THE STATE OF ARIZONA

96-002-014

SALT RIVER

001

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4399 (602) 942-3000

October 7, 1996

ORIGINAL

Mr. Jay Brashear, Chair
Arizona Navigable Stream Adjudication Commission
1700 W. Washington, Room 404
Phoenix, AZ 85007

RECEIVED 10-8-96

Re: Clarification of Submission of Exhibits

Dear Mr. Brashear:

The Arizona Game and Fish Department (Department) filed a "Notice of Appearance and Intent to Participate in the Matter of the Navigability of the Salt River" dated January 14, 1996 and "Exhibits, Arizona Game and Fish Commission, Navigable Streams Adjudication, Salt River, 1994". The Department is listed on "DOCKET NO. 94-1, Salt River Navigability, Notices of Appearance Received for 2-14-94" on page 10, under a heading "NON NAVIGABLE POSITION".

The Department was not intending to take a position on whether the river was navigable, but we were prepared to address the public trust values associated with the Salt River. The Department hereby resubmits the document titled "Exhibits, Arizona Game and Fish Commission, Navigable Streams Adjudication, Salt River, 1994" for use in that context.

We appreciate the opportunity to clarify our intentions. If you have any questions, our principal point of contact will be James E. Burton, Habitat Branch Chief, at (602) 789-3602.

Sincerely,

Duane S. Shroufe

Duane L. Shroufe
Director

DLS:ww

Enclosure

Maricopa County, Lower Salt River
03-005-NAV
4/7/03
Evidence Item No. 014

96-002-014

SALT RIVER

002

EXHIBITS

ARIZONA GAME & FISH COMMISSION

NAVIGABLE STREAMS ADJUDICATION

SALT RIVER

1994

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EXHIBITS

ARIZONA GAME & FISH COMMISSION

NAVIGABLE STREAMS ADJUDICATION

SALT RIVER

1994

Arizona Game & Fish Commission
Index of Exhibits

1. Documents pertaining to the acquisition of the Base & Meridian property (B & M Wildlife Area) from the Bureau of Land Management for "Recreation and Public Purposes", and documenting public purposes values.

2. Management plans for the B & M Wildlife Area.

3. Evidence of Arizona Game and Fish Commission mandates to manage state resources for public trust values.

   a. Title 17, particularly 17-102, 17-201, 17-231.

   b. Commission Policies A2.13, A2.16, I2.3.

4. Evidence of hunting, fishing, recreation and riparian protection as public trust values, including:

   a. Connecticut Department of Environmental Protection. 1990. ***Putting the Public Trust Doctrine to Work: The Application of the Public Trust Doctrine to the Management of Lands, Waters and Living Resources of the Coastal States.***

   b. Johnson, R.W., C. Goeppele, D. Jansen, and R. Paschal. 1992. ***The Public Trust Doctrine Handbook: A Description and Model for Washington's Shoreline Permit Administrators.*** Washington State Department of Ecology.

   c. North Dakota. 1989. Rule 89-10 Islands and Beds of Navigable Streams and Waters. pursuant to North Dakota Century Code Chapter 61-33.

   d. Swanson, E. 1993. Public Trust Values of Arizona's Navigable Streams. Presentation to the Arizona Navigable Streams Adjudication Commission, April, 13, 1993. 7 pp.

5. Documented evidence of public values along watercourses and particularly the Salt River, including:

   a. Arizona Game and Fish Department. 1987. Final Report. W-53-R-37. Gila River Use: Wildlife Investigation, July 1, 1984 - June 30, 1987.

   b. Biotic Communities of the American Southwest -- United States and Mexico. 1982. *In* D.E. Brown, ed. ***Desert Plants*** Vol 4 Nos. 1-4. University of Arizona Press. Tucson, AZ. 315 pp.

5. c. Carr, J.N. 1992. ***Arizona Wildlife Viewing Guide***. Falcon Press Publishing Company. Helena and Billings Montana. 95 pp.

d. Goode, P.D., Jr. 1982. ***Man and Wildlife In Arizona.*** Arizona Game and Fish Dept. Phoenix, AZ. 232 pp.

e. Lowe, C.H. 1964. ***Arizona's Natural Environment.*** University of Arizona Press. Tucson, AZ. 136 pp.

f. Lowe, C.H, and D.E. Brown. 1973. ***The Natural Vegetation of Arizona.*** Arizona Game and Fish Department and Arizona Resources Information System. Phoenix, AZ. 53 pp.

g. Minckley, W.L. 1973. ***Fishes Of Arizona.*** Arizona Game and Fish Department. Phoenix, AZ. 293 pp.

h. Ohmart, R.D. 1979. ***Past and Present Biotic communities of the Lower Colorado River Mainstem and Selected Tributaries***. Vol IV. Center for Environmental Studies, Arizona State University, Tempe, AZ.

i. Rinne, J.N. and W.L. Minckley. 1991. ***Native Fishes of Arid Lands: A Dwindling Resource of the Desert Southwest.*** USDA Forest Service Tech Report RM-206. 46 pp.

j. Valencia, R.A., J.A. Wennerlund, R.A. Winstead, S. Woods, L. Riley, E. Swanson, S. Olson. ***Arizona Riparian Inventory and Mapping Project.*** 1993. A Report to the Governor, President, and Speaker of the House. Arizona Game and Fish Department. 138 pp.

Form 2232-1
(December 1964)
(formerly 4-1267)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

APPLICATION FOR LAND FOR RECREATION OR PUBLIC PURPOSES

Act of June 14, 1926 (44 Stat. 741), as amended; Act of June 4, 1954 (48 Stat. 173; 43 U.S.C. 869 Sections 1-4)

FORM APPROVED
BUDGET BUREAU NO. 42-R1223.3

Date and time received

Land Office and Serial Number
Arizona 032525

PREVIOUS APPLICATIONS

SERIAL NUMBERS	DATE

1. Name and address of applicant *(include zip code)*
Arizona Game and Fish Commission
2222 West Greenway Road
Phoenix, Arizona 85023

2. Give legal description of the land applied for *(use metes and bounds description, if necessary)*

SECTION	TOWNSHIP	RANGE	MERIDIAN
31	1N	1E	Gila and Salt River

Lots 3, 5, 6, 7 and 8, NE 1/4 SW 1/4

State of Arizona — Containing 122.94 acres

3a. Are you applying to: ☐ Lease ☒ Purchase *(If to lease, indicate years)*

b. Is your use to be: ☒ Public Recreational ☒ Other public purposes *(If other public purposes, specify)*
Wildlife Purposes

4a. Does this application include withdrawn lands administered by an agency outside the Department of the Interior?
☐ Yes ☒ No *(If "yes," give name of agency)*

b. Are comments of agency attached? ☐ Yes ☐ No

5. Are plans for development, use, and maintenance attached? ☒ Yes ☐ No

6a. What is your authority to hold land for these purposes?
Sec. 17-231 and 17-241, A.R.S.

b. Is copy attached? ☐ Yes ☒ No

7. Proposed disposition of revenues, if any
None anticipated.

8. Have you enclosed filing fee of $10? ☒ Yes ☐ No

9. Have you attached the required Petition for Classification (Form 2400-7)? ☐ Yes ☒ No

I, the undersigned, submit this application on behalf of the applicant by virtue of the authority granted by
Article 2, Sec. 17-211, A.R.S.

Robert A. Jantzen
(Signature of Authorized Officer)

July 20, 1972
(Date)

Director and Secretary
Arizona Game and Fish Commission

Title 18 U.S.C. Section 1001, makes it a crime for any person knowingly and wilfully to make to any department or agency of the United States any false, fictitious, or fraudulent statements or representations as to any matter within its jurisdiction.

DI Form 1350
(March 1966)

Illustration No. 1

U.S. DEPARTMENT OF THE INTERIOR
ASSURANCE OF COMPLIANCE
(TITLE VI, CIVIL RIGHTS ACT OF 1964)

Arizona Game and Fish Commission (hereinafter called "Applicant-Recipient")
(Name of Applicant-Recipient)

HEREBY AGREES THAT IT will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352) and all requirements imposed by or pursuant to the Department of the Interior Regulation (43 CFR 17) issued pursuant to that title, to the end that, in accordance with Title VI of that Act and the Regulation, no person in the United States shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives financial assistance from Bureau of Land Management and
Bureau or Office

Hereby Gives Assurance That It will immediately take any measures to effectuate this agreement.

If any real property or structure thereon is provided or improved with the aid of Federal financial assistance extended to the Applicant-Recipient by Bureau of Land Management, This assurance obligates the
Bureau or Office

Applicant-Recipient, or in the case of any transfer of such property, any transferee for the period during which the real property or structure is used for a purpose involving the provision of similar services or benefits. If any personal property is so provided, this assurance obligates the Applicant-Recipient for the period during which it retains ownership or possession of the property. In all other cases, this assurance obligates the Applicant-Recipient for the period during which the Federal financial assistance is extended to it by Bureau of Land Management
Bureau or Office

THIS ASSURANCE is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property discounts or other Federal financial assistance extended after the date hereof to the Applicant-Recipient by the bureau or office, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The Applicant-Recipient recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall reserve the right to seek judicial enforcement of this assurance. This assurance is binding on the Applicant-Recipient, its successors, transferees, and assignees, and the person or persons whose signature appear below are authorized to sign this assurance on behalf of the Applicant-Recipient.

July 20, 1972
DATED

Arizona Game and Fish Commission
APPLICANT-RECIPIENT

By Robert A. Jantzen
(President, Chairman of Board or Comparable authorized Official
Robert A. Jantzen, Director and Secretary

2222 West Greenway Road, Phoenix, Arizona 85023
APPLICANT-RECIPIENT'S MAILING ADDRESS

U.S. GOVERNMENT PRINTING OFFICE : 1966 OF—226-926
919-773

Supplement to "Application for Land
for Recreation or Public Purposes"
in Maricopa County, Arizona

Under the provisions of the Act of Congress of June 14, 1926 (44 Stat. 741; 43 U.S.C. 869), as amended by the Act of June 4, 1954 (68 Stat. 173), the enclosed Application for Land for Recreation or Public Purposes is presented for action by the Bureau of Land Management.

In support of the application the following information is submitted for consideration:

A. Since 1961, and up to the present time, our Department has expressed an interest in the Base and Meridian Waterfowl Area.

B. Our letters of November 30, 1961 and May 1, 1963 described our interest in acquiring jurisdiction and management responsibility over the land described in the above application.

C. When the Department first acquired use of the land, we did so under lease No. Arizona 032525 since we were not sure of the effects of flooding on the project. We find now that the floodings of 1965, 1966, 1968 and 1970 had little affect on our management program and we are able to cope with these periodic floodings.

D. Since entering into the lease with the Bureau of Land Management on this property the Game and Fish Department has spent $9,890.48 on management. The expenditure is broken down as follows: $1,081.76 on preliminary costs (engineering and mapping), $7,722.12 on construction of dikes and $1,086.60 on maintenance (dikes, mosquito control and cleanup of litter).

E. Our plan of development includes maintenance and improvement of the dikes and spillway, closure of the area to vehicular travel, water level control and continuation of management for wildlife purposes. The present and future uses of the area include:

1. Maintenance of wildlife habitat (waterfowl, whitewing and mourning doves, quail, shore-birds and miscellaneous wildlife).

2. Utilization by hunters during open seasons.

3. Use by sightseers, birdwatchers and nature photographers.

4. Field trials for hunting dogs.

5. All other uses that are compatible with a wildlife area.

F. The Arizona Game and Fish Commission and Department agree to the following stipulations:

1. To maintain the lands open to use by the public for wildlife and recreational purposes without discrimination or favor.

2. To submit to the Bureau of Land Management a schedule of fees, if any, for use of the facilities. The charges shall be subject to review for conformance and subject to appropriate modification by the Secretary of the Interior or his delegate after reasonable notice and opportunity for hearing. However, we do not anticipate any program to charge the public for use of facilities except that hunters and/or fishermen will need licenses in accordance with State Law.

3. To develop the lands in accordance with the approved plan of management or program of utilization.

4. To allow the Bureau of Land Management to manage, consistent with the wildlife and recreational objectives of the area, all the other values of the lands and to recognize the right of the United States to retain the revenues from such management.

5. To maintain in a satisfactory condition the facilities constructed on these lands.

6. To execute an Assurance of Compliance to Title VI of the Civil Rights Act of 1964.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Phoenix District Office
2929 West Clarendon
Phoenix, Arizona 85017

IN REPLY REFER TO

AR-032525

FEB 27 1973

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Arizona Game & Fish Commission
2222 West Greenway Road
Phoenix, Arizona 85023

Gentlemen:

Pursuant to Title 43 of the Code of Federal Regulations, Part 2450.4(b), attached is a copy of the initial decision on the petition for classification filed for the lands described therein. This initial decision is designated as Attachment "A".

By proposed decision of January 23, 1973, the subject petition was allowed. No protests were received within the time allowed.

For a period of 30 days after receipt of this initial decision, in accordance with 43 CFR 2450.5(a), it shall be subject to the exercise of the supervisory authority by the Secretary of the Interior for the purpose of administrative review. If the Secretary exercises his supervisory authority, you will be so notified by the State Office. If he does not exercise his authority, this decision will become the final order of the Secretary.

All comments, objections, or protests to this decision should be sent to the Secretary of the Interior LLM 320, Washington, D. C. 20240. They must be sent within 30 days of receipt of this decision. However, they should be sent as early as possible to insure enough time for their full review.

Sincerely yours,

Guy E. Baier

For The State Director

Attachment "A"

AR-032525

ATTACHMENT "A"

CLASSIFICATION DECISION

The following described lands have been examined and found suitable for sale for public recreation and wildlife habitat. They are hereby classified for disposal under the provisions of the Recreation and Public Purposes Act of June 14, 1926, as amended (44 Stat. 741).

T. 1 N., R. 1 E., G&SRM, Arizona
Sec. 31: Lots 3, 5, 6, 7 and 8, NE¼SW¼

Totaling 122.94 Acres

This classification decision is based on the following reasons:

1. The area is physically suitable for maintenance of a wildlife habitat area for waterfowl, whitewing and mourning doves, quail and miscellaneous wildlife.

2. The lands are considered to be chiefly valuable for public purposes, which include use by hunters during open seasons, sightseers, birdwatchers, nature photographers, and other uses compatible with a wildlife area.

3. The land is to be administered by the Arizona Game and Fish Department, a non-profit state agency for use by the general public.

February 27, 1973
Date

Guy E. Baier
For The State Director

March 12, 1973

The Honorable Jack Williams
Governor, State of Arizona
State Capitol Building
Phoenix, Arizona 85007

Dear Governor Williams:

In accordance with Section 17-241(A), A.R.S., we request your approval of the purchase of 122.94 acres of land known as the Base and Meridian Wildlife Area in Maricopa County and described as follows:

T.1N., R.1E., G.S.R.B.&M.
Sec. 31, Lots 3, 5, 6, 7 and 8 NE 1/4 SW 1/4.

This parcel of land is being acquired from the United States Government under the provisions of the Act of Congress of June 14, 1926 (44 Stat. 741), as amended by the Act of June 4, 1954. This Act is more commonly known as the Recreation and Public Purposes Act of 1926.

A copy of the Classification Decision of the Bureau of Land Management, dated February 27, 1973, relative to the acquisition of this land is enclosed for your information.

The primary purpose of acquiring this property is to provide for the continuous maintenance of an existing wildlife area for wildlife habitat for waterfowl, whitewing and mourning doves, quail and a multitude of nongame species of wildlife.

This property is currently under a lease from the Bureau of Land Management dated September 10, 1964. This lease was approved by Former Governor Paul Fannin on January 23, 1964.

The Arizona Game and Fish Commission approved the purchase of this property at the December 2, 1961 public meeting in Phoenix.

Since the Game and Fish Department is limited by Federal regulation to the purchase of only 640 acres of Federal land under the Recreation and Public Purposes Act of 1926, we preferred to lease this area at that time. Further, since we will not exceed the 640 acres limitation in 1973, the Department determined that this was the year to purchase the B & M Wildlife Area.

Taking into consideration the public purposes and benefits for which these lands are to be used, they qualify for the Secretary of the Interior's special pricing schedule of $2.50 an acre. Therefore, the purchase price of the 122.94 acres is $307.35.

Following your approval of this purchase and upon payment of the purchase price, the United States Government will issue a patent to the State of Arizona by and through its Game and Fish Commission.

Should you have any questions or comments on this purchase do not hesitate to contact us.

Sincerely,

Robert A. Jantzen, Director

By: Robert D. Curtis, Chief
Wildlife Planning and Development Division

RDC/ljt

Enclosure

APPROVED:

Jack Williams, Governor
State of Arizona

IN REPLY REFER TO
AR-032525

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
PHOENIX DISTRICT OFFICE
2929 WEST CLARENDON AVENUE
PHOENIX, ARIZONA 85017

March 13, 1978

Mr. Robert D. Curtis
Arizona Game and Fish Department
2222 W. Greenway Road
Phoenix, AZ 85023

Dear Mr. Curtis:

On February 23, 1978, a compliance check was conducted on Arizona Game and Fish Department's wildlife habitat area near the confluence of the Gila and Salt Rivers. These lands were patented to your agency by BLM on May 11, 1973 (Land Patent 02-73-0060).

The recently-conducted compliance investigation revealed that the area is providing good habitat for many species of wildlife. It was also noted that there were two breaches in the dike on the west side of the parcel. These breaches greatly reduce the water storage capacity of the area. Whether these breaches were intentionally made for mosquito control or as a result of natural erosion could not be determined.

To enable us to update our file on this project, we would like to know the cause of the breaks in the dike. If they were man-made for mosquito control (or for any reason) our file whould so reflect, or if the breaks were caused by erosion, they should be repaired.

If you have any questions, please call Mike Kirby or me at 261-4231.

Sincerely yours,

Robert C. Archibald Jr.
Area Manager
Phoenix Resource Area

AMERICAN REVOLUTION BICENTENNIAL 1776-1976 wildlife Area

April 18, 1978

Mr. Robert E. Archibald, Jr.
Area Manager, Phoenix Resource Area
Bureau of Land Management
2929 West Clarendon Avenue
Phoenix, Arizona 85017

Dear Mr. Archibald:

This is in reply to your March 1978 letter relative to lands at the confluence of the Gila and Salt Rivers which were patented by BLM to Game and Fish in 1973.

With regard to your compliance investigation it is true that the area is providing good habitat for many species of wildlife. According to the Audubon Society it is an excellent birding area and could be the best in Arizona. Your note that there were two breaches in the dike is well taken. If your compliance check was conducted the following week, you would have noted no dike since upward of 120,000 c.f.s. of water removed all evidence of the dike. The high flows created new channels and caused much damage to local residences adjacent to the wildlife area.

As you are aware, we have had mosquito problems, citizen complaints, mosquito control and a never ending hassle with the public. Currently, the area is closed to vehicles and limited to hunting with shotgun only.

We would suggest that our management plan consist of protective withdrawal or custody to restrict off-road vehicles, refuse dumping, vegetation removal, and limited hunting.

The Department has constructed dikes in this area in three different years: 1965, 1966, and 1973, and all three times the high releases have washed them away. We try to maintain this area under the management plan that we agreed to, but without control of the water releases upstream we are fighting a losing struggle.

Hopefully, as flood control programs are completed upstream, the Department will be able to manage this area more effectively in the future. Productive-wise the area is excellent wildlife habitat now.

Sincerely,

Robert A. Jantzen, Director

By: Robert D. Curtis, Chief
Wildlife Planning and Development Division

RDC/ljt

IN REPLY REFER TO
AR-032525

United States Department of the Interior

BUREAU OF LAND MANAGEMENT

PHOENIX DISTRICT OFFICE
2929 WEST CLARENDON AVENUE
PHOENIX, ARIZONA 85017

May 9, 1978

Mr. Robert D. Curtis
Arizona Game & Fish Department
2222 W. Greenway Road
Phoenix, AZ 85023

Dear Mr. Curtis:

Thank you for your letter of April 18, 1978 concerning R&PP patent 02-73-0060, a wildlife habitat area near the confluence of the Gila and Salt Rivers.

On the basis of information in your letter, the management plan for the area is one of protective custody for wildlife habitat purposes with restrictions on off-road vehicle travel, refuse dumping and vegetation removal. Hunting will be limited to shot guns only. Also, the Plan of Development will be amended to reflect that no new dikes will be built until such time as upstream flood control programs reduce the flood potential of the area.

Again, thank you for your cooperation in this matter.

Sincerely yours,

Robert E. Archibald

Area Manager
Phoenix Resource Area

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

2) B&M Management

ARIZONA GAME AND FISH DEPARTMENT
BASE MERIDIAN/AMATOR WILDLIFE AREA
MANAGEMENT PLAN

I. Goal:

To preserve and enhance riparian habitat for its aesthetic value and wildlife benefits.

II. Objectives:

A. To retain existing cottonwood and willow communities.

B. To provide habitat for migratory birds and resident game and nongame wildlife species.

C. To provide hunting, produce fish forage for piscivorous wildlife species, and other recreational use by the public.

III. Management:

A. History:

The Arizona Game and Fish Commission purchased in fee title, two parcels of land, the Amator Tract and the Base and Meridian Wildlife Area for wildlife management purposes. The Base and Meridian Wildlife Area, approximately 123 acres, was purchased from the Bureau of Land Management (BLM) in 1972, under the provisions of the Recreation and Public Purposes Act. This parcel is located east of 115th Avenue in lots 3, 5, 6, 7, and 8, NE 1/4 SW 1/4, Section 31, T1N, R1E. The area is bounded on the west by the Amator Tract, on the north and east by private land, and on the south by the Gila Indian Reservation (map).

