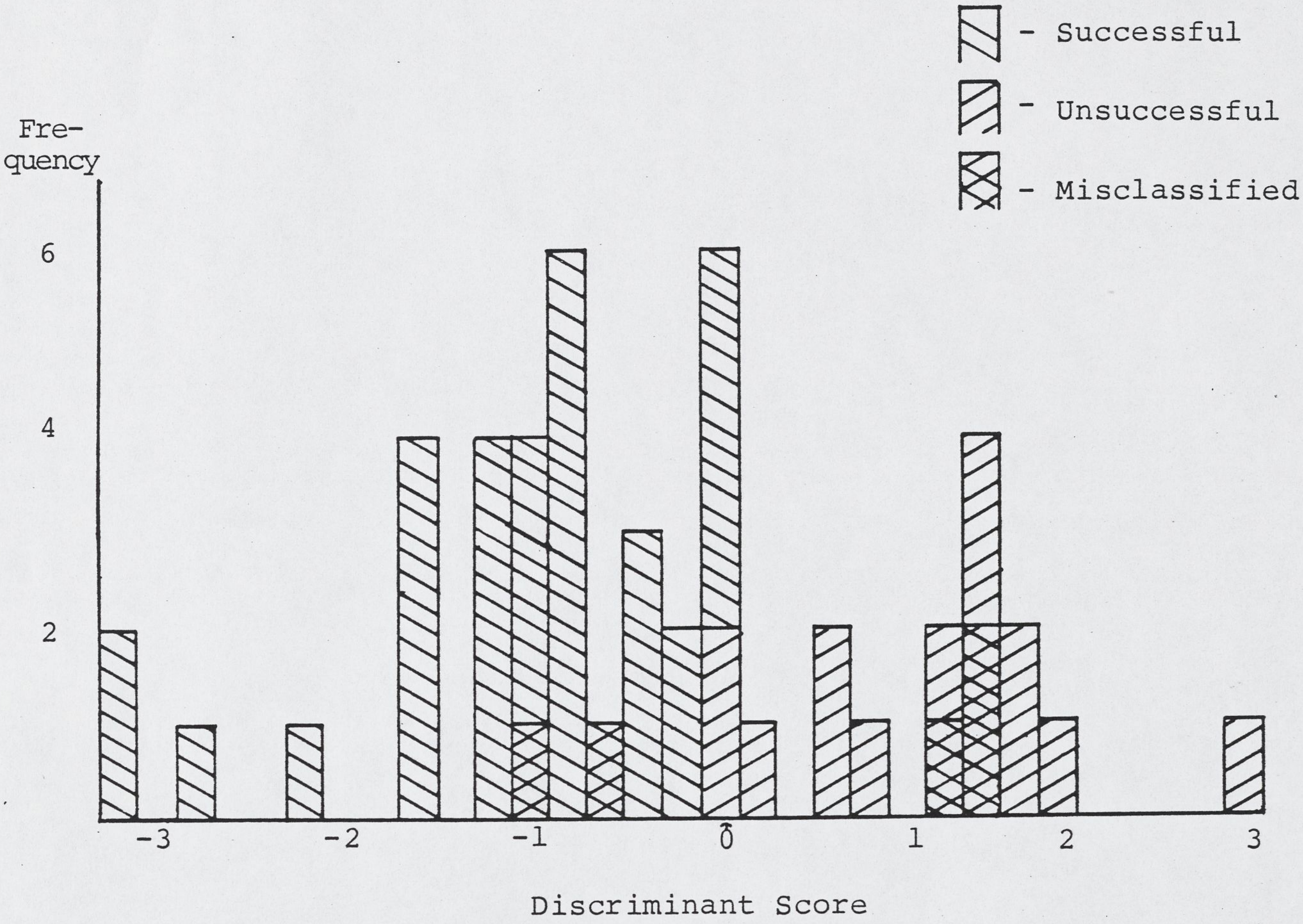

Fig. 3. Correct and incorrect predictions of success for 1982 Gila topminnow introduction sites based on the discriminant score for each.

Table VIII. Successful and unsuccessful Gila topminnow introduction sites classified by discriminant function (N = 50).