The Amator Tract, 50 acres, was acquired from William Amator in 1975. This parcel is located just west of 115th Avenue and is described as the south 50 acres of N 1/2 SE 1/4, Section 36, T1N, R1W. This parcel is bounded on the north and west by private land, on the south by Arizona State trust land and on the east by the Base and Meridian Wildlife Area.

B. Physical Aspects:

Area: (see attached map):

1. Location - Maricopa County, 17 miles west of Phoenix, Arizona.
2. Acreage - 123 acres Base and Meridian; 50 acres Amator Tract
3. Ownership - Arizona Game and Fish Department

Soil Characteristics:

The soil is classified as Gila loam, and river wash association.

Topography:

1. Floodplain
2. Elevation - 930 feet

Climate:

The area is hot and arid. Mean yearly temperature is approximately 69.6°F, while January and July means are 50.5°F and 90.6°F respectively. Summer temperatures may exceed 115°F. Precipitation averages an annual mean of 8.01 inches of rainfall. Precipitation occurs primarily during two distinct periods, July-September and December-February, with the driest periods occurring from April through June.

Vegetation Communities:

The property lies in a dense riparian community. The plant composition is dominated by salt cedar intermingled with Goodding Willows and Freemont Cottonwood. Some mesquite is also present.

Waters:

The area is traversed from east to west by the Gila River, a permanent flowing stream now comprised chiefly of effluent from the Phoenix sewage treatment facility.

Canals/Channels:

The Arizona State Legislature, on April 5, 1979, passed H.B. 2457 titled Omnibus Flood Control and Relief. This Bill provides funds to the Arizona Water Commission to clear vegetation in a 1,000 foot wide channel along the Salt and Gila Rivers from 91st Avenue to 123rd Avenue, southwest of Phoenix, Arizona. The purpose of the channel clearing project is to facilitate the flow of floodwaters. The channel alignment passes through both the Amator Tract and the Base and Meridian Wildlife Area. Approximately 113 acres of the Wildlife Area was devegetated during this clearing, leaving 60 acres of riparian habitat, mostly adjacent to the stream bank. Mitigation includes planting cottonwood, and willow trees along the edge of the clearing area.

Roads/Trails:

The main access road to the Wildlife Area is 115th Avenue to the Gila River crossing. There are no established roads within the wildlife area.

Fences:

There are no existing fences on the wildlife area.

C. Plan:

Administration:

The Game Branch is responsible for preparing the management plan and documents approving expenditures, inspecting work progress, and insuring that maintenance and operations are satisfactorily performed.

Supervision:

Region VI is responsible for maintenance and operation of the wildlife area under procedures prescribed in this plan.

Buildings:

No buildings are planned for this area.

Dam/Dikes:

No dams or dikes are planned for this area at the present time. Dikes were constructed in the Wildlife Area in 1965, 1966, and 1973, and each time flood waters washed the dike away. Maintenance of a dike in the area is impossible due to upstream water releases. However, the potential may arise subsequent to the completion of the complex of upstream flood control measures to construct small water retention dams in the area to enhance diverse wildlife habitat and general biological enhancement of water quality.

Canals/Channels:

Cottonwood and willow trees are planned along the outside boundary of the cleared flood channel.

Roads/Trails:

Off-road motor vehicle entry and travel will be prohibited, by the placement of permanent corner posts and connecting cable to delineate the wildlife area boundary and inhibit off road vehicle tresspass. This cable barrier is to be constructed by the Flood Control District of Maricopa County as mitigation for flood control works within the area. Internal two track roads will be revegetated with native vegetation and foot trails constructed.

Fences:

Boundary surveys need to be established and then permanent corner posts constructed to identify the property line. The potential for flooding in the area makes it unwise to construct fencing around the area.

Public Use Facilities:

Foot trails, and an unpaved parking lot shall be constructed for public use. The area is unsuitable in its present condition for any use other than hunting and general recreation.

Signs:

Legible signs that designate land ownership shall be posted around the boundary of the Department's land. A large redwood information sign is needed at the entrance of the wildlife area.

Tree/Shrubs Planting:

Cottonwoods, willow, cattails, bull rush, atriplex, canary grass, and native grasses need to be established in the wildlife area for food and cover. The Flood Control District of Maricopa County has agreed to cooperate with the Department in planting cottonwood and willow trees along the perimeter of the 1,000 foot clearing as mitigation for the clearing.

Vegetation Control:

Selective removal of scrub salt cedar may be needed in the area to help native vegetation grow.

Nesting/Loafing Structures:

Installments of nest boxes and raptor platforms need to be placed throughout the wildlife area. There is also a need to construct observation towers for wildlife viewing.

Hunting and Trapping:

The wildife area will be open to hunting and trapping as per Commission Order 1.

Camping:

Camping shall not be permitted within the wildlife area.

Grazing:

Grazing by livestock shall not be permitted within the wildlife area.

D. Inspection:

Personnel from Game Branch and Region VI will meet annually to inspect and identify the current needs for the area and to determine the annual maintenance schedules.

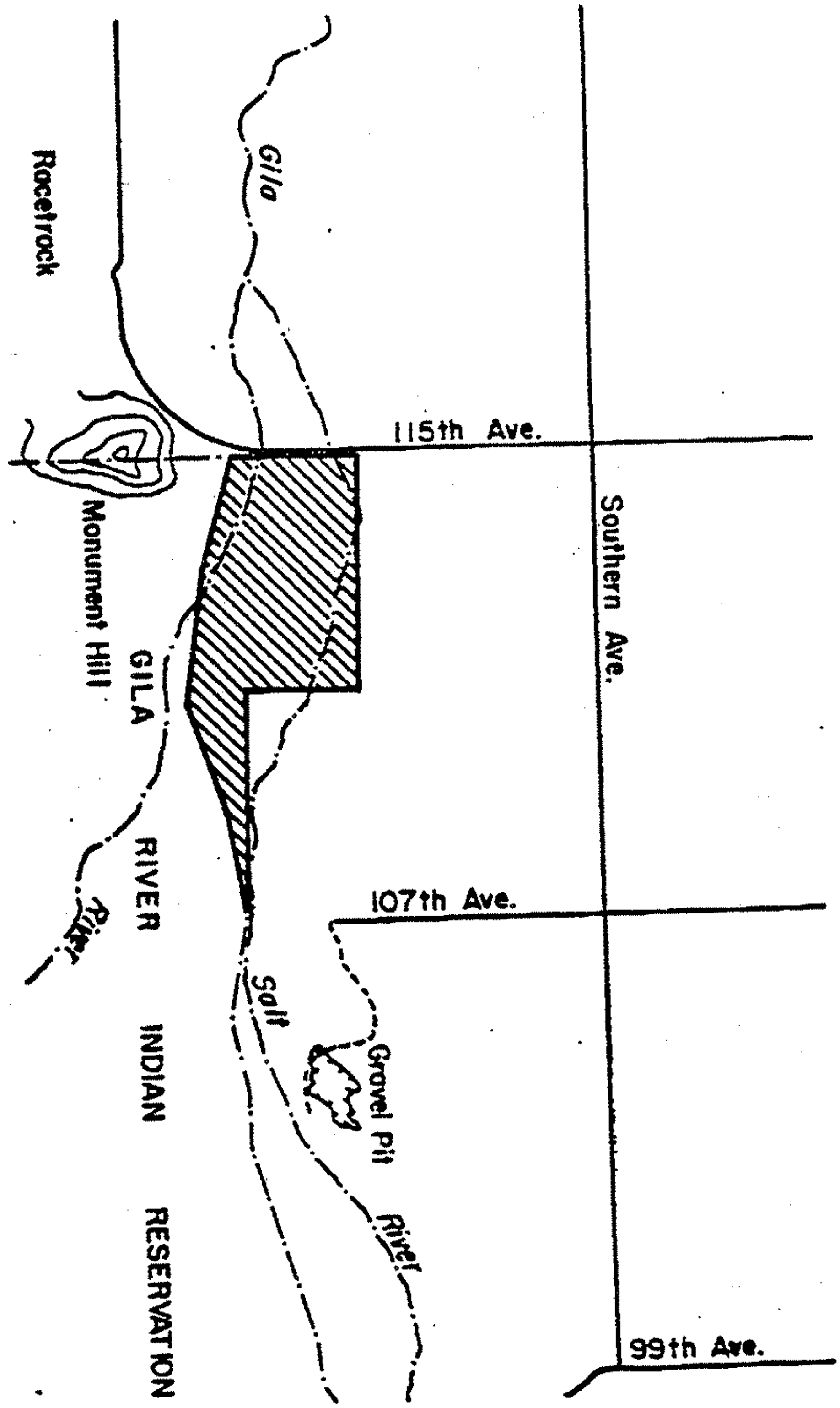
Identified needs for the area are to be handled under established Department procedures.

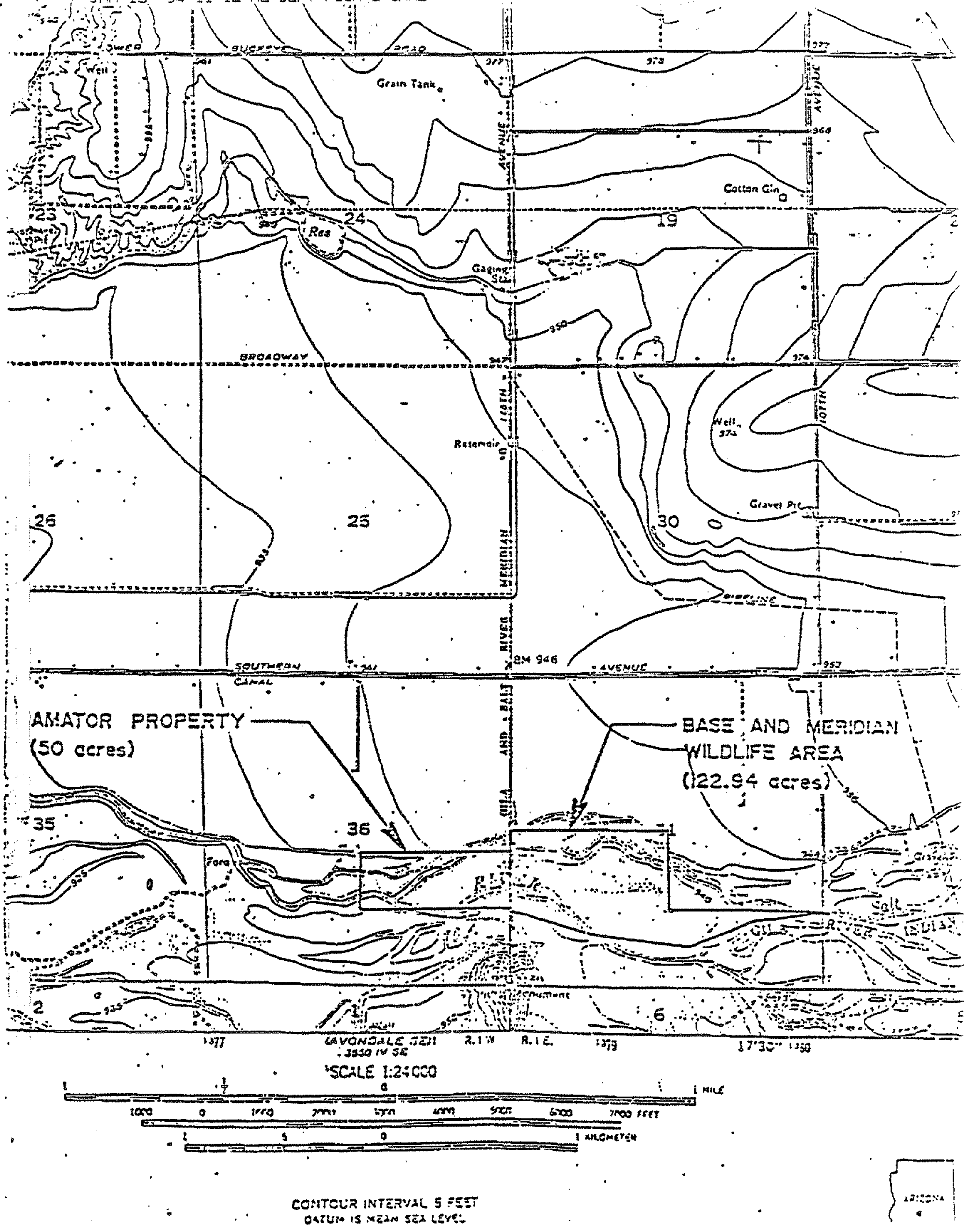
Approved by: Duane S. Shroufe

For Director's Staff

2-2-87

1/13/87


Racetrack
Gila
115th Ave.
Monument Hill
Southern Ave.
GILA RIVER INDIAN RESERVATION
River
107th Ave.
Salt
Gravel Pit
River
99th Ave.


BUCKEYE
Grain Tank
AVENUE
Cotton Gin
23
24
19
Res
Gaging Sta
BROADWAY
Well
Reservoir
Gravel Pit
26
25
30
MERIDIAN
PIPELINE
RIVER
BM 946
AVENUE
SOUTHERN
CANAL
AMATOR PROPERTY
(50 acres)
BASE AND MERIDIAN
WILDLIFE AREA
(122.94 acres)
35
36
GILA RIVER
2
6
R.1 W.
R.1 E.
SCALE 1:24000
1 MILE
7000 FEET
1 KILOMETER
CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL
ARIZONA

DRAFT
1993

B & M WILDLIFE AREA

1. <u>LOCATION:</u> The B&M Wildlife Area is located along the north bank of the Gila River at the confluence with the Salt River. It is at 115th Avenue and the Gila River. It lies within Section 31 of Township 1N, Range 1E. The area also functionally includes two other parcels, the Harper Tract and the Amator Tract both in the SE 1/4 of Section 36 of Township 1N, 1W.

2. <u>LAND STATUS:</u> The B&M Wildlife Area is a patented deeded parcel of the Arizona Game and Fish Commission (AGFC). The Amator and Harper parcels are deeded properties of the AGFC.

3. <u>SPECIES/HABITAT STATUS:</u> The B&M W.A. is vegetated in a mixed species riparian assemblage of cottonwood, willow, salt cedar, baccharis and the like. It has been heavily impacted by recent flooding, with vegetation lost to the current, and heavy deposition of landfill debris amongst the vegetation. Trespass by off-road vehicles has negatively impacted the area. Precise boundary definition is uncertain and contested by the Gila River Indian Reservation, whose charter defines the Gila River as its north boundary. The river has meandered since the date of charter, and is now farther north than previously, apparently reducing the extent of the B&M Wildlife Area.

   A further constraint to the preservation of the area's vegetative community is the possibility that the discharge of water from the City of Phoenix's 91st Ave. waste water treatment plant may be discontinued. This water is the support source for the riparian community which exists currently at the B&M. Although water ownership agreements have existed between the Department and the City of Phoenix for a number of years, they have never been finalized or formally implemented, despite their being a conditional aspect of a number of related agreements. This includes the initial acquisition of the B&M W.A. from the Federal Bureau of Land Management.

   Despite these constraints, substantial riparian gallery forest vegetation remains on the property and adjacent areas, and represents a genuine value to wildlife. Many riparian obligate species inhabit the area include such species as Common Egret, Great Blue Heron, raccoon, various warblers, etc. Ospreys have been present during migration seasons and during the winter. The area is used routinely for fishing recreation, birdwatching, hiking and target shooting.

4. <u>ASSETS:</u> There are no in-place Department-owned assets associated with the B&M Wildlife Area. Equipment based at the Robbins Butte Wildlife Area is available for use on site as needed.

5. <u>MANAGEMENT EMPHASIS:</u> The B&M Wildlife Area (including the Harper and Amator Tracts) is devoted to waterfowl management. Future program narrative revision should additionally emphasize its general riparian ecosystem value.

3) Authority

CHAPTER 1
GENERAL PROVISIONS

ARTICLE 1
DEFINITIONS AND AUTHORITY OF THE STATE

17-101. DEFINITIONS

A. In this title unless the context otherwise requires:

1. "Angling" means the taking of fish by one line and not to exceed two hooks, or by one line and one artificial lure which may have attached more than one hook, or by one line and not to exceed two artificial flies or lures.

2. "Bag limit" means the maximum limit, in number or amount, of wildlife which may lawfully be taken by any one person during a specified period of time.

3. "Closed season" means the time during which wildlife may not be lawfully taken.

4. "Commission" means the Arizona Game and Fish Commission.

5. "Department" means the Arizona Game and Fish Department.

6. "Device" means any net, trap, snare, salt lick, scaffold, deadfall, pit, explosive, poison or stupefying substance, crossbow, firearm, bow and arrow, or other implement used for taking wildlife.

7. "Fishing" means to lure, attract or pursue aquatic wildlife in such a manner that the wildlife may be captured or killed.

8. "Fur dealer" means any person engaged in the business of buying for resale, the raw pelts or furs of wild mammals.

9. "Guide" means a person who for pay, aids or assists any person in taking wildlife.

10. "License year" means the twelve-month period between January 1 and December 31, inclusive.

11. "Nonresident" means a citizen of the United States or an alien who has not been a bona fide resident of the state of Arizona for six months immediately preceding the date of application for a license.

12. "Open season" means the time during which wildlife may be taken.

13. "Possession limit" means the maximum limit, in number or amount of wildlife, which may be possessed at one time by any one person.

14. "Resident" means a person who has been a bona fide resident of the state of Arizona for six months immediately preceding the date of application for a license, or a member of the armed forces who has been stationed in Arizona for a period of thirty days immediately preceding the date of application for a license.

15. "Road" means any maintained right-of-way for public conveyance.

16. "Statewide" means all lands except those areas lying within the boundaries of state and federal refuges, parks and monuments, unless specifically provided differently by commission order.

17. "Take" means pursuing, shooting, hunting, fishing, trapping, killing, capturing, snaring or netting wildlife or the placing or using of any net or other device or trap in a manner that may result in the capturing or killing of wildlife.

18. "Taxidermist" means any person who engages for hire in the mounting, refurbishing, maintaining, restoring or preserving of any display specimen.

19. "Traps" or "trapping" means taking of wildlife in any manner except with a gun or other implement in hand.

20. "Wild" means, in reference to mammals and birds, those species which are normally found in a state of nature.

21. "Wildlife" means all wild mammals, wild birds and the nests or eggs thereof, reptiles, amphibians, mollusks, crustaceans, and fish, including their eggs or spawn.

22. "Zoo" means a commercial facility open to the public where the principal business is holding wildlife in captivity for exhibition purposes.

B. The following definitions of wildlife shall apply:

1. Aquatic wildlife are all fish, amphibians, mollusks, crustaceans and soft-shelled turtles.

2. Game mammals are deer, elk, bear, antelope, bighorn sheep, bison (buffalo), peccary (javelina), mountain lion, tree squirrel and cottontail rabbit.

3. Big game are wild turkey, deer, elk, antelope, bighorn sheep, bison (buffalo), peccary (javelina), bear and mountain lion.

4. Small game are cottontail rabbits, tree squirrels, upland game birds and migratory game birds.

5. Fur-bearing animals are muskrats, raccoons, otters, weasels, bobcats, beaver, badgers and ringtail cats.

6. Predatory animals are foxes, skunks, coyotes, and bobcats.

7. Nongame animals are all wildlife except game mammals, game birds, fur-bearing animals, predatory animals and aquatic wildlife.

8. Upland game birds are quail, partridge, grouse and pheasants.

9. Migratory game birds are wild waterfowl, including ducks, geese and swans; sand hill cranes; all coots, all gallinules, common snipe, wild doves and bandtail pigeons.

10. Nongame birds are all birds except upland game birds and migratory game birds.

11. Game fish are trout of all species, bass of all species, catfish of all species, sunfish, northern pike, walleye, and yellow perch.

12. Nongame fish are all the species of fish except game fish.

13. Trout means all species of the family salmonidae, including grayling.

17-102. WILDLIFE AS STATE PROPERTY; EXCEPTIONS.

Wildlife, both resident and migratory, native or introduced, found in this state except fish and bullfrogs impounded in private ponds or tanks or wildlife and birds reared or held in captivity under permit from the commission, are property of the state and may be taken at such times, in such places, in such manner and with such devices as provided by law or rule of the commission.

17-103. DUTIES OF COUNTY ATTORNEYS

Each county attorney shall prosecute and defend on behalf of the state, in all courts of the county, all actions, criminal or civil, arising under this title in which the state, commission member, or department employee is a party thereof.

17-104. DUTIES OF PEACE OFFICERS AS SPECIAL GAME RANGERS

All county, city and town peace officers are ex officio special game rangers and are required to carry out the duties of this title.

17-105. IMMUNITY OF WITNESSES

No person called upon by the state to testify as a witness in any action brought under this title shall be excused or exempted from so testifying or from producing documentary evidence on the grounds that the testimony or evidence might incriminate him, but the person shall not thereafter be prosecuted for an offense concerning which he is called upon to give such testimony or evidence.

CHAPTER 2
GAME AND FISH DEPARTMENT AND GAME AND FISH COMMISSION

ARTICLE 1
MEMBERSHIP

17-201. GAME AND FISH DEPARTMENT AND GAME AND FISH COMMISSION MEMBERS; APPOINTMENT; REMOVAL; MEETINGS

A. The laws of the state relating to wildlife shall be administered by the game and fish department. Control of the department is vested in the game and fish commission. The commission shall consist of five members, appointed by the governor pursuant to 38-211. Not more than three members shall be members of the same political party, and no two members may be residents of the same county. Members shall be well informed on the subject of wildlife and requirements for its conservation. Appointments shall be for a term of five years and shall expire on the third Monday in January of the appropriate year.

B. The governor may, after public hearing, remove a member for inefficiency, neglect of duty or misconduct in office. Upon removal of a member the governor shall file in the office of the secretary of state a complete statement of all charges made against the members and his findings thereon, together with a complete record of the proceedings.

C. Each member of the commission while attending general or specific meetings of the commission or while performing official duties for the commission shall receive compensation as determined pursuant to 38-611. A commission member who is otherwise employed as a public officer shall not receive such payment if it is prohibited by law. Compensation and expenses shall be paid monthly from the game and fish fund.

D. The commission shall have its principal office at the state capitol but meetings may be held at any time or place within the state. The commission shall meet at least once quarterly. Meetings may be held at the call of the chairman or majority of the commission. A majority of the commission shall constitute a quorum to transact business.

ARTICLE 2
DIRECTOR AND EMPLOYEES

17-211. DIRECTOR; SELECTION; REMOVAL; POWERS AND DUTIES; EMPLOYEES

A. The commission shall appoint a director of the Arizona game and fish department, who shall be the chief administrative officer of the game and fish department. The director shall receive compensation as determined pursuant to 38-611. The director shall be selected on the basis of administrative ability and general knowledge of wildlife management. The director shall act as secretary to the commission, and shall serve for a term of five years, but he may be removed by the commission, after public hearing, for inefficiency, neglect of duty or misconduct in office. If the director is removed, the commission shall make, in its minutes, a complete statement of the proceedings and all charges made against the director, and its findings thereon. The director shall not hold any other office, and shall devote his entire time to the duties of his office.

B. The commission shall prepare an examination for the post of director to comply with the requirements of this title. The examination shall be conducted at the offices of the commission at the capitol to establish an active list of eligible applicants. The director shall be selected from those scoring satisfactory grades and having other qualities deemed advisable by the commission, and the commission may call for additional examinations from time to time for selection of a new list of eligible applicants to fill a vacancy.

C. The director may appoint employees necessary to carry out the purposes of this title, when funds for the payment of their salaries are appropriated. Department employees shall be located in different sections of the state where their services are most needed. All appointments must be made in accordance with procedures and qualifications established by the commission.

Compensation for persons appointed shall be as determined pursuant to 38-611. The director may dismiss an employee for inefficiency, neglect of duty or misconduct. Such employee shall be entitled to an appeal before the commission after filing a written request for a hearing within thirty days after date of discharge. The director shall file in the department office a complete statement of charges made against the employee and the findings thereon after such written request is received. If the employee fails to file such request within the thirty-day period his rights to appeal are waived and the action of the director shall be final.

D. The director shall have general supervision and control of all activities, functions and employees of the department and shall enforce all provisions of this title, including all commission rules and regulations. Game rangers and wildlife managers may, in addition to other duties:

1. Execute all warrants issued for a violation of this title.

2. Execute subpoenas issued in any matter arising under this title.

3. Search without warrant any aircraft, boat, vehicle, box, game bag or other package where there is sufficient cause to believe that wildlife or parts thereof is possessed in violation of law.

4. Inspect all wildlife taken or transported and seize all wildlife taken or possessed in violation of law, or showing evidence of illegal taking.

5. Seize as evidence devices used illegally in taking wildlife and hold them subject to provisions of 17-240.

6. Generally exercise the powers of peace officers with primary duties the enforcement of this title.

7. Seize devices that cannot be lawfully used for the taking of wildlife and are being so used and hold and dispose of same pursuant to 17-240.

17-212. DIRECTOR'S SEAL; AUTHENTICATION OF RECORDS

A. The director shall adopt a seal of office which shall be used to authenticate records and copies of records required by law to be made and kept by the department.

B. The director and any department employees the director designates in writing may use the seal to authenticate records and copies of records.

C. Authenticated records or authenticated copies of records shall be received in evidence without further proof of their authenticity.

17-213. PROHIBITION ON POLITICAL ACTIVITY

Neither the director nor any employee of the department shall take active part in a political campaign nor use his office to influence in any way an election or the results thereof. Failure to abide by the provisions of this section shall constitute grounds for dismissal of the director or any employee.

17-214. ARIZONA GAME AND FISH DEPARTMENT RESERVE; MEMBERS, POWERS AND DUTIES; COMPENSATION

A. The commission may establish a volunteer organization known as the Arizona game and fish department reserve and prescribe the qualifications for membership. Members of the reserve serve at the pleasure of the director who has general supervision and control of all reserve activities.

B. The reserve shall assist the department as an auxiliary body and perform such duties in the areas of education, conservation and enforcement as the commission prescribes by rule or regulation. The director may designate qualified reservists as peace officers in the same manner and with the same powers as game rangers and wildlife managers. Such reservists are not entitled to participate in the public safety personnel retirement system pursuant to title 38, chapter 5, article 4.

C. Members of the reserve are not eligible to receive compensation but are eligible for reimbursement of expenses pursuant to title 38, chapter 4, article 2. Members of the reserve are deemed to be employees of this state for the purpose of coverage under Arizona workers' compensation pursuant to title 23, chapter 6.

ARTICLE 3
GAME AND FISH COMMISSION-POWERS AND DUTIES

17-231. GENERAL POWERS AND DUTIES OF THE COMMISSION

A. The commission shall:

1. Make rules and establish services it deems necessary to carry out the provisions and purposes of this title.

2. Establish broad policies and long range programs for the management, preservation and harvest of wildlife.

3. Establish hunting, trapping and fishing rules and prescribe the manner and methods which may be used in taking wildlife.

4. Be responsible for the enforcement of laws for the protection of wildlife.

5. Prescribe grades, qualifications and salary schedules for department employees.

6. Provide for the assembling and distribution of information to the public relating to wildlife and activities of the department.

7. Prescribe rules for the expenditure, by or under the control of the director, of all funds arising from appropriation, licenses, gifts or other sources.

8. Exercise such powers and duties necessary to carry out fully the provisions of this title and in general exercise powers and duties which relate to adopting and carrying out policies of the department and control of its financial affairs.

9. Prescribe procedures for use of department personnel, facilities, equipment, supplies and other resources in assisting search or rescue operations on request of the director of the division of emergency management.

B. The commission may:

1. Conduct investigations, inquiries or hearings in the performance of its powers and duties.

2. Establish game management units or refuges for the preservation and management of wildlife.

3. Construct and operate game farms, fish hatcheries, fishing lakes, or other facilities for or relating to the preservation or propagation of wildlife.

4. Expend funds to provide training in the safe handling and use of firearms and safe hunting practices.

5. Remove or permit to be removed from public or private waters fish which hinder or prevent propagation of game or food fish and dispose of such fish in such manner as it may designate.

6. Purchase, sell or barter wildlife for the purpose of stocking public or private lands and waters and take at any time in any manner wildlife for research, propagation and restocking purposes or for use at a game farm or fish hatchery and declare wildlife salable when in the public interest or the interest of conservation.

7. Enter into agreements with the federal government, other states or political subdivisions of the state and with private organizations for the construction and operation of facilities and for management studies, measures or procedures for or relating to the preservation and propagation of wildlife and expend funds for carrying out such agreements.

8. Prescribe rules for the sale, trade, importation, exportation or possession of wildlife.

9. Expend monies for the purpose of producing publications relating to wildlife and activities of the department for sale to the public and establish the price to be paid for annual subscriptions and single copies of such publications. All monies received from the sale of such publications shall be deposited in the game and fish publications revolving fund.

10. Contract with any person or entity to design and produce artwork on terms which, in the commission's judgment, will produce an original and valuable work of art relating to wildlife or wildlife habitat.

11. Sell or distribute the artwork authorized under paragraph 10 of this subsection on such terms and for such price as it deems acceptable.

12. Consider the adverse and beneficial short-term and long-term economic impacts on resource dependent communities, small businesses and the state of Arizona, of policies and programs for the management, preservation and harvest of wildife by holding a public hearing to receive and consider written comments and public

testimony from interested persons.

C. The commission shall confer and coordinate with the director of water resources with respect to the commission's activities, plans and negotiations relating to water development and use, restoration projects under the restoration acts pursuant to provisions of chapter 4 article 1 of this title where water development and use are involved, the abatement of pollution injurious to wildlife and in the formulation of fish and wildlife aspects of the director of water resources' plans to develop and utilize water resources of the state and shall have jurisdiction over fish and wildlife resources and fish and wildlife activities of projects constructed for the state under or pursuant to the jurisdiction of the Arizona water resources.

17-232. AGREEMENTS WITH OTHER STATES FOR RECIPROCAL USE OF LICENSES

The commission, subject to the approval of the governor and the attorney general, is authorized to enter into reciprocal agreements with corresponding state or county agencies of adjoining states pertaining to the establishment of a basis whereby licenses or permits issued by either of the parties may be used by the licensees within the jurisdiction of either party to the agreement.

17-233. ACQUISITION AND DISPOSITION OF BUFFALO AND BUFFALO MEAT

The commission may purch[illegible] sell, barter, or give a[illegible] buffalo or buffalo [illegible] provided the same may be g[illegible] only to public institutions charitable institutions [illegible] monies derived therefrom s[illegible] be deposited in the game a[illegible] fish fund.

17-234. OPEN OR CLOSED SEAS[illegible] BAG LIMITS; POSSESSION LIM[illegible]

The commission shall by ord[illegible] open, close or alter sea[illegible] and establish bag [illegible] possession limits for wildli[illegible] but a commission order to [illegible] a season shall be issued [illegible] less than ten days prior [illegible] such opening date. The ord[illegible] may apply statewide or to [illegible] portion of the state. Cl[illegible] season shall be in effe[illegible] unless opened by commis[illegible] order.

17-235. MIGRATORY BIRDS

The commission sh[illegible] prescribe seasons, bag lim[illegible] possession limits and o[illegible] regulations pertaining [illegible] taking migratory birds [illegible] accordance with the migra[illegible] bird treaty act a[illegible] regulations issued thereun[illegible] but the commission may sho[illegible] or modify seasons, bag a[illegible] possession limits and oth[illegible] regulations on migratory b[illegible] as it deems necessary.

17-236. TAKING BIRDS

It is unlawful to take [illegible] injure any bird or harass [illegible] bird upon its nest, or remo[illegible] the nests or eggs of any bi[illegible] except as may occur in no[illegible] horticultural and agricultu[illegible] practices and except a[illegible] authorized by commission ord[illegible] Nothing in this title shall [illegible] construed to prohibit the taking of such birds for scientific purposes under permits issued by the commission.

17-237. POLLUTION OF WATERS

The commission is authorized to bring suit in the name of the state against any person, corporation or government agency, to restrain or enjoin the person, corporation or government agency from discharging or dumping into a stream or body of water in the state any deleterious substance which is injurious to wildlife.

17-238. SPECIAL LICENSES FOR FIELD TRIALS, SHOOTING PRESERVES, AND FOR COLLECTING OR HOLDING WILDLIFE IN CAPTIVITY

A. The commission may adopt rules and regulations and issue licenses for the conduct of field trials, shooting preserves, private wildlife farms and zoos, or for the personal use and possession of wildlife so as to safeguard the interests of the wildlife and people of the state.

B. The commission, at its discretion and under such regulations as it deems necessary may issue a permit to take wildlife for scientific purposes to any person or duly accredited representative of public educational or scientific institutions, or governmental departments of the United States engaged in the scientific study of wildlife.

C. A person holding a permit issued pursuant to this section may, upon advance approval by the commission, buy, sell and transport wildlife legally possessed. Each person receiving a permit under this section shall file with the department within fifteen days after requested by the department a report of his activities under the permit. The commission may revoke such licenses or permits for noncompliance with regulations.

17-239. WILDLIFE DEPREDATIONS; INVESTIGATIONS; CORRECTIVE MEASURES; DISPOSAL; REPORTS; APPEAL

A. Any person suffering property damage from wildlife may exercise all reasonable measures to alleviate such damage except that reasonable measures shall not include injuring or killing game mammals, game birds or wildlife protected by federal law or regulation unless authorized under subsection D of this section. A person may not retain or sell any portion of an animal taken pursuant to this subsection except as provided in section 3-2403.

B. Any person suffering such property damage may, after resorting to such relief as is provided in subsection A, of this section, file a written report with the director, advising him of the damage suffered, and the species of animals causing such damage, and the director shall forthwith order an investigation and report by an employee trained in the handling of wild animal depredation.

C. The department shall provide technical advice and assist in the necessary antidepredation measures recommended in the report, including trapping, capturing and relocating animals.

D. If harvest of animals is found to be necessary to relieve damage, the commission may establish special seasons, or special bag limits, and either set reduced fees or waive any or all license fees required by this title, to crop such wildlife. If the commission determines that such cropping by hunters is impractical, it may issue a special permit for taking such wildlife to the landowner, lessee, livestock operator or municipality suffering damage, provided that the edible portions, or other portions as prescribed by the commission, of all such wildlife taken by the person suffering damage is turned over to an agent of the department for delivery to a public institution or charitable organization.

E. In the event any person suffering property damage from wildlife is dissatisfied with the decision of the commission, he shall have the right of appeal to the superior court under the title 12, chapter 7 article 6.

17-240. DISPOSITION OF WILDLIFE; DEVICES; UNLAWFUL DEVICES; NOTICE OF INTENTION TO DESTROY; WAITING PERIOD; DESTRUCTION; JURISDICTION OF RECOVERY ACTIONS; SALE OF UNCLAIMED PROPERTY

A. Wildlife seized under this title may be disposed of in such manner as the commission or the court may prescribe, except that the edible por[illegible] shall be given to public in[illegible] tutions or chari[illegible] organizations. In consult[illegible] with the department of he[illegible] services and the state ve[illegible] narian, the commission [illegible] adopt rules for the hand[illegible] transportation, processin[illegible] storing of game meat gi[illegible] public institutions and ch[illegible] able organizations.

B. Devices, exce[illegible] firearms, which cannot be [illegible] lawfully for the taking [illegible] wildlife and being so us[illegible] the time seized may [illegible] destroyed. Notice of intent to destroy such devices [illegible] prescribed in this section [illegible] be sent by registered ma[illegible] the last known address of [illegible] person from whom seize[illegible] known and posted in three [illegible] spicuous places within [illegible] county wherein seized, tw[illegible] said notices being poste[illegible] the customary place for po[illegible] public notices about the cou[illegible] courthouse of said county. [illegible] device shall be held by [illegible] department for thirty d[illegible] after such posting and mai[illegible] and if no action is comm[illegible] to recover possession of s[illegible] device within such time, [illegible] same shall be summ[illegible] destroyed by the departmen[illegible], if such device shall be held [illegible] the court in any such acti[illegible] have been used for the t[illegible] of wildlife, then such dev[illegible] shall be summarily destroy[illegible] the department immedi[illegible] after the decision of the cou[illegible] has become final. The justi[illegible] court shall have jurisdi[illegible] of any such actions[illegible] proceedings commenced to recover the possession of such devices.

C. Devices other than those referred to in subsection B, including firearms seized under this title shall, after final disposition of the case, be returned to the person from whom the device was seized. If the person from whom the device was seized cannot be located or ascertained, the device seized shall be retained by the department at least thirty days after final disposition of case, and all devices so held by the department shall be sold biannually at public auction. If no complaint is filed the device shall be returned to the person from whom seized within thirty days from the date seized.

D. A complete report of all wildlife and devices seized by the department showing a description of the items, the person from whom it was seized, if known, and a record of the disposition shall be kept by the department. The money derived from the sale of any devices shall be deposited in the game and fish fund.

17-241. ACQUISITION AND DISPOSITION OF LANDS AND WATERS; RETENTION OF RIGHTS; DISPOSITION OF PROCEEDS

A. The commission, in the name of the state, with the approval of the governor may:

1. Acquire by purchase, lease, exchange, gift or condemnation lands for use as fish hatcheries, game farms, firing ranges, reservoir sites or rights of way to fishing waters.

2. Acquire by purchase, lease, exchange or gift lands or waters for use as fish hatcheries, game farms, shooting areas, firing ranges or other purposes necessary to carry out the provisions of this title.

3. Acquire by condemnation waters for use as fish hatcheries. The acquisition of land acquired by condemnation shall be limited to a maximum of one hundred sixty acres unless first approved by the legislature.

B. The commission may, with approval of the governor and state land commissioner, lease, sublease, exchange, or sell, in the name of the state, any land acquired by gift, purchase, lease, exchange, or other method.

C. Notwithstanding any other provision of law, the sale or transfer of any lands under the provisions of this section shall be subject to a reservation to the state of all mineral rights and may be subject to the right of entry thereon by the public for hunting and fishing purposes.

D. Money derived from a sale or lease shall be deposited in the game and fish fund.

17-242. GUARANTEEING IRRIGATION DISTRICT ASSESSMENT; SALE OF LAND LOCATED WITHIN FEDERAL RECLAMATION PROJECTS AND IRRIGATION DISTRICTS

A. The commission, by and with the approval of the governor and state land commissioner, may make contracts with irrigation districts in the name of the state to guarantee the payment of and to pay to the irrigation district the full amount of district assessments or charges against land owned by the game and fish commission located within a federal reclamation project, or an irrigation district which is served wholly or in part by such federal reclamation project, at any time such assessments or charges become delinquent.

B. If the commission sells any of the land referred to in subsection A, it shall require at least one-fourth of the sale price to be paid at the time of sale and the balance payable in not less than twenty years. The contract of sale or other document of sale shall require that the purchaser pay such irrigation district assessments or charges before delinquency, and that failure to do so shall constitute a breach of the terms of sale. If a purchaser defaults in the payment of such irrigation district assessments or charges and the interest of the purchaser in such land is terminated, the subsequent purchaser shall pay to the commission as reimbursement the full amount of delinquent assessments due upon such land.

C. The contract or other document of sale shall also require that if the purchaser defaults upon any term or condition of the sale and does not remedy the default within six months, the irrigation district may perform or remedy the default of the purchaser. When the irrigation district cures the default in the terms of sale, the interest of the purchaser shall be cancelled and his interest in such land shall be transferred to the irrigation district subject to the contract of sale.

D. Nothing in this section shall be construed as creating any lien upon state lands or against the interests of the state therein, or as creating any obligation of the state to pay any charges, assessments or debts incurred by any districts other than those described in this section.

17-243. SALE OF SURPLUS PRODUCTS OF FEDERAL AID PROJECTS; DISPOSITION OF PROCEEDS

The commission may sell surplus products of federal aid wildlife projects. The proceeds of such sale shall be placed in a special game and fish fund to be known as the federal aid wildlife projects maintenance fund and may be used by the commission for maintenance of federal aid projects wherever located in the state.

17-244. BULLETIN; REFUGE SIGNBOARDS; POSTED LANDS

A. A hunting and fishing bulletin shall be available through all license dealers and at such places as the commission may designate.

B. Notices or signboards shall be of a size not less than eight by eleven inches and as many of the notices or signboards shall be posted as the commission determines necessary to give public notice of the location of the boundaries of the closed area.

Riparian Habitat

Commission Policy

Riparian habitat is defined as distinct vegetation and land shape which occur in or adjacent to drainage ways and/or their flood plains. It is characterized by different species or life forms, both plant and animal, than those of the immediately surrounding habitat. The riparian zone is typically the strip of land bordering lakes, rivers, and streams whose vegetation depends on a high water table resulting from proximity to an aquatic ecosystem or to subsurface water.

Riparian habitats in the arid Southwest provide forage, water, and cover for a substantial number of game and nongame species, as well as providing essential components for aquatic life. Importance of riparian habitats is further evidenced by considering that a majority of special category wildlife species are obligate riparian inhabitants.

Riparian habitat in Arizona has been a focal point for human development and resource utilization since the early 1800s. The result has been the deterioration and loss of this rare and valuable natural resource. Less than 15 percent of historic riparian areas remain at this time.

It is the policy of the Arizona Game and Fish Commission that the Department shall recognize riparian habitats as areas of critical environmental importance to wildlife and fisheries. The Department shall actively encourage management practices that will result in maintenance of current riparian habitat, and restoration of past or deteriorated riparian habitat in accordance with the Department Wildlife Habitat Compensation procedures. Further, the Department shall actively encourage the maintenance, restoration, and protection of instream flows, which are often essential to maintaining riparian habitat.

Note: Former Commission Policy J1.1, Eff. 10/16/87; renumbered to I2.4 on 01-01-91; revised by motion of the Commission on 03-15-91, and renumbered to A2.13.

Wildlife and Wildlife Habitat Compensation

Commission Policy

It is the policy of the Arizona Game and Fish Commission that the Department shall not accept compensation at less than a 100% level for actual or potential habitat losses resulting from land and water projects. Further, habitat compensation plans developed in accordance with Federal and State law, will utilize resource category designations as stipulated in the Department's Wildlife and Wildlife Habitat Compensation Procedures. Among factors deemed important by the Commission are potential impacts to special category species and/or economically important wildlife species as well as issues which reflect the value, quantity, and quality of habitats which may be impacted by proposed projects.

Note: Former Commission Policy J11, Eff. 6/26/87, renumbered to I2.7 on 01-01-91; reviewed without change by the Commission on 03-15-91, and renumbered to A2.16.

Wildlife and Wildlife Habitat Compensation

Department Policy

It shall be the policy of the Department to develop adequate compensation plans for actual or potential habitat losses resulting from land and water projects in accordance with State and Federal laws. Habitat compensation plans will be predicated upon a 100% level of compensation and will be developed using habitat resource category designations. See Commission Policy A2.16.

Authority

The Director of the Arizona Game and Fish Department is authorized under A.R.S. Title 17-211, Subsection D, to perform the necessary administrative tasks required to manage the wildlife resources of the State of Arizona. Pursuant to those duties and in accordance with federal environmental laws and resource management acts, such as the National Environmental Policy Act, Fish and Wildlife Coordination Act, and Endangered Species Act, the Director is further charged with cooperating in the determination of potential impacts to Arizona's wildlife resources resulting from federally funded land and water projects. In addition, a Commission M.O.U. assigns similar responsibilities for evaluating proposed projects on lands administered by the State Land Department. An integral part of this process is the development of adequate compensation measures aimed at eliminating or reducing project-associated impacts.