		Classified: Suc.	Classified: Unsuc.	
Actual	Suc.	26	4	30
	Unsuc.	6	14	20
		32	18	50

DISCUSSION

General

Both qualitative and quantitative data were collected during monitoring. Those presented for habitat, cover, and substrate types are qualitative and identify dominant types at each introduction site. Quantitative data are those for drainage area, elevation, dissolved oxygen, pH, temperature and conductivity. These two data sets are discussed somewhat differently below. Qualitative data are related to success rate in each general type while quantitative data are discussed in terms of absolute numbers related to introduction successes.

Environments formerly and/or presently occupied by Gila topminnows have been described by several authors (Collins et al. 1981; Constantz 1976; Johnson and Kobetich 1970; Meffe et al. 1982; McNatt 1979; Minckley 1969, 1973; Minckley et al. 1977; Rinne et al. 1980; Schoenherr 1974). Minckley (1973) stated that topminnows "...lived in, or lateral to, almost all kinds of aquatic habitat present in southern Arizona." More recently, Meffe et al. (1983) reviewed environmental conditions experienced by extant, naturally occurring topminnow populations in Arizona. Gila topminnow were demonstrated to occur in highly variable environments, and Meffe et al. (1983) felt that ranges in environmental condition in present habitats were a minimum of what they historically inhabited. This suggested that a wide tolerance to habitat type would be documented in the recovery effort and this in fact has occurred.

The more stable habitat present in small spring streams and ponds had the highest introduction success rate. Stream habitat experienced the least introduction success apparently due to its propensity for floods. However, stability of habitat consists of many variables other than physical size of the system and is evaluated in more detail with the drainage area discussion below.

Aquatic plants, present at most introduction sites, appear to be an important aspect of habitats with successful introductions. Aquatic vegetation, including algal mats, has been cited as a common component of topminnow habitat (Meffe et al. 1983, Minckley 1973). Terrestrial vegetation and abiotic cover constituted the remaining cover types monitored but did not contribute significantly to the total number of successful sites. No cover was present at seven sites and only two of those contained topminnow.

Minckley (1973) stated that topminnow were characteristic of sandy-bottomed streams but did not place any significance on substrate type. Since the topminnow is a livebearer (family Poeciliidae) spawning substrate is not a consideration. However, detritus is a major food of the omnivorous topminnow and is likely more common in silt bottoms. Substrate, then, may actually heavily influence introduction success through food availability. Most of the introduction sites had substrate composed primarily of silt, but their contribution to the total number of successful sites (15 of 30) did not differ significantly from their representation in the total number of introduction sites (23 of 50).

Physicochemical parameters (D.O., pH, Temp., Cond.) varied widely in both successful and unsuccessful Gila topminnow introduction sites and were similar to those reported by Meffe et al. (1983), Minckley (1969), Rinne et al. (1980) and Schoenherr (1974) for other topminnow populations. For these parameters, significant differences (T-test, $P < .001$) were demonstrated between successful and unsuccessful sites only for mean temperatures However, since thermal tolerance appears to be wide for topminnow in the introduction sites as well as in naturally occurring populations (Meffe et al. 1983) and since single point sampling was utilized in this study, these temperature data should be used conservatively.

Mean elevations for successful and unsuccessful introduction sites were significantly different (T-test, $P < .001$). Mean elevation for successful introduction sites was 970 ± 45 m with a range of 599 to 1465 m compared to a mean of 1071 ± 60 m (587 to 1682 m) for unsuccessful sites. Both of these means, however, are within the elevational range of 695 to 1600 m (1318 ± 76 m) recorded by Meffe et al. (1983) for other introduced and natural topminnow populations. Considering this, elevation may not be highly correlated to suitable habitat for a topminnow introduction but should have a recommended maximum similar to that observed by Meffe et al. (1983).

Drainage area unequivocally exhibited the greatest difference between successful and unsuccessful introduction sites. Mean drainage area for successful sites was significantly less than that recorded for unsuccessful sites. That large drainage areas (greater than 5.0 km^2) yield correspondingly high amounts of runoff was evidenced at the introduction sites by piling of debris, scouring and bank instability. Sites with smaller drainage areas (and a higher success rate) rarely demonstrated similar evidence of severe flooding.