Procedure

Criteria used to identify general compensation goals are as follows:

A. Resource Category I.

1. Designation Criteria:

   Habitat in this category are of the highest value to Arizona wildlife species, and are unique and/or irreplaceable on a statewide or ecoregion basis.

2. Compensation Goal:

   No loss of existing in-kind habitat value.

3. Guideline:

The Department will recommend that all potential losses of existing habitat values be prevented. Insignificant changes that would not result in adverse impacts to habitat values may be acceptable provided they will have no significant cumulative impact.

4. Habitat Types:

Habitat types associated with Resource Category I shall include, but not limited to the following examples:

a. Perennial Stream Habitats.

b. Westlands and Riparian habitats of at least one acre in size which are associated with perennial waters. Biotic communities included in this classification follow descriptions provided in Brown (1982) and Henderson and Minckley (1984).

c. Key utilization areas for species listed or proposed for listing under the Endangered Species Act of 1973 as Threatened or Endangered and Endangered State Threatened Native Wildlife species.

B. Resource Category II.

1. Designation Criteria:

Habitats in this category are of high value for Arizona wildlife species and are relatively scarce or becoming scarce on a statewide or ecoregion basis.

2. Compensation Goal:

No net loss of existing habitat value, while minimizing loss of in-kind value.

Wildlife and Wildlife Habitat Compensation

3. Guideline:

The Department will recommend that all potential losses of Resource Category II habitat values be avoided or minimized. If significant losses are likely to occur, the Department will recommend alternatives to immediately rectify, reduce, or eliminate these losses over time.

4. Habitat Types:

Habitat types associated with Resource Category II shall include, but not limited to, the following examples:

a. Key utilization areas for antelope and bighorn sheep.

b. Key utilization areas for Threatened and Candidate State Threatened Native Wildlife species, candidate species for federal listing as Threatened or Endangered (Categories 1 and 2).

c. Actual or potential reintroduction sites for species that are listed as Extirpated or Endangered on the State Threatened Native Wildlife list.

d. Blue ribbon fishing areas (i.e., Lee's Ferry and Becker Lake).

e. Isolated mountain ranges providing Subalpine-coniferous forest habitats (i.e., Pinaleno Mountains).

f. State and federally operated game preserves, refuges or wildlife areas.

g. Montane meadows.

C. Resource Category III.

1. Designation Criteria:

Habitats in this category are of high to medium value for Arizona wildlife species, and are relatively abundant on a statewide basis.

Wildlife and Wildlife Habitat Compensation

2. Mitigation Goal:

No net loss of habitat value.

3. Guidelines:

The Department will recommend ways to minimize or avoid habitat losses. Anticipated losses will be compensated by replacement of habitat values in-kind, or by substitution of high value habitat types, or by increased management of replacement habitats, so that no net loss occurs.

4. Habitat Types Involved:

Habitats in this category are of a natural, undisturbed condition or they involve bodies of water of economic importance and shall include, but not be limited to, the following examples:

a. Chihuahua, Great Basin, Mohave, and Sonoran Desert habitat types.

b. Desert-grasslands and Chaparral zones.

c. Oak and coniferous woodlands and coniferous forests.

d. Reservoir habitats.

D. Resource Category IV.

1. Designation Criteria:

Habitats in this category are of medium to low value for Arizona wildlife species, due to proximity to urban developments or low productivity associated with these lands.

2. Mitigation Goal:

Minimize loss of habitat value.

Wildlife and Wildlife Habitat Compensation

3. Guideline:

The Department will recommend ways to avoid or minimize habitat losses. Should losses be unavoidable, the Department may make a recommendation for compensation, based on the significance of the loss.

4. Habitat Types Involved:

Habitat types associated with Resource Category IV shall include, but not be limited to, the following examples:

a. Agricultural Lands.

b. Undeveloped urban areas (i.e., land proximal to waste water treatment facilities, municipal mountain preserves, and undeveloped lands in proximity to municipal and industrial areas).

c. Habitats exhibiting low wildlife productivity as a result of man's influence.

4)Definition
PublicTrust

Putting the Public Trust Doctrine to Work

The Application of the Public Trust Doctrine To the Management of Lands, Waters and Living Resources of the Coastal States

November 1990

THIS REPORT WAS PREPARED UNDER CONTRACT WITH THE CONNECTICUT DEPARTMENT OF ENVIRONMENTAL PROTECTION, COASTAL RESOURCES MANAGEMENT DIVISION, WITH FUNDS PROVIDED UNDER SECTION 309 OF THE FEDERAL COASTAL ZONE MANAGEMENT ACT BY THE OFFICE OF OCEAN AND COASTAL RESOURCES MANAGEMENT, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, UNITED STATES DEPARTMENT OF COMMERCE, AS PART OF A NATIONAL PROJECT ON THE PUBLIC TRUST DOCTRINE.

- What considerations are there for State agencies with public trust responsibilities? (Ch. VI and IX).
- What role does the federal government play under the Public Trust Doctrine? (Ch. X).
- How can the Public Trust Doctrine be used on common day-to-day issues facing coastal resource managers? (Ch. VIII, §3).
- How can the Public Trust Doctrine be used through the federal consistency provisions of the CZMA? (See Ch. VIII, §4)
- How can the Public Trust Doctrine be used for long-term management and planning? (Ch. VIII, §§1 and 2).
- Does the analogous body of private and charitable trust law have any guidance to offer for those implementing the Public Trust Doctrine? (Ch. XI).
- What must a State consider when trying to incorporate the Public Trust Doctrine into its coastal resource program? (Ch. XII).

This volume is intended to serve as an overall review of the subject—a starting point for anyone interested in the Public Trust Doctrine or managing trust lands, waters and resources. It is our hope that the reader will gain a national perspective on how to use and apply this ancient body of law to coastal resource management in today's modern world.

What is the Public Trust Doctrine?

In the United States, shorelands, bottomlands, tidelands, tidewaters, navigable freshwaters and the plant and animal life living in these waters are accorded special treatment under State and Federal law. For the most part, these lands, waters and wildlife are owned by the public, but held in trust by the State for the benefit of the public. Generically, the body of law pertaining to these lands, waters and living resources is called the Public Trust Doctrine.

The Public Trust Doctrine provides that title to tidal and navigable freshwaters, the lands beneath, as well as the living resources inhabiting these waters within a State is a special title. It is a title held by the State in trust for the benefit of the public, and establishes the right of the public to use and enjoy these trust waters, lands and resources for a wide variety of recognized public uses. Of great importance, it is also a title with two components: the public's trust title (*jus publicum*) and a private proprietary title (*jus privatum*), discussed more fully below.

Lands. Waters and Living Resources Subject to the Public Trust Doctrine

To apply the Public Trust Doctrine, one must first determine whether the land, water or living resources in question are indeed within the geographic scope of the doctrine. **Generally speaking, all "navigable waters," the lands beneath these waters and the living resources inhabiting them are subject to the Public Trust Doctrine.**

What is meant by the term "navigable waters" has been the source of confusion for centuries in both State and Federal courts. Under the English common law, due to the geography of England, the term "tidewaters" and "navigable waters" were synonomous. The presumption was that tidelands were owned by the king, although a grant of the private *jus privatum* interest could be conveyed into private hands. In such a case, the public's *jus publicum* interest remained paramount over the *jus privatum* interest. See Ch. II, §1.A.3.

English common law became the law of the thirteen colonies, and then of the Thirteen Original States. Each of the Thirteen Original States held, and continues to hold, a public trust interest in their lands subject to the ebb and flow of the tide, up to the ordinary high water line. Each also had, and continues to have, the authority to define the term "navigable waters" under State law, define the boundary limits of the lands held in public trust, as well as the authority to recognize private rights in their trust lands, and thus diminish the public's rights therein.

As the Thirteen Original States held their lands beneath navigable waters in trust, so did the 37 new States receive them on an equal footing with the original thirteen. The question of what lands each of the 37 new States, in contrast to the Thirteen Original States, received in trust upon entering the Union is a Federal question. Because the term "navigable waters" has evolved and changed over time, one must look to the Federal law at the time the State entered the Union to determine what trust lands passed to the State upon statehood. See Ch. II, §1.A.2 and 3.

After statehood, State law (if not in conflict with Federal law) applies to determine ownership of the lands beneath navigable waters, as well as the public rights in those waters. **As a result, as the definition of navigable waters has changed and evolved on both the Federal and State level, so too has the area of lands and waters subject to the Public Trust Doctrine.**

The Dual Title in Public Trust Lands: Jus Publicum & Jus Privatum

Public trust lands, i.e. tidelands, freshwater shorelands and submerged lands, are special in nature. Because of the salt content, weathering action, constant flooding and adverse environment, they are useless for nearly all types of agriculture. Structures built on trust lands must be strongly reinforced to weather the tremendous forces of wind, wave and ice placed upon them. Traditionally, "permanent" structures built on trust lands were to further navigation or waterborne commerce.

Because of the special nature and public character of these lands, the title is not a singular title in the manner of most other real estate titles. Rather, public trust land is vested with two titles: the *jus publicum*—the collective rights of the public to fully use and enjoy trust lands and waters for commerce, navigation, fishing, bathing and other related public purposes—and the *jus privatum*, or the private proprietary rights in the use and possession of trust lands. See Ch. I.D and E.

The *jus publicum* interest cannot be conveyed or alienated to private ownership, for the State cannot abdicate its trust responsibilities to the people. These collective rights are the public's property rights in these lands, waters and resources, rights that are held in trust by the State.

On the other hand, the *jus privatum* interest may be and often is conveyed into private ownership. Nearly one-third of all public trust land is privately owned. In most cases, when a private individual or firm "owns" tidelands, shorelands, or submerged lands, he or she holds only the *jus privatum* interest, an interest that remains subject to the public's dominant *jus publicum* interest.

It is commonly stated that trust lands are either publicly owned or privately owned. In both instances, however, the State retains and holds in trust the public's *jus publicum* interest. For 'publicly' owned trust lands, the State also holds the *jus privatum* title, whereas for 'privately' owned trust lands the State has conveyed the *jus privatum* into private ownership. Thus, the difference between publicly owned and privately owned trust lands is whether the State has validly conveyed the *jus privatum*. See Ch. V.A.

Upper Boundary of Public Trust Lands

In general, the upper boundary of public trust shorelands, whether those lands are privately or publicly held, is the "ordinary high water line." For tidal shorelands, this term is generally defined as the mean high tide line, although many exceptions and diverse interpretations exist throughout the country. For freshwater shorelands, this term generally means the line to which high water reaches under normal conditions, not the line reached in floods nor by the great annual rises of a river. In all situations, however, the location and description of the upper boundary of trust shorelands is determined by local law, custom and practice.

A growing number of States recognize some public trust interests in privately owned "dry sand" areas immediately upland of the mean high tide line, usually extending up to the vegetation or debris line. These States have judicially recognized that the use of the dry sand beach is essential for the public to fully enjoy their public trust rights of access and use to trust lands (below the mean high tide line) and waters. This is certainly a common sense approach, in that the tides rise above the "mean" high tide line atleast half the time; the public's trust rights should not be temporarily cut off during these times of higher high tides. See Ch. IV.B.1.

Further, there may be public trust considerations concerning the use of non-navigable tributaries to navigable freshwaters and public trust uses therein. See Ch. II, §2.

Boundaries of Public Trust Land: A Moveable Freehold

Natural, gradual and imperceptible changes in the shoreline (erosion and accretion) generally act to change the boundaries of both the privately owned uplands and the public trust lands. Natural, sudden changes in the shoreline, such as those caused by severe storms or earthquakes (avulsion), usually do not act to change boundary lines.

Man-induced changes such as filling or other modifications of the shoreline by the upland owner normally do not act to change boundary lines unless a clear legislative grant provides otherwise. Some States do provide, however, that accretion or erosion resulting from artificial changes to the shoreline, such as groins and jetties, will change the upland boundary line if the upland owner is a "stranger" to the man-induced change.

The public's trust rights in "new" shoreland resulting from natural, gradual and imperceptible forces remain unchanged. The public's trust rights to use shoreland within the boundaries of the upland owner due to avulsion, however, remain unclear. **The public's trust rights to use filled trust land also is unclear, with significant variation between State court rulings and statutes on the point.** See Ch. II, §3.

Lands Exempt from the Public Trust Doctrine

Lands beneath tidal and navigable fresh waters and below the ordinary high water mark are presumptively subject to the Public Trust Doctrine. In fact, many States apply the Public Trust Doctrine to all tide waters, navigable freshwaters and the lands below these waters within their respective jurisdictions without exception.

Exceptions do exist, however, although their occurrence is infrequent and usually strictly limited. Nonetheless, these exceptions are important, for if presumably public trust lands are found to fall within one or more of these exceptions, the Public Trust Doctrine does not apply. Exceptions include conveyances of shorelands prior to statehood, conveyances in accordance with international obligations, federal condemnation of State public trust land, Indian treaties, artificially created shorelands, and other minor exceptions. See Ch. II, §4.

Public Uses Protected by the Public Trust Doctrine

The original purpose of the doctrine was to assure public access to navigable waters for navigation and commerce (waterways being the principal transportation arteries of early days) and for fishing, an important source of food. Thus, **historically, the common law rights of the public in trust lands and waters were related to navigation, commerce and fishing.** But State and Federal courts have recognized that "when administering the trust the State is not burdened with an outmoded classification favoring one mode of utilization over another."

As society and technology have evolved, however, the public's use of trust lands and waters has necessarily changed. Over the centuries the Public Trust Doctrine has kept pace with the changing times, assuring the public's continued use and enjoyment of these lands and waters. Recognized public uses of trust lands today include fishing, bathing, sunbathing, swimming, strolling, pushing a baby stroller, hunting, fowling, both recreational and commercial navigation, environmental protection, preservation of scenic beauty, and perhaps the most basic use, just being there.

The Public Trust Doctrine has evolved from preserving the public's rights to use trust lands and waters for commerce, navigation and fishing, to protecting modern uses that are "related to the natural uses peculiar to that resource." This dynamic nature, firmly documented by the courts over the centuries and fundamental to the application of the doctrine, has enabled it to persist for over 1,500 years. **Strip away the inherent flexibility of the doctrine to assure public access to, and use of, trust lands, waters and living resources and the doctrine would slowly whither away.** See Ch. III.

The Conveyance of Public Trust Land

As noted, the *jus publicum* interest in trust lands cannot be conveyed or alienated to private ownership, for the State cannot abdicate its trust responsibilities to the people. The *jus privatum* interest, however, may be and often is, conveyed into private ownership.

There are strict limitations upon the State in order to convey the *jus privatum* to private ownership. The Legislature must act through legislation to authorize the conveyance. The conveyance must be described in clear and definite language, with all ambiguities construed in favor of the State and against the grantee. The conveyance must primarily further the public interest, with benefits to private parties being secondary or corollary. There must be no substantial impairment of the public interest in the lands and waters remaining. Non-compliance with any of these requirements violates the Public Trust Doctrine, and can render the conveyance void.

Courts will strictly scrutinize a conveyance of public trust lands for compliance with all of the above requirements. In addition, if a State legislature later determines that a prior conveyance of trust land has the effect of diminishing or destroying its control of the *jus publicum*, the conveyance may be lawfully revoked. See Ch. V.A.

The majority of states hold themselves immune from losing title of public trust lands by adverse possession, although a handful of states recognize adverse possession against public trust lands. See Ch. V.C.

The public's rights and interests in trust lands and waters can only be terminated in certain small parcels, usually those necessary for the construction of docks and wharves to further navigation or waterborne commerce. The termination must further the public's trust interests, although some courts have accepted the furtherance of any public interest—regardless of whether it is related to trust lands and waters—as sufficient to terminate the trust. See Ch. V.D.

The Nature of the Remaining Public Trust Servitude

Once the *jus privatum* interest has been conveyed from the State to private hands, the public's remaining trust rights in the trust land, collectively known as the public's trust servitude, are usually diminished. The nature of the remaining public trust servitude in privately held trust lands varies from State to State. In one State, the servitude may not include many rights of the public, not even the right to use trust lands solely for recreational purposes. In other states, the bundle of rights held by the public remain so broad, and the corresponding private rights so limited, that the private owner's title has been described as a 'naked fee.' In either case, all of the public's trust rights are dominant to the private rights. See Ch. V.B.

State Exercise of its Public Trust Authority

Authority vested in the State through the Public Trust Doctrine is based upon its power over State property, rather than a State's regulatory powers through its sovereign "police powers." Thus, if the lands, waters or living resources are within the scope of the doctrine, then the State can govern and manage them as its own property. This is in sharp contrast to a State regulating a citizen's private property through its police powers.

At the same time, whenever a State exercises its public trust authority, it does so immediately adjacent to some of the most expensive real estate in America—waterfront property. Waterfront property owners hold extremely strong property interests, especially if they also own the *jus privatum* rights in the adjacent public trust land.

Usually a private *jus privatum* owner of public trust land pays property taxes on the trust lands, lending a certain credence to the perception that he or she has sole possession and control of the property, exclusive of the public. Adding to the confusion, boundary descriptions in deeds and property titles of waterfront property often are silent as to any *jus publicum* retained by the State, giving the landowner the further expectation that he or she has exclusive rights of possession and use of the land. Boundary descriptions may simply state that the property extends "to the water" or even to the "low water mark" or some similar phrase. Waterfront property owners commonly regard their property as extending to where the water is, unaware that the State has a reserved *jus publicum* interest up to the "ordinary high water mark"—a boundary line that is often difficult to factually determine. It is also very common for a commercial upland owner, such as a resort or marina owner, to have a strong economic interest in the use of adjacent publicly owned trust lands and waters.

Given the strong property interests of private upland owners, coupled with the confusion over the distinction of the *jus publicum* and *jus privatum* in trust lands and how the Public Trust Doctrine applies, coastal managers need to be keenly aware that their actions under the doctrine may be met with strong resistance. Claims of "takings and charges of governmental interference in private property rights should be expected. See Ch. I.F.

for such persons to explore or producethe oil and gas resource, while remaining subject to the public's continued trust rights to use the area in accordance with the Public Trust Doctrine in that State.

The production of oil and gas from State trust lands has been found to further the public's trust interests by promoting both commerce and navigation, and therefore is a proper use of public trust land. Revenue flowing to the State from oil and gas production is often partly or fully appropriated to study, preserve and manage coastal resources. Such funds clearly provide a public benefit for the public's trust resources. See Ch. VIII, §3.C.

5. *Aquaculture*

Fish are held in trust by the State for the public, and the State is obligated to preserve and protect this trust. Regulations governing the artificial cultivation of fish and shellfish are clearly within the scope of the Public Trust Doctrine, and in fact should incorporate public trust principles.

In the issuance of leases or permits for aquaculture, many states include provisions that the aquaculture operation will not interfere with other public uses of the area, such as fishing, lobstering, shellfishing, bathing or boating. Such express limitations on the operations are encouraged to clearly inform all parties that the aquaculture operation is subject to the State's Public Trust Doctrine.

Limitations have been placed on aquaculture, such as artificial oyster propagation, in order to protect naturally occuring marine species. For example, private shellfish aquaculture operations often are not allowed on public trust lands where natural shellfish beds occur.

The issuance of leases or permits for aquaculture becomes more problematic when the trust land is privately owned. In this case, the State is in the more difficult position of asserting that aquaculture is one of the public trust uses that, like navigation, commerce and fishing, was reserved by the State when the conveyance was made. In other words, the State must assert that aquaculture is part of the *jus publicum* interest reserved by the State, and was not included in the *jus privatum* conveyance to the private trust land owner.

If the aquaculture lease holder is different from the private trust land owner, questions will naturally arise as to how the rights of the two parties compare. Although it is broadly held that the public's *jus publicum* rights are superior to any *jus privatum* rights, it has been held in Massachusetts that a license to shellfish must not impair the private rights of the landowner to moor his boat in the area covered by the license, even if at low tide the boat would rest on, and therefore damage, the shellfish beds. See Ch. VIII, §3.D.

6. Environmental Protection

Historically, the common law rights of the public in trust lands and waters were related to navigation, commerce and fishing. **Recently, however, several states have recognized that in order for the public to exercise their right of fishing, there must be fish.** That is, there must be a sustaining environment within which the fish can live. Thus, the step from managing trust fisheries to preserving the ecological integrity of trust waters is not such a large one. As a result, the Public Trust Doctrine serves as a solid basis for environmental protection legislation or regulations.

Some State courts have upheld the regulation, and prohibition, of certain activities in order to protect water quality in accordance with the Public Trust Doctrine. A limitation on the diversion of water from tributaries feeding into navigable trust waters, which would result in a deterioration of trust water quality, as well as a moratorium on shorefront building permits have both been upheld by the courts based on public trust grounds.

A major problem confronting coastal resource managers is the deterioration of water quality due to non-point pollution resulting from upland land use practices. To date, no court has upheld an expansion of the doctrine as a basis for regulating land use above the ordinary high water mark.

Even as a basis for such regulation below the high water mark, applying the Public Trust Doctrine to water quality protection may be challenged in court. While water quality regulations would serve the public interest in one respect, they are likely to restrict other uses which the doctrine protects. See Ch. III.B.2.

7. Estuarine Ecosystems

Several States, in response to judicial decisions that have brought preservation of estuarine ecosystems within the scope of the Public Trust Doctrine, have included public trust principles into their estuarine management programs. Typically, these programs contain a "public purpose" test developed by the courts under the Public Trust Doctrine: the use must be water-dependent with minimal impact on public trust lands, waters and resources.

Estuarine management plans often exist in context, or are required to be consistent, with a State's federally-approved CZM plan. The CZMA requires comprehensive management plans, and encourages special area management plans. As a result, several States have designated estuaries as "areas of environmental concern" or "critical areas," and developed management plans to preserve the quality and integrity of entire estuarine ecosystems. See Ch. VIII, §3.E.

authority, the power tolease as well as license may well be implied. See Ch. IX, §1. This is so because a lease is essentially a legal authorization for the landowner to possess and use a parcel of land, which is not functionally different than a license. See Ch. VIII, §2.E.3.

By implementing a licensing or leasing program for public trust lands, a State agency can assume much greater control over activities and development of coastal resources, as well as having each license or lease come up periodically for renewal. Further, the fees raised by the licenses or lease payments should be applied towards coastal resource management, thus helping the agency accomplish its chief mission.

Since the trust lands subject to leasing is of great public importance and subject to potential controversy, the prudent agency should use regulations to establish the terms of years for various types of leases. Although an agency may be empowered to issue leases without regulations on an *ad hoc* adjudicatory basis, promulgating leasing regulations forces important issues to full public display, as well as putting the agency in a much better position in the case of a court challenge. Courts subject regulations to less rigorous judicial scrutiney than agency adjudicatory decisions and are consequently more likely to survive intact if challenged. See Ch. VIII, §2.E

Conclusion

The Public Trust Doctrine offers a coastal resource manager a powerful tool in addition to a State's regulatory police power. The doctrine places the coastal manager in the stronger position of managing publicly owned resources, rather than regulating privately owned property. The doctrine also provides a sound legal basis for requiring all uses of trust lands and waters to be water-dependent. Further, although much trust land is privately owned, these private rights in trust land are for the great part subject to the dominant rights of the public to use these same lands for a wide variety of recognized uses.

The Public Trust Doctrine is tremendously versatile. It can be used to address problems as diverse as public access to coastal areas, oil and gas production, and environmental quality. For example, negotiations on a permit application for a marina development, the promulgation of regulations to improve water quality, statutory restrictions on conveyances of trust lands to private ownership, or assessing leases and royalties on leasehold or mineral development, can all be based upon the Public Trust Doctrine.

In short, the Public Trust Doctrine is applicable whenever navigable waters or the lands beneath are altered, developed, conveyed, or otherwise managed or preserved. It applies whether the trust lands are publicly or privately owned. The doctrine articulates not only the public rights in these lands and waters. It also sets limitations on the States, the public, and private owners, as well as establishing duties and responsibilities of the States when managing these public trust assets.

In addition, exercising a State's public trust authority is to exercise power over a State's own property. This places the coastal resource manager in a well protected positic from successful "takings" arguments. The State and Federal case law concerning the "taking" of private property by a government without "just compensation" stems almost solely from the exercise of State police power; i.e. when the State attempts to regulate the use of someone else's property. By exercising its public trust authority, however, a State is managing its own property. Nearly all of the "takings" case law is thus irrelevant to this situation.

In the final analysis, the Public Trust Doctrine is a valuable legal legacy from Roman emperors and English kings to the American Public—the right to use and enjoy America's trust lands, waters and resources for a wide variety of legally protected public uses. This legal doctrine places over 191,000 square miles of lands and waters and the aquatic life therein, plus the 98,664 miles of shoreland below the ordinary nigh water line, in trust for the benefit of the public. As the public's trustee of these assets, each State is an important steward over what Roman Emperor Justinian claimed by the law of nature to be common to all mankind.

Ordinary high water mark: The line to which high water normally reaches under natural conditions, but not including floods, storms, or severe meteorological conditions.

Ordinary low water mark: The line to which low water normally reaches under natural conditions, but not including droughts or severe meteorological conditions.

***Prima facie* public trust lands:** Lands that appear to be subject to the Public Trust Doctrine in that they lay beneath tidal or navigable-in-fact waters below the ordinary high water mark.

Public trust servitude: The bundle of rights held by the public to use and enjoy privately held trust lands for certain public purposes. The burden on the subordinate *jus privatum* owner by the dominant *jus publicum* interest of the public.

Riparian: Associated with or appurtenant to shorelands of non-tidal waters.

Riparian Rights: The rights of an owner of land contiguous to a navigable body of water, including principally the right of access to the water, the right to accretions and relictions, and the right to other improvements.

Shorelands: General term including tidelands and navigable freshwater shores below the ordinary high water mark.

Submerged land: Land lying below tidal waters, seaward of the ordinary low water mark, including bays, inlets and other arms of the sea, out to the seaward boundary of the State.

Tideland: Land that is covered and uncovered by the daily rise and fall of the ordinary tides. More specifically, it is the zone between the "ordinary high water mark" and the "ordinary low watermark."

Tide waters: Waters that markedly and regularly ebb and flow in response to the gravitational forces of the moon and sun.

Upland: Land lying above the "ordinary high water mark."

Wet sand beach: Area between the mean high tide and the mean low tide lines.

they adopted the Articles of Confederation, or when the Confederated Congress enacted the Northwest Ordinance of 1787 (discussed below). Nor did this change when the first Congress reenacted the Northwest Ordinance on August 7, 1789.[15] Thus, at the time of the adoption of the Constitution, the Thirteen Original States reserved full sovereignty, dominion, ownership and control over their tidelands, "subject only to the rights surrendered by the Constitution of the United States."[16]

Because the Federal government never had original jurisdiction over the trust lands and waters of the Thirteen Original States, it never conveyed these lands to any of them. Thus, no Federal question arises as to what lands were held in trust by any of the original States when they formed the Union. This is in contrast to the situation of the 37 new states, as discussed below.

Nonetheless, as this public trust was 'funded' and controlled by the Thirteen Original States at the time of adoption of the Constitution, so has it been perpetuated by the Equal Footing Doctrine to the 37 "new" States that have since joined the Union.

2. *Equal Footing Doctrine and the 37 "New" States*

Just prior to the ratification of the U.S. Constitution in 1788, the Confederated Congress adopted the "Ordinance of 1787: The Northwest Territorial Government," known simply as the Northwest Ordinance. In general, the Northwest Ordinance established guidelines for the government of the northwest territory and for the admission of new States, formed from the territory, into the Union. Specifically, it also provided that any State joining the Union "shall be admitted ... on an equal footing with the original States, in all respects whatever ... ."[17] This provision became the model for the enabling legislation of all of the 37 new States entering the Union, albeit the actual terminology is often different. This practice of admitting new States as equals to the original 13 has long been referred to as the Equal Footing Doctrine.

In applying the Equal Footing Doctrine the United States Supreme Court has consistently found that "the new States admitted into the Union since the adoption of the Constitution have the same rights as the original States in the *tide waters*, and in the lands under them, within their respective jurisdictions."[18] Alternatively put, "First, The shores of *navigable waters*, and the soils under them, were not granted by the Constitution to the United States, but were reserved to the states respectively. Secondly, The new states have the same rights, sovereignty, and jurisdiction over this subject as the original states."[19] These rights, sovereignty, and jurisdiction of the states were "subject only to the rights surrendered by the Constitution of the United States."[20] As can be seen, these rights have been variously described as pertaining to lands beneath either "tide waters" or "navigable waters," a dichotomy of definitions that would trouble and confuse courts for two centuries.

Thus, the Equal Footing Doctrine has served to perpetuate the Public Trust Doctrine from the Thirteen Original States to each of the 37 new States. As each new State entered the Union she received in trust those lands beneath "tide waters" or "navigable waters," and the waters themselves, in trust for the citizens of the new State. What lands and waters were received by each of the 37 new States, in contrast to the Thirteen Original States, from the Federal Government upon Statehood is singularly a Federal question.[21] Thus, the Federal definition of "navigable waters" is of primary importance in determining what lands and waters were received in trust by each new State upon entering the Union.

But unfortunately, the confusion surrounding the term 'navigable waters' — whether it means only tide waters regardless of the navigability of those waters, or all waters that are actually navigable regardless of the tide — has troubled courts from the founding of the country up to recent times. The 1988 United States Supreme Court case *Phillips Petroleum v. Mississippi* pivoted around whether Mississippi received in trust all lands beneath tide waters, regardless of navigability of those tide waters, when she entered the Union in 1817, or whether she received in trust only those lands beneath waters that were navigable-in-fact at the time of statehood. The Court ruled that all lands beneath tide waters, regardless of navigability of those tide waters, were received by the State when she entered the Union.

Early on, however, English common law was strictly adhered to, and only tidal waters were considered navigable. But this legal definition defied reality in the United States with our large inland rivers and lakes. Courts recognized the problem, and grappled with the legal, commercial and practical ramifications of the confusion generated by the term 'navigable waters.' As a result, from the entry of Vermont into the Union as the fourteenth State on March 4, 1791, to the entry of Hawaii as the fiftieth State on August 21, 1959, the definition of the term 'navigable waters' has continued to evolve and change, both at the Federal and State level. Because of this evolving meaning, the Federal test of 'navigable waters' for title purposes is "determined as of the time of admission of the State to the United States."[22]

3. *Evolution of the term 'Navigable Waters'*

The definition of the term 'navigable waters' is of critical importance; upon its interpretation rests the title claims and property interests of governments and private entities, and the application of the Public Trust Doctrine to lands, waters and living resources. It has been said that "The division of waters into navigable and nonnavigable is but a way of dividing them into public and private waters."[23] Confusion over the meaning of the term 'navigable waters' has resulted in a well-spring of contentious litigation nationwide over the ownership of bottomlands and submerged lands, and claims of exclusive use of the waters and living resources therein.

Precisely what is meant by the term 'navigable waters' depends upon whether the Federal or State government is inquiring, and for what purpose. There are Federal definitions of 'navigable waters' for title purposes, for admiralty court jurisdiction, and for constitutionally enumerated powers and authorities. In addition, there are State definitions of 'navigable waters' for title purposes, as well as defining those waters wherein the public has trust rights.

For title purposes, the Federal definition of 'navigable waters' is of primary interest, although State definitions have an important bearing on the matter. The situation is confounded, however, due to the changing and evolving Federal definition of 'navigable Waters.' To discuss the evolution of the meaning of this term, it is best to start with English common law.

a. English common law definition of 'navigable waters'

"[In England], no waters are navigable in fact, or, at least, to any considerable extent, which are not subject to the tide; and from this circumstance tide water and navigable water there signify substantially the same thing."[24] In other words, under English common law, the terms "navigable waters" and "tidal waters" were considered as being synonymous,[25] simply because no rivers above the ebb and flow of the tide were significant with respect to navigation. The tremendous difference in topography between England and the American continent, however, presented the Federal and State courts with great difficulties in reconciling this English common law term with the geographical realities of the United States.

b. Federal definitions of 'Navigable Waters'

In 1851, the United States Supreme Court described the origin and history of the term 'navigable waters' under Federal law.

> "At the time the Constitution of the United States was adopted, ...the definition [of navigable waters] which had been adopted in England was only proper here. In the old thirteen States the far greater part of the navigable waters are tide-waters. And in the States which were at that period in any degree commercial ... every public river was tide-water to the head of navigation."[26]

Thus, it was only natural for Federal courts to adhere to the tidal test for determining public waters. The tidal test:

> "became, after a time, the familiar mode of describing a public river, and was repeated, as cases occurred, without particularly examining whether it was as universally applicable in this country as it was in England. ... And as the English definition was adopted in our courts, and constantly used in judicial proceedings and forms of pleading, borrowed from England, the public character of the river

D. Living Resources Within the Public Trust

Several State courts have recently stated that the scope of the Public Trust Doctrine includes the aquatic wildlife living in trust waters,[96] most notable of which are fish. Thus, not only is fishing a traditionally recognized public trust use (see Ch. III.B.2) but fish and all other aquatic wildlife form a part of the trust's assets.

Title to the fish within trust waters vests in the State in trust for the benefit of the people.[97] At least one State court has held that this trust ownership of the fish creates "a sovereign right primarily and essentially of preservation, conservation and regulation for the people of the State ... ."[98] States, through their legislatures, are empowered to impose such statutory restrictions and limitations on fishing "as may be reasonably necessary for the protection of the public's rights therein."[99]

To the extent that a State has statutorily regulated fishing, the legislation would supersede any common law trust rights the public may have in the fish. At the same time, fishery legislation often specifically regulates fish that are of commercial or nutritional interest; it generally does not regulate the public's use of all aquatic life. As a result, a State's public trust interest in the aquatic life is generally much broader than the fisheries regulated by statute.

It is self-evident that in order to have fish to regulate, there must be a sustaining environment within which they can live. In fact, preservation of the fishery is a public trust responsibility of the State. The inclusion of all aquatic life (upon which all fish depend) within the scope of the Public Trust Doctrine, gives a coastal resource manager the authority, and responsibility, to not only take into account a State's fishery resource, but to also consider the ecological system sustaining the fishery resource whenever trust lands or waters are managered. In other words, the step from managing trust fisheries to preserving the ecological integrity of trust waters is not such a large one. See Ch. III, § B.2.

CHAPTER III

PROTECTED USES OF THE PUBLIC TRUST DOCTRINE

Summary

Historically, the common law rights of the public in trust lands and waters were directly related to navigation, commerce and fishing. As society and technology have evolved, however, the public's use of trust lands and waters has necessarily changed. Over the centuries the Public Trust Doctrine has kept pace with the changing times, assuring the public's continued use and enjoyment of these lands and waters. This dynamic nature, fundamental to the application of the doctrine, has enabled it to persist for over 1,500 years. Strip away the inherent flexibility of the doctrine, and it would slowly whither as an effective tool for coastal management.

As recently stated by the New Jersey Supreme Court, "The original purpose of the doctrine was to preserve for the use of all the public natural water resources for navigation and commerce, waterways being the principal transportation arteries of early days, and for fishing, an important source of food."[1] But State and Federal courts have recognized that when "administering the trust the State is not burdened with an outmoded classification favoring one mode of utilization over another."[2] This "dynamic common-law principle" supports the current recognition of uses protected by the Public Trust Doctrine to include recreation, environmental protection, and preservation of scenic beauty.

Over the last 1,500 years, the Public Trust Doctrine has evolved from preserving the public's rights to use trust lands and waters for commerce, navigation and fishing, to protecting modern uses that are "related to the natural uses peculiar to that resource."[3]

A. Traditional Public Uses of Trust Lands and Waters

The traditional uses of public trust lands and waters are often stated as the simple trilogy of commerce, navigation and fishing. Nonetheless, this often-stated trilogy is an oversimplification. Many uses, not necessarily related to any of these three terms, of trust lands and waters have long been recognized. For example, the Massachusetts Supreme Court stated in 1863 that "It would scarcely be necessary to mention bathing, or the use of the waters for washing, or watering cattle, preparation of flax, or other agricultural uses, to all which uses a large body of water, devoted to the public enjoyment, would usually be applied."[4]

1. Navigation and Commerce

Navigable waters and the shorelands have traditionally served as highways for navigation and commerce. The ancient public trust rights, navigation and commerce, date back to pre-Roman days. The tremendous importance of preserving the public's unfettered use of the Nation's navigable waters was recognized in the beginning days of the United States in the Northwest Ordinance of 1787:

> "The navigable waters leading into the Mississippi and St. Lawrence, and the carrying places between the same, shall be common highways, and forever free, as well to the inhabitants of the said territory, as to the citizens of the United States, and those of any other States that may be admitted into the confederacy, without any tax, impost, or duty therefor."[5]

Both navigation and commerce are recognized as protected uses in nearly all coastal states.[6]

In many states, travelers used beaches to traverse the length of the coast. Passing and repassing was one of the original uses protected by the Public Trust Doctrine during the founding years of the Nation.[7] Often, the presence of lagoons and marshes behind the primary dunes of the coast made road construction difficult. In contrast, the compact sand between the shore and the line of vegetation easily supported the weight of a stagecoach or a mule-drawn wagon, and has historically been used for such purposes.[8]

The meaning of the term "navigation" changes from State to State. The majority rule is that both commercial and recreational purposes are included,[9] as well as other uses of the water for transport, such as the flotation of logs.[10] Some States, however, limit "navigation" to only commercial activities.[11]

The scope of the term "commerce" has likewise expanded and evolved in both Federal and State law. At least one State court has noted that commerce is not limited to activities for economic gain, but also includes activities for pleasure and recreation.[12]

2. Fishing

Fishing is a natural incident of the public right to use public trust lands and waters,[13] as well as such incidental uses such as fowling[14], and shellfishing.[15] The public right of fishing has been closely related by the courts to the public right of navigation.[16] Numerous claims of exclusive fishing rights of upland owners owning the bottomlands of navigable lakes and rivers have been defeated on public trust grounds.[17]

The fish inhabiting navigable waters are not owned by the riparian owners, even if the bottomland is privately held. Rather, the fish, as well as all naturally occurring living resources in trust waters, are owned by the public.[18] "Fish in the stream [are] not the property of the [riparian owner] any more than the birds that [fly] over its land."[19] See Ch. II, § 1.D.

State ownership of fish has been recognized by the United States Supreme Court as the source of authority to restrict, or prohibit fishing. "The state holds the propriety of this [bottomland] for conservation of public rights of fishery thereon, and may regulate the modes of that enjoyment so as to prevent the destruction of that fishery. In other words, it may forbid all such acts as would render the public right less valuable or destroy it altogether."[20]

Some States do provide for exclusive fishing rights in private parties, generally for shellfish beds or aquaculture. In some states, such privately held rights (e.g. a license or lease) to a fishery may revert back to the public if these rights are not continuously exercised,[21] or if the license or lease is unlawfully registered.[22]

3. Other Traditional Uses: Bathing, Hunting, Skating, Cutting Ice, Etc.

From the early days of the United States, the public's trust interests recognized by the courts have been much broader than merely commerce, navigation and fishing. For example, in the 1821 New Jersey case *Arnold v. Mundy*, the State Supreme Court recognized "fishing, fowling, sustenance *and all other uses of the water and its products*"23 were rights assured to the public.

Many other traditional uses of the nation's public trust lands and waters have been noted by the courts. Among these are boating, hunting, bathing, swimming, skating, cutting sedge, cutting ice, pushing a baby carriage, washing, watering cattle, preparation of flax, and sustenance, as well as other uses of the trust land and waters that are public in nature and water dependent.[24] The gathering of seaweed is recognized as a natural incident of the public right to use trust lands and waters in at least one State,[25] while being expressly rejected in another.[26]

One of the products of trust waters is ice. Ice cutting can be viewed as an outdated, though traditional public trust use of frozen navigable waters.[27] In some states the right to cut and remove ice may belong only to the owner of the bottomland.[28]

B. The Public Trust Doctrine: A "Dynamic Common-Law Principle"

English common law recognized the inherent dynamic nature of the Public Trust Doctrine. The English public's rights of "egress and regress, for fishing, trading, and other uses claimed or used by [the King's] subjects ... are variously modified, promoted or restrained by the common law."[29] The need for the Public Trust Doctrine to evolve as the needs of society change has been recognized in State and Federal jurisprudence.

> "Traditionally, the doctrine has functioned as a constraint on states' ability to alienate public trust lands and as a limitation on uses that interfere with trust purposes. More recently, courts and commentators have found in the doctrine a dynamic common-law principle flexible enough to meet diverse modern needs. The doctrine has been expanded to protect additional water-related uses such as swimming and similar recreation, aesthetic enjoyment of rivers and lakes, and preservation of flora and fauna indigenous to public trust lands."[30]

Likewise, several states recognize that the Public Trust Doctrine must remain sufficiently flexible to address changing public needs, so that application of the trust does not hinder the state by continuing to favor outdated uses over more modern ones.[31] Early case law recognized that the list of uses would increase with "the growth of the community and its progress in the arts."[32]

Not only do the needs of society change over time, but one legislature cannot terminate or dissolve the authority of a successor legislature because "[t]he legislation which may be needed one day ... may be different from the legislation that may be required at another day. Every legislature must, at the time of its existence, exercise the power of the State in the execution of the trust devolved upon it."[33]

On the other hand, some State courts have been reluctant to extend protection to "new" public uses of trust lands and waters if it would impair any of the traditional rights of commerce, navigation or fishing.[34] Courts often have resorted to whether the public use is really a "new" use, or rather merely an "incidental" use of commerce, navigation or fishing.[35] Other courts have applied a "related-to-the-resource" test to determine whether a public use is protected by the doctrine. For example, preservation of trust land in its natural condition has been upheld in two states as a valid public use because preservation is clearly related to the resource's value of providing food, wildlife habitat and scientific study.[36]

1. Recreational Uses

Arguably, there is nothing new about using trust lands and waters for recreation. Certainly the Romans must have used the tidelands for purely recreational purposes. Several older American cases have recognized the public's traditional use of the shorelands and waters for uses that are non-commercial in nature.[37] Nonetheless, recognition of a public right to use trust lands and waters for recreation is not universal. At least one State, Maine, has expressly excluded recreation as a recognized public trust right.[38] However, the right of the public to use trust lands and waters for recreational purposes has come to be specifically established in most states.[39] Recreational fishing, bathing, surfing, and swimming, even pushing a baby carriage along the public trust shores, have been recognized as public recreational rights in lands and waters subject to the public trust.[40] Even more generally, some states have broadened the rights of the public by establishing public rights in "recreational uses,"[41] tourism,[42] or most broadly, "whatever is needed for the complete and innocent enjoyment" of trust lands.[43]

2. Environmental Protection

Several states have interpreted public trust rights to include restrictions for the prevention of environmental harm and preservation of trust lands and waters. "[O]ne of the most important public uses of the tidelands ... is the preservation of those lands in theimatural state, so that they may serve as ecological units for scientific study, as open space, and as environments which provide food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area."[44] In Hawaii, the State constitution creates an environmental right for the protection of public trust lands and provides for a private cause of action.[45] A Washington State court recently cited the Public Trust Doctrine to support damage claims for the killing of waterfowl as a result of an oil spill, to protect ecological values, to preserve tidelands in their natural state for the benefit of wildlife, and to preserve public lands with special importance for public health, safety, and welfare.[46] In New York, one court has broadly stated that the "entire ecological system supporting the waterways" is within the purview of the trust.[47]

3. Preservation of Scenic Beauty

A more liberal judicial recognition of a protected public use is that the public has a right to the preservation of scenic views and aesthetics in trust lands and waters. At least three State courts have recognized the right of the public to preserve trust lands and waters so as to preserve the scenic beauty of the area.[48] One of these State courts described the right to preservation of scenic beauty as "an incident of navigation."[49]

C. Uses of Trust Lands as Determining Geographic Scope of Public Trust Doctrine

The United States Supreme Court, in *Phillips Petroleum v. Mississippi*, recognized that "the States have interests in lands beneath tidal waters which have nothing to do with navigation,"[50] such as "bathing, swimming, recreation, fishing and mineral development."[51] In regard to the many uses of trust tidelands that have nothing to do with navigation, the Court recognized that "It would be odd to acknowledge such diverse uses of public trust tidelands, and then suggest that the sole measure of the expanse of such lands is the navigability of the waters over them."[52] As a result, the Court rejected navigability as the sole measure of the geographic scope of the Public Trust Doctrine over tide waters and the lands beneath, and affirmed that the proper test is the ebb and flow of the tide.