The ability of Arizona's native ichthyofauna to withstand flooding has been previously documented (Minckley 1981, Siebert 1980). Cienega Creek, with a relatively large drainage and seasonally frequent flash flooding, currently harbors a natural Gila topminnow population (Minckley 1973, Meffe et al. 1983, USFWS 1983). Meffe (1984) documented the topminnows ability to withstand a series of flash floods that eliminated the non-native *Gambusia affinis*. However, Collins et al. (1981) documented the loss of an introduced topminnow population in Tule Creek due to flooding 10 years after an apparently successful introduction. Additionally, an introduced population in Seven Springs is maintained primarily by escape habitat, an irrigation diversion channel (AGF files), that provides a refuge from flooding.

In light of the aforementioned topminnow populations it is apparent that drainage area should not be used as the sole factor in determining the suitability of a potential site. Inter-relationships of factors such as stream gradient, topography, habitat complexity and watershed use, as well as drainage area, affect the success of a topminnow introduction.

Discriminant Analysis

The use of discriminant analysis may prove to be a valuable tool in explaining inter-relationships that determine successful and unsuccessful sites. Based upon classification functions derived from the discriminant function, data pertaining to drainage area, elevation, cover type and dissolved oxygen can be utilized to predict probability of success or failure of an introduction at a given site. The reliability of these functions will need refinement for accuracy by evaluating future sites, however, due to the inherent biases present in discriminant analysis (Frank et al. 1965; Morrison 1969). Also of concern is the nature of data used in classification of sites (cover = qualitative; drainage, elevation and D.O. = quantitative). For example, D.O. may not be a reliable variable since it represents a single collection at each site and wide ranges of D.O. have been observed at natural topminnow habitats (Meffe et al. 1983). Future classifications of potential sites will give a more reliable test of the discriminant function developed here.

Reasons for Introduction Failures

Failure of an introduction is attributable to many factors. Absolute evidence for causes is based on field observations after the fact and interpretations from data in the literature. Flooding appears to be the major cause for failure in larger stream habitats with large drainage areas. Desiccation also contributed to failure of many introductions. In most cases complete drying occurred but some sites failed due to dwindling amounts of water during summer months. Other reasons for failure include water development (vegetation removal, deepening, etc.), trampling by livestock at times when water availability was low and the presence of predatory non-native fishes (pond habitat, primarily).

Introduction Site Selection Criteria

Revised criteria for selection of suitable Gila topminnow introduction sites (Table IX) were developed from data collected during monitoring, literature review, and initial site selection criteria. Future selection criteria will be refined from those listed in Table IX based on continued monitoring of introduction sites. The degree of refinement will depend upon data needs for reliably predicting success or failure of an introduction. Practicality must be a consideration in regard to effort expended for types and amounts of data collected. However, one major purpose of this recovery effort should be to increase our knowledge of the biology of Gila topminnow through collection of more detailed monitoring data.

Table IX. Recommended criteria for selecting suitable Gila topminnow introduction sites.

Criterion	Comments
Drainage Area	< 1.0 km^2
Elevation	< 1600 m
Stream Flow	< .1 $m^{3/sec}$
Stream Gradient	< 3%
Pond Surface Area	< 2 ha.
Pond Depth	< 2 m
Channelization	Little or None
Habitat Composition	Complex, heterogeneous
Cover	Present, Aquatic vegetation
Other Fishes	Native, Nonpredatory
Water Quality	ADHS Surface Water Quality Standards
Water Source	Perennial; Presence of *Physella*, *Planorbella* and/or Hydrobiids
Developmental Potential	Low or none
Location	Gila River drainage

RECOMMENDATIONS

1. Criteria based on initial observations are listed in Table IX and should be used to identify future suitable Gila topminnow introduction sites and re-evaluate unsuccessful sites.

2. Continue annual monitoring and collect quantitative data pertaining to habitat and fish populations as shown in the Appendix A.

3. Monitor all other introduced and natural topminnow populations and collect data specified on the data sheet in Appendix A.

4. Evaluate unsuccessful and potential introduction sites for suitability based on the suitability criteria developed from monitoring (Table IX).