In contrast to lands beneath tide waters, navigability of fresh waters is currently the sole measure of the expanse of such lands subject to the Public Trust Doctrine. This is so, even though the United States Supreme Court rejected the logic of this in *Phillips Petroleum v. Mississippi*. But fresh water bodies, whether navigable in fact or not, are used by the public for the same purposes as the public uses tidal waters and tidelands — bathing, swimming, recreation, and fishing, to name a few. Why navigability should be the sole measure of the geographic scope of the Public Trust Doctrine for freshwaters, when it has been specifically rejected for tidewaters, remains a paradox of American public trust law.

Nonetheless, the many and various uses that the public makes of tidelands and waters was the basis for rejecting navigability as the sole measure of the scope of trust tidelands. This same logic is available to argue that the geographic scope of freshwaters subject to the Public Trust Doctrine should also not be delimited by any sole criterium, such as navigability, but should be sufficiently expansive so as to include all freshwaters that are used by the public for the many recognized public trust uses.

CHAPTER VI

STATE POWERS, DUTIES, LIMITATIONS AND PROHIBITIONS UNDER THE PUBLIC TRUST DOCTRINE

Summary

Under the Public Trust Doctrine, states have certain powers and corollary duties, along with limitations and prohibitions on these powers. A fundamental point, however, is that the common intent and purpose of each power, duty or limitation is the full preservation of the public's trust rights.

State powers under the Public Trust Doctrine include the authority to:

- Govern, manage and protect the public's trust rights in lands and water subject to the Public Trust Doctrine;
- Exercise a continuous supervision and control over public trust lands, waters and living resources;
- Define the limits of the lands held in public trust;
- Convey the *jus privatum* title to public trust lands;
- Revoke a conveyance that unduly diminishes or destroys the State's *jus publicum* control over the conveyed land;
- Require leases for structures on state's public trust lands;
- Restrict or prohibit fishing.

State duties under the Public Trust Doctrine include the obligations to:

- Supervise the trust;
- Preserve, so far as consistent with the public interest, the uses protected by the trust;
- Protect and maintain trust property and regulate its use by devoting trust lands, waters and living resources to actual public uses.

Of the powers and authorities listed above, the courts have only circumscribed a state's power to convey trust lands into private ownership. Judging from the lack of judicial or legislative findings covered by this Compilation, however, all other powers and authorities remain plenary.

The limitations on a State's conveyance of the *jus privatum* title into private ownership provide that there must be:

- Clear legislative authority for the conveyance;
- A definite furtherance of public trust purposes;

- No substantial impairment of the public's use of the remaining public trust lands, waters or living resources.

Finally, although the Public Trust Doctrine completely prohibits States from abdicating their sovereignty or dominion over public trust lands, waters and living resources, termination of the public's trust rights in lands can be accomplished by a State, but only if there is legislation with the clear intent to convey a certain parcel of trust land out of the trust.

Over the last two centuries the American Public Trust Doctrine has evolved into a powerful tool for managing public trust lands, waters and living resources within each state. Under the doctrine, states have certain powers and corollary duties, along with limitations on these powers. Of central importance, however, is that the common intent and purpose of each power, duty or limitation is the full preservation of the public's trust rights.

The utility of the Public Trust Doctrine as a tool for coastal resource management can best be seen by summarizing the state powers, and the concurrent limitations on such power, and the duties and obligations placed on the states by the doctrine. The powers, duties, and limitations that are discussed in the next sections are all derived from cases discussed in the preceding chapters of this Compilation.

A. State Powers and Authorities Under the Public Trust Doctrine

Under the Public Trust Doctrine, states have the power and authority to:

- Govern, manage and protect the public's trust rights in lands and water subject to the Public Trust Doctrine.[1]
- Exercise a continuous supervision and control over public trust lands, waters and living resources.[2]
- Define the limits of the lands held in public trust.[3]
- Convey the *jus privatum* title to public trust lands.[4]
- Revoke a conveyance that unduly diminishes or destroys the State's *jus publicum* control over the conveyed land.[5]
- Require leases for structures on state's public trust lands.[6]
- Restrict or prohibit fishing.[7]

B. State Duties and Obligations Under The Public Trust Doctrine

The Public Trust Doctrine has been described as "an affirmation of the duty of the state to protect the people's common heritage in streams, lakes, marshlands and tidelands, surrendering that right of protection only in rare cases when the abandonment of that right is consistent with the purposes of the trust."[8] This duty of protecting public trust resources is central to the Public Trust Doctrine, for as stated by an Oregon court "These resources, after all, can only be spent once. Therefore the law has historically and consistently recognized that rivers and estuaries, once destroyed or diminished may never be restored to the public and, accordingly, has required the highest degree of protection from the public trustee."[9]

As one reviews the following duties and obligations of states under the doctrine, it becomes clear that each of the powers and authorities listed in the preceding section has a corollary duty to implement the authority through some affirmative action. At the same time, there is little case law concerning the enforcement any specific State duty or obligation. Nonetheless, according to the cases discussed within this compilation, under the Public Trust Doctrine each state has the duty and obligation to:

- Supervise the trust;[10]
- Preserve, so far as consistent with the public interest, the uses protected by the trust;[11]

- Protect and maintain trust property and regulate its use by devoting trust lands, waters and living resources to actual public uses.[12]

C. Limitations on State Powers and Authority

Of the powers and authorities listed in section A. above, the courts have only circumscribed a state's power to convey trust lands into private ownership. Judging from the lack of judicial or legislative findings covered by this Compilation, however, all other powers and authorities remain plenary.

The limitations on a State's conveyance of the *jus privatum* title into private ownership have been discussed in Chapter V. In summary, however, there are several limitations on this state power. In order to validly convey the *jus privatum* in trust lands to private ownership there must be:

- Clear legislative authority for the conveyance;
- A definite furtherance of public trust purposes; and
- No substantial impairment of the public's use of the remaining public trust lands, waters or living resources.

D. Prohibitions on State Powers and Authorities

Under the Public Trust Doctrine, states are completely prohibited from abdicating their sovereignty or dominion over public trust lands, waters and living resources.[13] In other words, a conveyance of public trust lands to private ownership transfers only the *jus privatum* title, not the *jus publicum* title.

Nonetheless, the complete termination of the public's trust rights in trust lands can be accomplished by a State, although only in accordance with certain required conditions. There must be legislation authorizing the conveyance of trust lands out of the trust.[14] The legislation must be clear in its intent to convey the parcel out of the trust.[15] At a minimum the intent must be "necessarily implied."[16] Establishing that termination of the trust is necessarily implied, however, is a heavy burden, for if a court can interpret the statute so as to retain the public's interest in tidelands, the statute should be so construed.[17] Finally, the legislation authorizing the termination of the public's trust rights in trust land must further the public's trust interests.[18] See Ch. V.D.

The Public Trust Doctrine Handbook

A Description and Model for Washington's Shoreline Permit Administrators

Prepared for the
Washington State Department of Ecology

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<u>Illustrations:</u>

I. *Introduction to the Public Trust Doctrine*

The public trust doctrine is an ancient doctrine that has recently re-emerged as a tool for protecting the public interest in coastal lands and waters. The doctrine provides that the state retains an ownership interest in certain tidelands and shorelands, even where those lands have been sold to private individuals. The public trust interest has been broadly defined in Washington to include navigation, commerce, fisheries, wildlife, recreation and environmental quality.

The doctrine helps to prevent both private actors and the state from impairing public trust interests in coastal lands and waters. Under the public trust doctrine, the state has always retained an ownership interest in those resources. That ownership interest has often been compared to an easement or covenant that burdens private landowners' property. The state can prevent private land owners from doing anything that would impair the trust without owing compensation to the owner. For example, the state can prevent tideland fills, or prohibit construction that interferes with navigation.

The doctrine also guides the state in the management of state lands. The Washington Supreme Court has made it clear that if the state legislature attempts to convey or impair its ownership interest in public trust lands and waters, the court will review the legislation to see if it is consistent with the public trust interest in those resources.

Three state statutes have a direct effect on public trust lands and waters, interrelating closely with the doctrine. The Aquatic Lands Act, administered by the state Department of Natural Resources, governs state management of its own aquatic lands. This statute provides for tideland leasing by the state, a program that directly impacts public trust resources and that is guided by public trust goals and policies.

The Seashore Conservation Act asserts state policy governing Washington's Pacific beaches not held by tribes or previously sold into private hands. The Act forbids future sale of these lands and directs that the state shall hold them in trust for public benefit. These policies clearly reflect public trust goals to preserve coastal lands and waters for purposes of navigation, fisheries, and public enjoyment.

The Shoreline Management Act governs land use policies and practices for shorelines that are privately owned. This program is administered by local government, the state Department of Ecology providing oversight and assistance. Because all shorelines are public trust resources whether privately or publicly owned, the public trust doctrine may restrict the disposition and use of these lands.

The public trust doctrine is part of the common law of property of the state. Even though it is a judicial rather than a legislative doctrine, it is nonetheless binding on administrators and planners. The purpose of this handbook is two-fold. First, it is designed to educate planners and administrators about the public trust doctrine. Second, the handbook presents an analytic model of the doctrine that may be used in administrative decisionmaking.

A word of caution is necessary at the outset. While the Washington Supreme Court has clearly embraced the public trust doctrine in two recent decisions, the doctrine's full contours are not yet known. This is because, like other judicially developed doctrines, the public trust doctrine is slowly evolved through case law. While this may add to the flexibility and vitality of the doctrine in the future, it is bound to frustrate resource managers who understandably prefer precise administrative rules. In explaining the doctrine, this study will describe what is now known about the doctrine in Washington, and ways in which our state supreme court may follow other states in extending the doctrine in the future. The handbook begins with a summary of the doctrine. The summary contains a brief historical account of the doctrine, a description of the scope of the doctrine and the resources it protects, an analysis of the way in which it constrains private and state action that can impair trust resources, and a discussion of the way in which the federal government may affect the application of the public trust doctrine. Part II discusses the relationship between existing statutes and regulations and the public trust doctrine as it has been developed by the Washington courts.[1] Part III presents a decisionmaking model for the public trust doctrine, and a public trust "checklist," intended to distill the doctrine into an administratively useful form. This chapter first presents the model in a generic form, and then applies it to the Shoreline Management Act's substantial development permit process, as an example of how the model may work in administrative decisionmaking.

A. SUMMARY OF THE DOCTRINE

1. History of the Doctrine

The public trust doctrine originated from the widespread public practice, since ancient times, of using navigable waters as public highways for navigation, commerce, and fisheries. The Romans recognized many of the basic principles of the doctrine, which were included in the Institutes of Justinian issued in 533 A.D. In England the doctrine was already well-established by the time of the Magna Charta. Leading English court decisions recognized that the Crown held the beds of navigable waters in trust for the people for navigation, commerce, and fisheries. Even the Crown could not destroy the trust.

In the United States, state courts began recognizing the public trust doctrine in the early nineteenth century. The individual states are sovereign governments, and hold the beds of navigable waters for the public interest. In England, the doctrine had been applied primarily to the bed of the sea and to tidelands. Unlike England, the United States has large, navigable lakes and rivers. Early in this country's history, the courts applied the doctrine not only to the bed of the sea and to tidelands, but also to the beds of commercially navigable rivers and lakes. The word "navigable" is a term of art meaning "navigable for title" and refers to those waters navigable for commercial purposes at the time of statehood.

Washington first obtained ownership of these lands when it entered the Union, through the equal footing doctrine. This federal to state passage of title was confirmed in the Washington Constitution. It extinguished riparian rights in these navigable waters. However, with burgeoning industrial and commercial growth, Washington conveyed large amounts of these lands into private hands prior to 1970. One study indicates that the state transferred 60% of tidelands on Puget Sound and 30% of shorelands into private ownership.[2] Despite these transfers to private owners, the state still retains a public trust interest in those lands. The law that governs this public ownership interest is known as the public trust doctrine.

[illegible] OF OWNERSHIP

Although Washington's Supreme Court has often employed principles that closely resemble the public trust doctrine, it was not until 1987 that the Supreme Court made it clear that the public trust doctrine is, and always has been, the law in Washington state. The two cases in which the court announced the public trust doctrine are further explored below.[3]

2. Scope of the Doctrine

Because the public trust doctrine develops through case law, the precise contours of the doctrine are still evolving in Washington. The following subsections each begin with a discussion of what can clearly be discerned from Washington case law. The discussion in each subsection then expands to consider how Washington courts might develop the doctrine in light of cases from other jurisdictions, state legislative policies, and academic commentary. Further development of the doctrine seems likely. In its Orion decision, the Washington Supreme Court noted that it had not decided the total scope of the doctrine.

a. Geographic Scope

i. Known Geographic Scope of the Doctrine

As noted above, Washington, like other states, obtained title to the beds of navigable waters and waters subject to the ebb and flow of the tides at statehood. Article XVII, section

1 of the Washington State Constitution announced the scope of the state's ownership rights: "The state of Washington asserts its ownership to the beds and shores of all navigable waters in the state up to and including the line of ordinary high tide, in waters where the tide ebbs and flows, and up to and including the line of ordinary high water within banks of all navigable rivers and lakes." Even though the state subsequently transferred large parts of these lands into private hands, the public trust ownership interest in most lands remains. Public trust and private interests co-exist in those parcels conveyed into private hands.

Washington Supreme Court decisions provide that the geographical scope of the doctrine extends at least to navigable waterways and the tidelands and shorelands underneath them that the state has owned since statehood. No cases reveal precisely how far the Washington Supreme Court may extend the geographic scope of the doctrine in the future.

ii. Possible Extensions of the Geographic Scope of the Doctrine

Many questions about the scope of the doctrine remain unanswered by the court's opinions. For example, can the public trust doctrine be used to prevent harmful spillover effects from non-navigable tributaries? How about development of uplands and related wetlands? Yet another issue is public access. Can the public walk over and enjoy not only tidelands, but also the dry sand areas of beaches? Finally, what about public rights to use the surface of non-navigable lakes and streams for fishing and recreation? There is no way of predicting exactly how the courts will decide these issues. Some courts have interpreted the public trust doctrine expansively to protect navigable waters and tidelands from pollution and to insure public access. Other courts have been more cautious in extending the doctrine, concerned about its effects on private property rights. In the past, the Washington Supreme Court has relied on cases from other jurisdictions and state legislative policies in developing the doctrine. Therefore, these sources may provide guidance in determining the eventual scope of the doctrine.

Non-Navigable Tributaries. The California Supreme Court's decision in the Mono Lake case is an excellent example of an extension of the geographic scope of the public trust doctrine.[4] Mono Lake is a large, navigable lake that sits at the base of the Sierra Nevada Mountains in California. Since 1940, the city of Los Angeles has diverted virtually the entire flow of four of the five non-navigable tributaries that originally fed the lake. These diversions have had a devastating impact on Mono Lake. The surface area of the lake shrank by a third, and its salinity increased. Many of the islands located in the middle of the lake became linked to the mainland, exposing migratory and nesting birds to predators. The California Supreme Court concluded that the public trust doctrine extended to the non-navigable tributaries of Mono Lake, reasoning that the doctrine protects navigable waters from harm caused by diversion of non-navigable tributaries. It decided that Los Angeles's water permit must be reconsidered in light of the impact on public trust resources.

It follows from the logic of Mono Lake that states should have the power under the public trust doctrine to prevent upland activities that cause harmful spillover effects to public trust resources. For example, a state might have the power under the public trust doctrine to control upstream pollution or appropriations of water which reduce the volume, and therefore the assimilative capacity of navigable waterbodies. The Washington Supreme Court has not had occasion to address this issue, however, the Mono Lake case has been cited widely with approval by other courts.

Wetlands and Uplands. Recognizing the interconnectedness of water systems, courts in some states have extended the doctrine to cover wetlands and uplands related to navigable water bodies. For example, the high court of Massachusetts extended the doctrine to cover state parks and swamps.[5] Similarly, the Wisconsin Supreme Court, recognizing that wetlands serve a vital role in purifying the waters of lakes and streams, concluded that filling wetlands was contrary to the public trust doctrine.[6] The Massachusetts and Wisconsin decisions, like the Mono Lake case, show other courts' willingness to extend the public trust doctrine beyond tidelands and navigable waters to prevent harmful spill-over effects from spoiling the integrity of public trust resources.

Public Access, the Dry Sand Area of Beaches, and Uplands. Public access to trust resources raises several issues. First, what kind of access does the public have--lateral access (along the water) or perpendicular access (crossing private property to get to the water)? Second, do the public's rights extend above the level of ordinary high tide to include the dry sand area? Finally, what is the extent of the public's right to use such lands? Do they simply have a right of access, or do they have a right to sunbathe and generally enjoy recreational activities?

Courts around the country have generally not used the public trust doctrine as a basis for perpendicular access across private property to tide and shorelands. A number of states have found, however, that the public has a right of lateral access over public trust lands.[7] In other words, the public has a right to walk on beaches below the mark of ordinary high tide.[8]

But some state courts have recognized the simple fact that when the tide is in, the public often cannot enjoy its rights to use public trust resources unless it can utilize the dry sand area above the line of ordinary high tide. These courts have employed numerous theories, including the public trust doctrine and custom, to recognize public rights in the dry sand area of beaches, i.e. those areas above ordinary high tide. For example, the New Jersey Supreme Court extended the public trust doctrine to the dry sand area of beaches.[9] The court recognized that in order for the public to fully exercise its right to swim and bathe below the mean high water mark, the public must also have both a right of access and a right to use the dry sand area of beaches.

Significantly, the New Jersey court not only recognized the public's right to cross privately owned dry sand areas, but also the public's right to sunbathe and generally enjoy recreational activities in those areas. The Oregon Supreme Court reached a similar result by using the ancient doctrine of custom to recognize public rights in the dry sand area of all state beaches.[10]

A recent Montana case provides an excellent example of the delicate balance between public and private rights to uplands.[11] The Montana court acknowledged that the public trust doctrine gave the public a right to use the beds and banks of streams, because such a right is necessary for the public to enjoy using the waters. The court went on to hold, however, that the public's right must be narrowly confined so that the impact to beds and banks owned by private individuals is minimal. Accordingly, the court found a state law allowing people to, among other things, camp overnight, build duck blinds, and hunt big game, to be an unconstitutional taking of property. The court limited public rights in privately owned beds and banks to those that are necessary.

The existence and scope of a public right above the ordinary high water mark is bound to be contentious. Although no Washington Supreme Court cases have embraced either the public trust doctrine or the doctrine of custom to protect public rights in the dry sand area of beaches, an Attorney Generals Opinion concluded that the public has the right to use and enjoy the dry sand area of ocean beaches through the doctrine of custom.[12] The Washington Supreme Court made a tentative step toward recognizing public rights in areas above the line of ordinary high tide in Caminiti, when it stated that the public must be able to get around, under or over private docks. Policies favoring public access contained in the Shoreline Management Act might also persuade the court to extend the geographic scope of the doctrine. Thus, the Washington Supreme Court may turn to the public trust doctrine to widen the geographic scope of the public's rights.

Rights to Use the Surface of Commercially Non-Navigable Waters. As the population of Washington state continues to grow, and the appetite for water-related recreation increases, the issue of the public's right to use the surface of non-navigable waters will become increasingly important. Although the Washington Supreme Court has not denominated these as public trust cases, it has limited private activities on non-navigable lakes that would impair the rights of other riparians (i.e. waterfront owners), and their licensees.[13] Because the state can become a riparian to these waters by buying property along a lake or stream and opening up the property for public use, those decisions indirectly protect public rights.

Other states, including Montana, Wyoming and California, have extended the public trust doctrine to protect the public's right to use the surface of waters which are navigable only for recreational purposes. The Washington Court might also extend the public trust doctrine to cover waters which are navigable only for recreation.

The Shoreline Act Suggests a Broad Geographic Scope. In addition to the afore-mentioned cases from other states, the Washington Supreme Court may consider the Shoreline Management Act (Shoreline Act) as a factor in determining the geographic scope of the public trust doctrine. The public trust doctrine and the Shoreline Act are distinct,[14] the doctrine coming from the courts while the Act is a legislative statute. The public trust doctrine also protects certain uses not always impacted by activities governed by the Shoreline Act. However, the court has noted many similarities between the public trust doctrine and the goals of the Shoreline Act, which may provide guidance in shaping its future contours. The Shoreline Act's coverage extends to lands within two hundred feet of the high water mark, as well as flood plains, flood ways, bogs, swamps, and river deltas. The Shoreline Act also covers many rivers and lakes that are too small to meet the navigability-for-title test.

iii. Other Issues Affecting Geography

Additions and Losses of Public Trust Land and Waters Due to Natural and Artificial Changes. Both natural and artificial activities cause accretions (gradual additions of land), relictions (gradual erosions of land) and avulsions (rapid changes). These changes raise issues about who owns new lands or recently submerged lands, and whether the public trust doctrine applies to them.

For relictions and accretions along the shorelines of lakes and rivers, Washington follows the "moving boundary" rule observed by other states. Under this rule, upland owners gain a right to any accretions, but lose part of their property when there is a reliction. The Washington Supreme Court has applied a different rule, however, for accretions to ocean beaches. Accretions that have occurred since statehood belong to the state. Those people owning oceanfront property with title issued prior to statehood, however, do have a right to their accretions. While the moving boundary rule is probably applicable to relictions, attempts to stave off erosion by building breakwaters and other structures may ultimately interfere with the public's interest.

Generally, the rule is that for avulsions and artificial changes, boundaries remain fixed, and presumably the scope of the public trust doctrine remains the same. Another artificial change, filling of privately owned tidelands or shorelands, is also worth mentioning. While this does not change title to tidelands and shorelands, it may affect the application of the public trust doctrine. The public trust will still apply to tidelands "still physically adaptable to trust uses" but not to lands "rendered substantially valueless for those purposes."[15]

Lands Which May Be Exempt from the Public Trust Doctrine. Several other types of land may be exempt from the public trust doctrine. These include 1) lands conveyed in pre-statehood grants where there is unequivocal language extinguishing public rights, 2) conveyances in accordance with international treaty obligations, 3) federal acquisitions of state public trust lands, and 4) lands covered by Indian treaties.[16]

b. Protected Uses

i. Known Protected Uses in Washington

The Washington Supreme Court has boldly announced a broad catalogue of public rights protected by the public trust doctrine. These rights include not only navigation and commercial fishing, but also "incidental rights of fishing, boating, swimming, water skiing, and other related recreational purposes."[17] Thus, the court has recognized the flexibility of the doctrine to accommodate the ever-evolving public interest.

The language of the Orion decision also strongly supports a public right to environmental preservation and water quality. Moreover, this is a common-sense corollary to the public's right to fish. Obviously, the public can only exercise its protected right to fish if fish can actually live in waters protected by the doctrine.

The Washington Supreme Court has indicated that it has not finished defining the scope of the public trust doctrine. Therefore, its catalogue of protected uses may develop and expand to fit the public's need.

ii. Possible Extensions of Protected Uses

The Washington Supreme Court has not had the opportunity to address whether walking across privately owned tidelands, digging clams, or simply enjoying trust resources in their natural state are protected rights under the public trust doctrine. Several other states have recognized these rights, and the Washington Court may decide to follow them, given its broad interpretation of protected rights.

As the list of protected rights grows, a new question arises: what should be done when two or more of them are in conflict? For example, what should happen when the interests of commerce or recreation conflict with preserving the environmental integrity of trust resources? It is unlikely that the courts of this state will ever develop a hierarchy of public trust uses.

Instead, courts will likely decide such conflicts on a case-by-case basis. Further, any rigid hierarchy would be contrary to the Aquatic Lands Act and Shoreline Act, which generally balance competing uses, while giving priority to certain activities, such as water dependent uses, and furthering public enjoyment of state waters. Finding similarities between the public trust doctrine and the Shoreline Act, courts would probably be reluctant to upset this balancing process for competing public trust rights.

3. The Public Trust Doctrine Binds Both Private Individuals and the State

As mentioned earlier, the Washington Supreme Court embraced the public trust doctrine in two cases in 1987, Caminiti v. Boyle and Orion Corp. v. State. A brief description of each of those cases provides a starting point for showing how the public trust doctrine protects public trust resources from both private and state actions.

a. The Public Trust Limits Private Activity

Orion shows how the public trust doctrine helps protect public trust resources from conflicting private development. Orion Corporation acquired a large part of Padilla Bay, an ecologically important estuary that is navigable at high tide. Originally, Orion Corporation planned to dredge and fill the bay to create a Venetian-style community. In 1971 the Shoreline Act identified the bay as a shoreline of statewide significance, and declared that state policy required preservation and protection of the area. The Skagit County Shoreline Management Master Program was later approved by the state, and it designated Orion's lands as "aquatic," thus prohibiting dredging and filling of the tidelands. The only permissible uses of any value left for the land were non-intensive recreation and aquaculture, the latter of which required a conditional use permit.

The Orion Corporation argued that an aquatic designation was an unconstitutional taking of their property without compensation. The Washington Supreme Court, however, decided that

FIGURE 1. Illustration of the Public Trust Doctrine Decision Making Model

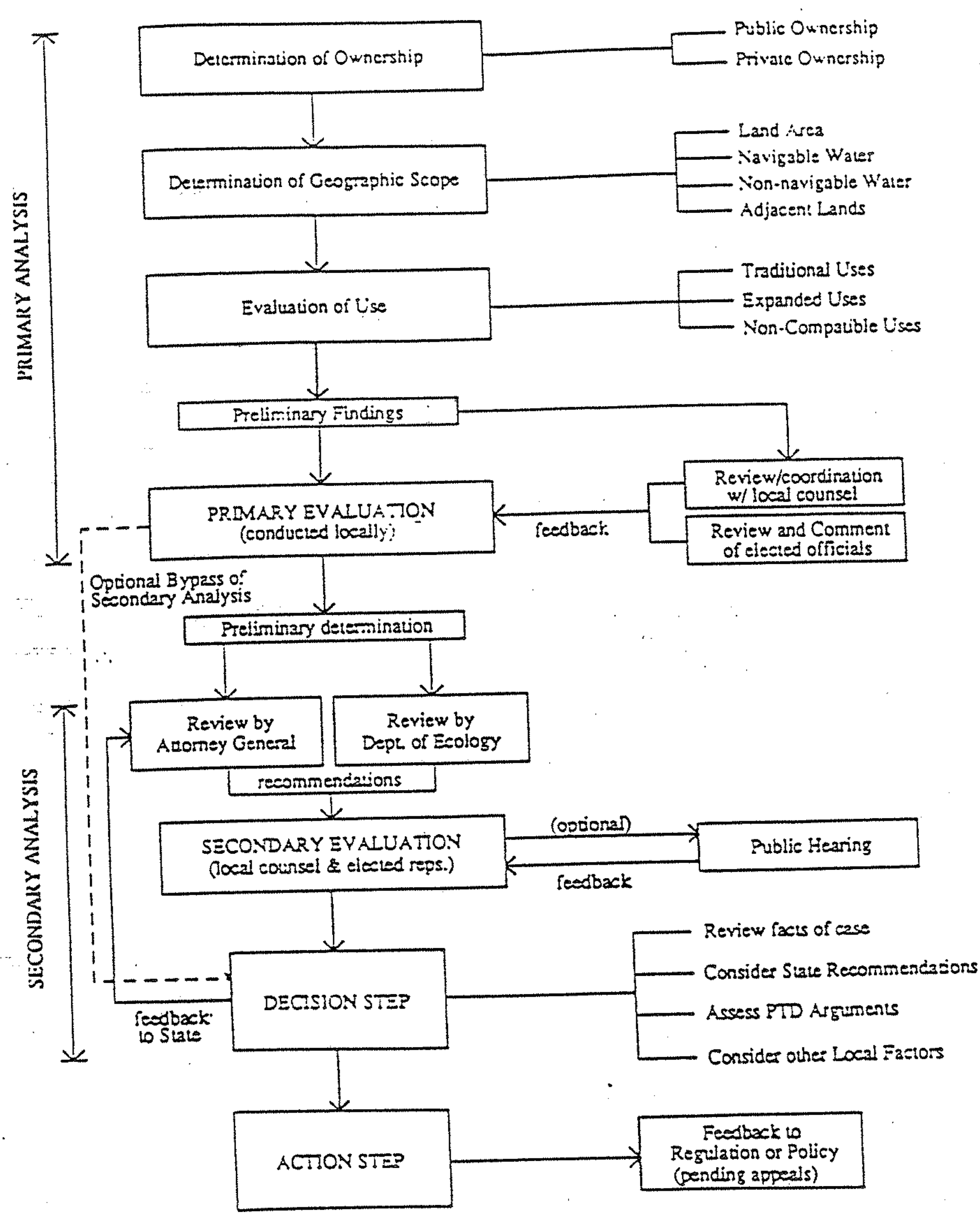

FIGURE 3. Administrator Checklist for the Public Trust Doctrine Decision Model

Part 1. General Information.

Name of Site: ______________________ Date: ______________

Name of Applicant: ______________________ Reviewer: ______________

Address: ____

Jurisdiction: ______________________ Watershed/shoreline: ______________

Proposed Use(s): ____

____

Comments: ____

____

Part 2. Determination of Ownership. Compatible with Doctrine Yes_____ No_____

Public Ownership

State Aquatic Lands _____ Harbor Area _____ Waterway _____ Accreted Lands _____ State Leased _____ Other _____

Private Ownership

Submerged Lands _____ Tideland _____ Adjacent Upland _____ Leased Land _____ Variance _____

Implied Dedication _____ Permit conditons _____ Prescribed Easement _____ Other _____

Transitory Lands:

Accretion _____ Avulsion _____ Erosion _____ Reliction _____

Comments: ____

Part 3. Determination of Geographic Scope. Compatible with Doctrine Yes_____ No_____

Land Area		Navigable Waters		Non-navigable Waters		Adjacent Lands			
Submerged Lands	_____	Oceanic	_____	Non-tidal Stream	_____	State-owned	_____	Urban	_____
Tideland	_____	Bay	_____	Intermittent Stream	_____	Industrial	_____	Ports	_____
Other Wetland	_____	River	_____	Irrigation ditch	_____	Residential	_____	Wetlands	_____
Dry Sand Area	_____	Lake	_____	Floodway	_____	Agriculture	_____	Natural	_____
Floodplain	_____	Stream	_____	Other	_____	Aquaculture	_____	Other	_____
Upland	_____	Canal	_____			Conservation	_____		

Comments: ____

Part 4. Evaluation of Use. Compatible with Doctrine Yes_____ No_____

Traditional Uses		Expanded Uses				Non-compatible Uses	
Navigation	_____	Waterborne Recreation	_____	Public Access	_____	Mineral Exploration	_____
Commerce/Ports	_____	Recreational Navigation	_____	Aesthetics	_____	Landfilling	_____
Fishing	_____	Habitat Protection	_____	Aquaculture	_____	Commercial Development	_____
				Other	_____	Hydropower Development	_____
Mitigation: Yes_____ No_____						Other	_____

Comments: ____

____

ARTICLE 89-10

ISLANDS AND BEDS OF NAVIGABLE STREAMS AND WATERS

CHAPTER 89-10-01
ISLANDS AND BEDS OF NAVIGABLE STREAMS AND WATERS

89-10-01-01. Authority. These rules are adopted and promulgated by the state engineer pursuant to North Dakota Century Code chapter 61-33 to provide consistency in the administration and management of the islands and beds of navigable streams and waters. These rules do not action to take on a permit application, the state engineer shall consider the potential effects of the proposed project on the following:

1. Riparian owner's rights;
2. Recreation;
3. Navigation;
4. Aesthetics;
5. Environment;
6. Erosion;
7. Maintenance of existing water flows;
8. Fish and wildlife;
9. Water quality; and
10. Alternative uses.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-33

89-10-01-09. Specific project requirements.

1. In addition to the considerations set forth in section 89-10-01-08, the following conditions apply when a permit application involves the mining of gravel, sand, or other resources other than oil, gas, and related hydrocarbons:
   a. Mining must be completed in the shortest practicable period of time and during the season which will minimize the effects on the waterway and biotic life in the waterway.
   b. Mining may be prohibited or restricted when it would, in the judgment of the state engineer, adversely affect the maintenance or reproduction of fish or other wildlife populations.
   c. If the state engineer determines mining will have a significant adverse impact on downstream riparian owners, the grantee must obtain the riparian owner's written consent.
2. In addition to the considerations set forth in section 89-10-01-08, the following considerations apply when a permit application involves dredging or filling:

a. Unless there is no reasonable alternative or the public need exceeds other values, dredging or filling will not be permitted.

b. Dredged material must be removed to a site above the permit line unless otherwise authorized by the state engineer.

c. Approved fill must be clean, nonpolluting material free of waste metal, organic material, and unsightly debris.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-33

89-10-01-10. Projects not requiring a permit. The following projects do not require a permit:

1. Boat docks if:

   a. They are constructed, operated, and maintained by the riparian owner or the riparian owner's lessee for the riparian owner's or lessee's personal use;

   b. The dock is used only for embarkation, debarkation, moorage of boats, or recreation;

   c. Only clean, nonpolluting materials are used;

   d. The dock is no more than twenty-five feet [7.6 meters] in length on a river and fifty feet [15.24 meters] in length on a lake, and there is no unreasonable interference with navigation or access to adjacent riparian owner's property;

   e. The dock is connected to shore by a walkway, and removed from below the permit line each fall;

   f. There is no excavation or filling below the permit line in excess of that authorized in subsection 4; and

   g. Upon abandonment, the grantee restores the bank as closely as practicable to its original condition.

2. Boat ramps if:

   a. They are constructed, operated, and maintained by the riparian owner or the riparian owner's lessee for the riparian owner's or lessee's personal use;

   b. Excavation of the bank is limited to the minimum width necessary for the placement of a single lane boat ramp adjacent to privately owned property or a double lane boat ramp adjacent to publicly owned property;

c. Material excavated from the bank is removed to a location above the permit line;

d. Only such clean, nonpolluting fill and riprap material free of waste metal, organic materials, and unsightly debris are placed below the permit line as necessary to construct and stabilize the boat ramp; and

e. Upon abandonment, the grantee restores the bank as closely as practicable to its original condition.

3. Water intakes if:

   a. They are constructed, operated, and maintained by the riparian owner or the riparian owner's lessee for riparian owner's or lessee's personal use;

   b. Excavation of the bank is limited to the minimum width necessary to install and maintain the water intake;

   c. Materials excavated from the bank are removed to a location above the permit line;

   d. The intake is entirely removed each fall; and

   e. Upon abandonment, the grantee restores the bank as closely as practicable to its original condition.

4. Dredging or filling if:

   a. The work is completed and maintained by the riparian owner or the riparian owner's lessee;

   b. The amount of dredge or fill material does not exceed ten cubic yards as part of a single and complete project;

   c. No stream diversion results;

   d. No extension of a claim of ownership to an island or any portion of the bed of a navigable stream or water results; and

   e. Only clean, nonpolluting material free of waste metal, organic materials, and unsightly debris is used.

5. Bridges and bank stabilization by a governmental entity if:

   a. The project is approved by the state engineer;

b. Only clear nonpolluting material free of waste metal, organic materials, and unsightly debris is used for bank stabilization;

c. On the Little Missouri River, only washed field stone is used for bank stabilization;

d. Work does not exceed the minimum necessary to complete the project; and

e. Upon abandonment, the grantee restores the bank as closely as practicable to its original condition.

6. Fences crossing the Little Missouri River if:

a. The fence is marked so it is clearly visible at two hundred yards [182.88 meters]; and

b. A clearly marked opening at least eight feet [2.44 meters] in width is provided.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-33

89-10-01-11. Structures below permit line. Excluding boats that are temporarily moored, the construction or moorage of any residential structure or structure designed for human occupancy will not be permitted below the permit line.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-33

89-10-01-12. Public recreational use. The public's right to use the islands and beds of navigable streams and waters for nondestructive, recreational purposes is not prohibited except as otherwise provided by these rules.

History: Effective November 1, 1989.
General Authority: NDCC 28-32-02, 61-03-13
Law Implemented: NDCC 61-33

89-10-01-13. Vehicular access. The use of motorized vehicles other than boats below the permit line is authorized only in designated areas, in conjunction with the use of navigable waters for transportation or recreation, or as reasonably necessary for activities allowed pursuant to these rules. This section does not authorize use of property outside the permit line but does contemplate use of trails

THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4399 (602) 942-3000

April 19, 1993

Mr. Clyde Anderson
State Land Department
1616 West Adams
Phoenix, AZ 85007

Dear Mr. Anderson:

Re: Information Requests From April 13, 1993, Arizona Navigable Streams Adjudication Commission Meeting

As requested, I am submitting a written version of my presentation on the Arizona Game and Fish Department's perceived Public Trust Values of Arizona's navigable streams for your records. Chairman Jennings also requested copies of the Department Urban Fishing Program brochure. I have enclosed brochures for each commissioner and a couple extra for your records. Feel free to call me at 789-3607 if I can be of any help or if you have questions.

Sincerely,

Eric Swanson

Eric Swanson
Aquatic Habitat Coordinator

EDS:es
Attachments

cc: Sue Morgensen
Bruce Taubert

PUBLIC TRUST VALUES. PRESENTED TO AASAL APRIL 13, 19--

THE STATE OF ARIZONA

GAME & FISH DEPARTMENT

2221 West Greenway Road, Phoenix, Arizona 85023-4399 (602) 942-3000

Governor
Fife Symington

Commissioners:
Gordon K. Whiting, Central, Chairman
Larry Taylor, Yuma
Elizabeth T. Woodin, Tucson
Arthur Porter, Phoenix
Nonie Johnson, Snowflake

Director
Duane L. Shroufe

Deputy Director
Thomas W. Spalding

MISSION STATEMENT

The wildlife resources of Arizona add to the quality of life and the economic well being of Arizona.

The Department is committed *to conserve, enhance, and restore Arizona's diverse wildlife resources and habitats through aggressive protection and management programs, and to provide wildlife resources and safe watercraft recreation for the enjoyment, appreciation, and use of present and future generations.*

This commitment is extended to the administrative and enforcement activities necessary to provide for public safety and protection of resources, authorized by statute, on the lands and waters of Arizona.

AUTHORITY

The authority and the responsibility for the maintenance and management of the state's wildlife resources are vested in the Arizona Game and Fish Department by Arizona Revised Statute Title 17. Department responsibility for the management of safe watercraft recreation is given by ARS Title 5.

ARS-17-102. "Wildlife, both resident and migratory, native or introduced found in this state except fish and bullfrogs impounded in private ponds or tanks or wildlife and birds reared or held in captivity under permit from the commission, are property of the state...".

ARS-17-201. "The laws of the state relating to wildlife shall be administered by the Game and Fish Department. Control of the Department is vested in the Game and Fish Commission.

ARS-17-231. "The Commission shall: ...establish broad policies and long range programs for the management, preservation and harvest of wildlife."

COMMISSION POLICIES

Riparian Habitat (A2.13): This policy recognizes riparian habitats as areas of critical environmental importance to wildlife and fisheries. The Department is directed to actively encourage management practices that will result in maintenance of current riparian habitat, and restoration of past or deteriorated riparian habitat. Riparian habitats provide forage, water and cover for a substantial number of game and nongame species, as well as providing essential components for aquatic life. This policy recognizes that a majority of special category wildlife species are obligate riparian inhabitants.

Wildlife Habitat Compensation (I2.3): This policy identifies Resource Category I areas as those habitats of highest value to wildlife, and as areas unique and/or irreplaceable on a statewide or ecoregional basis. This Resource Category designation includes perennial stream habitats, and wetlands and riparian habitats of at least one acre which are associated with perennial waters.

Under Arizona law, the Department is responsible for all wildlife in the state, including more than 800 native and resident species of mammals, birds, reptiles, amphibians, and fish. More than 90 species or subspecies are listed by the state as Threatened Native Wildlife.

PUBLIC TRUST DOCTRINE (Source: "Putting the Public Trust Doctrine To Work")

The Public Trust Doctrine provides that "navigable waters", the lands beneath, as well as the living resources inhabiting these waters within a State is a special title. The title to these lands, waters and wildlife are owned by the public, but held by the State in trust for the benefit of the public. The Public Trust Doctrine establishes the right of the public to use and enjoy these trust waters, lands and resources for a wide variety of recognized public uses.

The *jus publicum* title interest of public trust lands includes the collective rights of the public to fully use and enjoy trust lands and waters for commerce, navigation, fishing, bathing and other related public purposes. The *jus publicum* interest cannot be conveyed or alienated to private ownership, for the State cannot abdicate its trust responsibilities of the people.

The original purpose of the doctrine was to assure public access to navigable waters for navigation, commerce, and fishing. But State and Federal courts have recognized that "when administering the trust the State is not burdened with an outmoded classification favoring one mode of utilization over another."

Recognized public uses of trust lands today include:

fishing (fish)
swimming
hunting (wildlife)
both **recreational** and commercial **navigation**
environmental protection
preservation of scenic beauty
value of existence, or just being there

This inherent flexibility of the pubic trust doctrine assures public access to, and use of, trust lands, waters and living resources. This dynamic nature of the doctrine has allowed its fundamental application to persist for over 1,500 years.

As the public's trustee of these public use assets, each State is an important steward of all "navigable waters."

State Obligations under the Public Trust Doctrine:

* Supervise the trust;
* Preserve, so far as consistent with the public interest, the uses protected by the trust;
* Protect and maintain trust property and regulate its use by devoting trust lands, waters and living resources to actual public uses.

I. FISHERIES

HISTORIC PERSPECTIVE

In the mid 1800's miners, trappers, cattlemen, and other entrepreneurs were using native fishes to provide diversity to their diet. Recreation or sportfishing was of little importance, sustenance or meat harvest was their intent. Most of the available food fishes included the Colorado River squawfish, razorback sucker, roundtail chub, Yaqui catfish, and the Arizona and Gila trouts.

The vast array of Arizona's fishes that anglers enjoy today are the result of 114 years of introductions that have provided angling opportunity. Fish culture technology began developing during the late 1800's and by the early 1900 the old U.S. Bureau of Fisheries began culturing and distributing various fish species throughout the country to meet angler demand. Few people realize that fish sought by anglers today are, like themselves, transplants to the State from elsewhere.