5. Recommend and stock (or restock) approved sites meeting the suitability criteria.

6. Do not stock topminnow into sites that do not count toward recovery according to the approved FWS Recovery Plan.

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Appendix A

GILA TOPMINNOW SURVEY FORM

Water: ______ Date: ______ Time: ______

Observers: ______

Location: ______ Elev (m): ______ Dr.(km^2): ______

Water Source:		Bank Veg.:		Canopy:	
	Spring				
	Runoff		None		None
	Natural		Sparse		Sparse
	Modified		Moderate		Moderate
	Snails		Dense		Dense

Bank Stability:		Depth:			Width:
	Cut	____	____	____	______
	Uncut	____	____	____	______
		____	____	____	______

Gradient:		Velocity:	Length:	Water Quality:
____	____	____	____	D.O.____ T^0C____
____	____	____	____	pH ____ Cond. ____
____	____	____	____	

Substrate:	%	Cover:	%	Habitat Type:	%
Silt	____	None	____	Spring Stream	____
Sand	____	Aq Veg-Em	____	Stream	____
Gravel	____	Aq Veg-Sub	____	Pond	____
Rubble	____	Fil. Att.	____	Marsh	____
Bedrock	____	Fil. Unatt.	____	Art. Well	____
	____	Terr Veg.	____		____
	____		____		____
	____		____		____

Fish Collection:

Species	N	Area Sampled

Comments:

______

______

______

______

______

FORM 82-5005
FORM 137-4400

Memorandum

SALT RIVER PROJECT

Date November 20, 1986

TO Distribution

FROM Bill Warskow

RE: CAP MAY 1986 WATER SUPPLY STUDY

The Water Rights Division has acquired a copy of the subject study for the WRA library. Copies of the Title Page, Table of contents, List of Tables and List of Figures are attached for your information.

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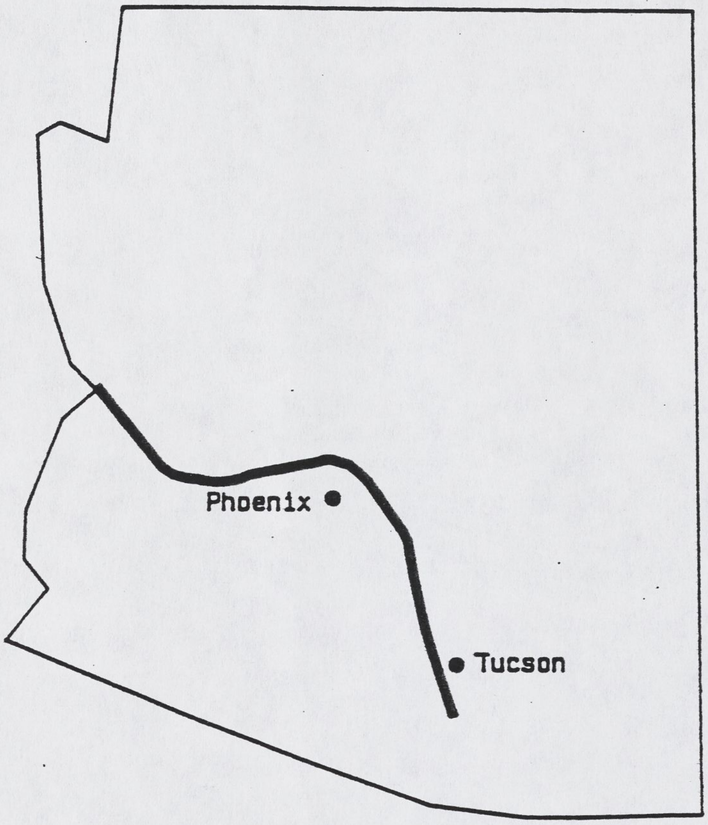

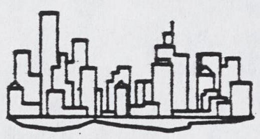

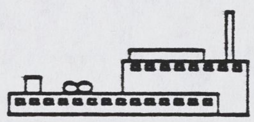

U.S. Department of the Interior
Bureau of Reclamation
Lower Colorado Region
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