Concurrent with the growing diversity of fishes was an increasing awareness of the need to protect these new resources through regulations. The first game laws of the Territory of Arizona were formulated in 1887, wherein taking of fish by seine, net, giant powder or other explosive substance was made unlawful. The Laws of 1903 furthered this protection by defining it as unlawful to take fish by any other means than hook and line. In the Laws of 1905 fish were defined as "all fish except suckers and carp." By this time the carp had already lost the high esteem it held in 1880 when first introduced into Arizona.

Today's angling regulations are essentially variations of those identified in Territorial Laws. These regulations have been necessary to maintain and manage the state's limited fisheries resources.

The Department has programs in sportfish management, nongame and native fisheries management, and species specific programs for threatened and endangered species.

II. ENVIRONMENTAL EVALUATION

For the public to exercise their right to fishing, there must be a sustaining environment within which the fish can live. This has been recognized recently by several states who have used the Public Trust Doctrine as a basis for environmental protection legislation or regulations. A sustainable environment for fish includes maintenance of existing water flows and maintenance of water quality standards.

Protection of fish, wildlife, water quality and the environment is already afforded to some degree at waters likely to be designated as "navigable." This protection includes Federal regulations such as the Clean Water Act (Section 404) and Endangered Species Act, and State regulations that include ARS title 49 (Water Quality Laws), and ARS title 17 (Game and Fish laws).

III. RIPARIAN HABITATS AND THEIR ROLE IN SUPPORTING WILDLIFE

Because of Arizona's arid climate, and because Arizona's riparian areas are limited in extent, they have a disproportionately higher value to wildlife. Because riparian habitats occur in the transition between drier uplands and the water source, they serve as important wildlife oases that influence not only local, but regional wildlife species diversity and richness. Riparian habitats occupy one-half of one percent of the total southwestern landscape, yet they constitute Arizona's richest environment in terms of fish and wildlife diversity and productivity.

FACTS:

- of 27 remaining native species of fish in Arizona, 21 are either threatened, endangered or under study for listing.

- some of the highest density of breeding birds in North America have been observed in Arizona's riparian habitats.

- riparian areas provide forage, water, and cover for 75% or more of Arizona's native wildlife species during some portion of their life cycle.

- the majority of special category (threatened, endangered, sensitive) wildlife species in Arizona are obligate riparian inhabitants.

IMPACTS SINCE STATEHOOD

Arizona's rivers have played a vital role in the state's exploration, settlement, and continuing prosperity. In the late 1800's and early 1900's waterways provided both transportation and sustenance to trappers, miners, hunters and early settlers.

Natural and man-caused changes within watercourses result in accretions, relictions, and avulsions. These changes in stream bed location raise issues about who owns new lands or recently submerged lands, and whether the public trust doctrine applies to them. The Alternative Boundary Determination Methodology in the Streambed Program Implementation Plan provides a reasoned approach to this issue. However, it is important to recognize that public uses of these streambeds (i.e., fishing, recreation, boating) have also been affected by natural and man-caused changes.

Water storage projects in Arizona often conflict with the objectives of fisheries and wildlife management since their primary purposes are for irrigation, hydroelectric power, flood control, and municipal uses. Whereas fisheries communities, particularly native fish, have been adversely affected by dam construction and subsequent changes in river conditions, opportunities to introduce sportfish have created tremendous angling recreation growth to areas such as Lee's Ferry on the Colorado River. Additionally, the increase in the number and size of reservoirs has created rapid growth in boating recreation.

Surveys of the quality of riparian areas within the public and private domain indicate that an overwhelming majority are in poor to fair condition. We must consider cumulative and additive impacts on riparian areas of various land use practices such as grazing, ground water pumping, diversions, sand and gravel operations, vegetation removal, and floodplain developments for agricultural and municipal projects. It has been estimated that 90% of the riparian habitats of major desert watercourses in Arizona have been lost, altered, <u>or</u> degraded.

RECREATION DEMAND AND VALUES

Over the past 5 years, the Department has licensed approximately 350,000 resident anglers and 44,000 non-residents. Licensed resident anglers spent more than 6.6 million user days on all waters in Arizona. Nonresidents, primarily from California, Nevada, and Utah, expended an additional 461,000 user days. These estimates do not include approximately 130,000 unlicensed juveniles.

	User days	
Colorado River	401,000	
Large Inland Rivers	308,000	17% of statewide user days
Other Streams and Rivers	120,000	

Hunting and fishing expenditures equaled more than $430 million in 1985. This included 8.6 million days of fishing and 4.6 million hunting days.

Non-consumptive experiences include interactions with watchable wildlife such as birds, small mammals, and big game. Other water-oriented outdoor activities include boating, swimming, camping, hiking, and wildlife or nature photography. There were 1.9 million Arizonans that considered themselves non-consumptive wildlife users in 1985.

Eco-tourism is a new and evolving concept as recreation (consumptive and nonconsumptive) is being recognized as an important economic component to many communities in Arizona.

PUBLIC INTERESTS

The State's interest in riparian protection (SB 1030) is reflective of public interest. In the 1992 report entitled <u>Arizonans and the</u>

Environment: Attitudes toward the key environmental issues facing the state public opinion was surveyed in several areas of the environment. Regarding streams and rivers, this report found that "74% of the state's population favor preserving the remaining free-flowing rivers and stream-side habitats, even if it means restricting the use of privately owned lands that may abut these areas."

In another survey, The 1992 Arizona Outdoor Recreation Needs Survey prepared by the College of Public Programs at Arizona State University, residents of Arizona expressed dramatic support for preservation related outdoor recreation uses. The top four general recreation issues in which residents expressed greatest support were for the protection of Arizona's rivers, streams, and wetlands (94,7%), the protection of the natural environment (94.5%), the protection of historic places and archaeological sites (84.4%), and for undeveloped natural areas (83.1%).

Both these studies make it clear that many Arizonans value water-based recreational opportunities. As more streams are dewatered and riparian areas damaged or altered, fewer prime recreational areas will be available.

Riparian and wetland habitats are dependent or interconnected to waterways and provide critical supporting habitat for the sustainability of fish and wildlife populations. The environmental quality of "navigable waters" is largely a function of adjacent riparian and wetland vegetation. The wise stewardship of waterways under the Public Trust Doctrine should logically include protection and maintenance of riparian values. This was recognized by the Arizona legislature when they passed HB 2594 which includes establishment of a riparian trust fund for the acquisition and management of riparian lands.

Selected Department Activities and Programs:

Fisheries Program
Game Program
Nongame Program
Environmental Protection Program
Watercraft Enforcement and Education, and Navigational Aid Program
Heritage Fund
Statewide Riparian Inventory and Mapping (SRIM)
Riparian Areas Advisory Committee (SB 1030)
Riparian Areas Coordinating Council (EO 91-6)
Participant/contributor in Arizona State Parks' Arizona Rivers Assessment, and Wetlands/Riparian Priority Plan

5)SaltRiver
PublicTrust

FINAL REPORT

State: Arizona Project Number: W-53-R-37

Project Title: Wildlife Surveys and Investigations

Study Title: Gila River Use: Wildlife Investigations

Contract Period: From: July 1, 1984 To: June 30, 1987

Program Narrative Objective No.: (WP3, J16) Objective: To determine the impact of human activity on the abundance of small game and non-game birds and mammals on lands managed by the Game and Fish Department along the Gila River.

JOB SEGMENT OBJECTIVES:

1. A Request For Proposal (RFP) and bid for contract will be advertised for two weeks. A RFP will be selected and contract written. The RFP must contain study designs that will insure that the following data will be collected:

    a. Seasonal use recovered in man-days.

    b. Spatial distribution of users plotted on a vegetation type map of the area.

    c. Demography data on the users. Surveys will be conducted each month beginning in August for the duration of the study. Sign in sheets for recreation users will be maintained at a minimum of six locations within the study area. Activity pattern data will be collected by the investigator on all holidays, season openings, and a minimum of two Saturdays, two Sundays, and one for each weekday each month for the duration of the study.

    d. Vehicle counters will be used to determine traffic levels on selected roads in the area.

SUMMARY OF PROGRESS:

The on-site observations for the third year were started on July 1st, 1986. The following schedule was followed through the month of June 1987.

July 1986: One weekend day and one weekday plus the Fourth of July were selected and visited by the research team.

August 1986: Three weekend days and two weekdays were selected and visited by the research team.

September 1986: Four weekend days, two weekdays, one opening day and Labor Day (simultaneous) were selected and visited by the research team.

October 1986: Three weekend day trips and two weekday trips plus an opening day weekend were selected and visited by the research team.

November 1986: Four weekend days and two weekdays, one holiday and one opening day were selected and visited by the research team.

December 1986: Two weekend days, one weekday and one holiday (Christmas) were selected and visited by the research team.

January 1987: Two weekend days, one weekday days plus New Years Day were selected and recorded for hunter participation for that period.

February 1987: Two weekend days, one weekday and one holiday (Washington's Birthday) were selected and visited by the research team.

March 1987: Two weekend days and one weekday were selected and visited by the research team.

April 1987: Two weekend days and one weekday were selected and visited by the research team.

May 1987: Two weekend days and one weekday were selected and visited by the research team.

June 1987: Two weekend days and one weekday were selected and visited by the research team.

All twelve sites were visited on all the dates selected. The number of vehicles were recorded and man-days use were recorded by observation for the following nine activities:

1. Hunting
2. Picnicing
3. Hiking
4. Motocycling
5. Horseback Riding
6. ORV use
7. Swimming
8. Camping
9. Fishing

A ratio of persons per vehicle was determined after several on-site observations and was set at 2.3 individuals per vehicle.

The sampled data derived from on-site observation was averaged to determine the "typical" weekend day and week-day for each month. These values were expanded relative to the number of days contained in any given month.

The monthly totals were combined to determine the total yearly use. This second year report will reflect the average monthly use and daily monthly use, total yearly use, etc. It must be noted that the first yearly report was based on a nine-month study from October 1986 through June of 1985. The second yearly report covered a full year from July 1, 1985 to June 30, 1986. The third year covers a full year July 1, 1986 to June 30, 1987 and completes the three year study of the wildlife area.

Study Team Observations For The Final Year Of The Study:

1. For hunters use days, the most popular areas were Robbins Butte, Arlington, Bullard Avenue and 115th Avenue.

2. The Buckeye Hills Recreation Area borders Robbins Butte and for the third year is very popular as a way station between San Diego and Phoenix or Yuma and Phoenix. Most are groups of older or retired individuals driving mobile campers who camp one night, rest, hike, birdwatch and a nominal number hunt during the hunting season. Transients still use the area for short periods of time during the winter months.

3. Gillespie Dam's popularity increased this past year due to excellent fishing. Some duck hunters also frequent this area.

4. Robbin Butte Wildlife Area is still the most visited area. More improvements were made in the fields and general improvement to roads were made. For a while it seemed to the study team that quail outnumbered the rabbits in the area.

5. Power Butte has been improved with a new BLM fence in place which keeps the cattle from trampling the new trees which have been placed in the area. A general clean up is in progress at the present time along with much planting to take place in the near future.

6. The new road between Robbins Butte and Mummy Farm was roughed out in the fall and more improvements were made after the spring rains. The more this road is improved the more visitors will travel between the two areas. The beginning of the road from the vicinity of Gillespie Dam to Mummy Farm has been much improved in the wash areas. This also will attract more hunters to the area.

7. In spite of the closing of the Arlington feed lot, this area still attracts large numbers of hunters.

8. The 91st Avenue and 115th Avenue areas were closed rather late in the spring for approximately 2 weeks, due to upstream water releases.

MAILED SURVEY RESULTS:

A questionnaire was mailed to 635 households. The names and addresses were obtained at dove check stations located at Robbins Buttle Wildlife Area and Hassayampa during the September 1984 Dove Season. A total of 110 questionnaires were returned with an additional 58 returned undeliverable for a return rate of 19 percent. This was a biased sample in favor of hunters due to the method the names were collected. Although, biased the activity in the area from the questionnaire tracks well with observation from field inspections (Table 1 and 11).

The peak months of activity in the area are September through February, this conincides with opening of bird hunting seasons (Table 2 and 10). Most trips are made on weekends or opening days (Table 2 and 10). The two areas presently managed by the Department as small game hunting areas were consistant areas of activity (Table 3).

An average party size was 4.1 (Table 4) but the average number of people per vehicle was 2.3 indicates that for most trips 2 or more vehicles were driven. This is also brought out by the average number of house holds in the party figured at 2.8 (Table 5). The percentage of individuals 16 years and older was 76 percent (Table 6). The average cost of a trip per party was $45.00 (Tables 7 and 8), and the average number of individual per party was 4.1 for an average cost per person per trip being $10.98, (this does not include cost of transportation or admission fees). The estimated expenditures per year are 1984-85: $206,906; 1985-86: $229,104 and 1986-87: 306,432.

The availability of game ranked high as a reason for visiting the study area, 98 percent said it was "most important" or "important" to them (Table 9). Closeness of the area to their homes was "somewhat important". Uniqueness of the area was fairly evenly spit across the five categories as were access and admission charges. One could assume from these results that the majority of the people would travel some distance, pay some charges for access to an area that was some what unique if there were lots of game available. The questionnaire did not yeild any information on attitudes about fishing or other topics listed. Additional comments regarding respondent's experiences in the area were received.

Most were supportive of the Departments management of the Wildlife Areas. Some of the comments were about crowded conditions on the areas during dove hunts. Some examples are as follows:

1. "Great for hunting, keep the areas open".

2. "Watch out for rattlers, and gunners"!

3. "Most of my visits have been to Robbins Butte Area. With every visit the Game and Fish Staff were very helpful and a credit to the Department".

4. "Still need more policing. Found evidence of slob hunter's habits and saw young hunters shoot nongame birds and birds out of season. No vehicles were seen to get license plate numbers...."

5. "The State should ban ALL 3 AND 4 wheeled ATV's and noisy motorcycles from any National Forest.... If necessary, areas close to Phoenix, like sandy washes could be set aside for this non-hunting initiating activity"!

6. "I think your roadblocks for dove are illegal and some of your officers are rude".

7. "On the premise that the funds would be used solely for these purposes, I would support increased fees, taxes etc. Agencies are currently doing a good job and I'd like to financially support an opportunity for them to do an outstanding job."

8. "Dangerously crowded".

9. "The Mumme Farm (Powers Butte Wildlife Area) which I believe is across from the C & C feed lot was very poor last year for dove hunting. I would like to see this area planted with more feed for game birds. Even if a minor cost was to be charged for hunting in that area. The C & C feed lot is over crowded and a serious accident is bound to happen."

10. "My friends and I use that area for hunting doves, quail, and rabbits. The area is easy to walk in and it is a very pleasant place to relax".

Table 1. Activities participated in during visit.

Boating	1 (0.1)
Fishing	7 (5)
Horseback Riding	2 (1)
Hiking/Related	5 (3)
Swimming	3 (2)
ORV's	6 (4)
Picknicking	8 (6)
Motorcycling	3 (2)
Hunting	110(76)

Numbers in () are percentages.

Table 2. Number of days study area was visited by month and by day of the week.

January	43	(7.4)	April	7	(1.2)	July	8	(1.3)
February	31	(5.3)	May	4	(0.6)	August	29	(5.0)
March	7	(1.2)	June	5	(0.8)	September	269	(46.0)
October	72	(12.3)						
November	48	(8.2)						
December	63	(10.8)						

Weekends	52	(36.0)	Equally divided	15	(10.0)
Week days	8	(11.0)	Opening day		(47.0)

Numbers in ( ) are percentages.

Table 3. Number of days each of the twelve areas were visited.

91st Ave. and the Gila River	28	(3)
107th Ave. and the Gila River	11	(1)
115th Ave. and the Gila River	27	(3)
Bullard Ave. Siena Estrella Park	30	(4)
Arlington Wildlife Area	181	(22)
Robbins Butte - Black Butte Wildlife Area	153	(18)
Salt Cedar Shooting Preserve	48	(6)
Gillespie Dam Area	71	(9)
C & C Feedlot (Arlington Cattle Company)	157	(19)
317 Ave. and the Gila River	35	(4)
Palo Verde Road and the Gila River	52	(6)
Powers Butte Wildlife Area	42	(5)

Numbers in () are percentages.

Table 4. Distribution of party size on an average trip.

Number in Party	Frequency	Percent
1	5	5
2	20	19
3	28	26
4	27	25
5	4	4
6	10	9
7	1	1
8	8	7
9 or more	4	4

Mean size of party per trip 4.1.

Table 5. Number of different households per party.

Number of Households	Frequency	Percent
1	12	11
2	40	38
3	28	26
4	18	17
5	5	5
6 or more	3	3

Numbers of households per party 2.8.

Table 6. Number of individuals 16 years and older and 15 years and younger in the party.

Number Per Party	16 Years and Older Frequency	15 Years and Younger Frequency
1	5	21
2	37	8
3	26	3
4	15	1
5	7	0
6	6	1
7	3	
8	2	
9	1	
10 or more	5	

Percentage of adults and juveniles is 76% adults and 24% juveniles.

Table 7. Average cost per trip other than direct travel costs or admission fees rounded to nearest 5 dollars.

Expenditure $	Frequency	Percent
5	4	4
10	14	13
15	8	8
20	12	11
25	10	9
30	9	8
35	7	7
40	9	8
45	0	0
50	12	11
55	0	0
60	4	4
65 and more	12	11

Cost per trip $45.00.

Table 8. Average length of time spent in the area in hours.

Number of Hours	Frequency	Percent
1	0	
2	3	
3	13	
4	34	
5	12	
6	24	
7	2	
8	5	
9	0	
10 or more	12	—

Length of trip to the area was 6.8 hours.

Table 9. Attractions that led to selection of the area.

	Most Important		Important		Somewhat Important		Not Very Important		Least Important	
Availability of Game	90	(92)	6	(6)	2	(2)	—	—	—	—
Closeness to your home	4	(4)	18	(20)	28	(31)	18	(20)	21	(24)
Uniqueness of the area and its surroundings	9	(10)	33	(37)	20	(22)	15	(17)	13	(14)
Ease of access to site	9	(10)	33	(37)	28	(31)	15	(17)	6	(7)
No admission is charged	19	(21)	25	(28)	17	(19)	13	(15)	15	(17)

Numbers in () are percentages.

SIGNIFICANT DEVIATION:

Vehicle counters and wing barrels were not operated the final year of the study because of vandals, budget, weather, and equipment problems.

CONCLUSIONS, EVALUATIONS, AND RECOMMENDATIONS:

A completed set of tables by site, month, and year are available at the Arizona Game and Fish Department, Phoenix, Arizona.

The area studied is close to a highly developed metro-complex of cities. The population of the valley area is expected to continue to increase. As the population grows the demand for natural areas where people can fish, hike, bird watch, and hunt will also increase. This demand will necessitate better planning and judicial stewardship of the properties presently owned and/or managed by Arizona Game and Fish. The Robbins Butte - Black Butte Wildlife Area is the only area presently under active management and is visited by more people annually than any other in the study site area. Another area, Powers Butte Wildlife Area, should be under active management by 1989. This area is not anticipated to reduce activity on Robbins Butte - Black Butte because of the anticipated increase of activity in the area. These areas, as well as additional areas, should continue to be actively managed by Arizona Game and Fish Department.

It may be necessary to charge a user fee in the future to off set the additional cost of operation, development and maintenance of this area.

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Summary

The three year study of recreational man-days use on the Gila River (Fred eller Green Belt including Robbins and Powers Butte Wildlife Areas), is now mpleted.

neral Purpose of the Study: To determine the seasonal and spatial stribution and the number of recreational man-use days on the study area and also to determine the characteristics of the user population.

eographic Location: Primarily this area includes 91st Avenue on the east including access points both sides of the river) and Gillespie Dam on the west. Twelve areas were selected for visits and are as follows:

1. 91st Avenue
2. 115th Avenue
3. Bullard Avenue and Estrella Park
4. Jack Rabbit Lane
5. Robbins Butte Wildlife Area
6. Buckeye Hills Recreation Area
7. Power Butte Wildlife Area
8. Gillespie Dam
9. Arlington Area
10. Arlington Canal
11. Palo Verde Road
12. Palo Verde Road to Rte. 80

Survey Visits: One hundred and fifty (Table 10) trips were taken by the research team and all 12 sites were visited on a random selection of dates for each month of the study. All major holidays, and all opening days were included. Data was recorded on Field Sheets and transferred to permanent tables shortly thereafter. The number of vehicles and man-use days were recorded for the following activities:

1. Hunting
2. Picnicking
3. Hiking
4. Motorcycling
5. Horseback Riding
6. ORV Use
7. Swimming
8. Camping
9. Fishing

Man-use days were derived from the on-site observations and were averaged to determine the "typical" weekend day and weekday for each month. These values were expanded relative to the number of days contained in any given month. The monthly totals were combined to determine the total yearly use (Table 11).

GENERAL COMMENTS ON TOTAL USE: Refer to Table 11 for details

Vehicles: The characteristics of the data on the 3 year study show that the number of vehicles visiting the study area increased 11 percent the second year and 33 percent the third year for a 22 percent average.

Hunting: The number of man-use days increased from 27 percent to second year and 10 percent the third year for a 19 percent average.

Picnicking: The number of man-use days increased from 10 percent the second year to 38 percent the third year for a 24 percent average.

Hiking: The number of man-use days decreased from 61 percent the second year to 55 percent the third year for 58 percent average. The large increase over the 3 years is partly due to more hunters going out and observing concentration of game the 3 or 4 weeks before the opening of dove season and the general national craze for exercise.

Horseback: The number of man-use days increased to 707 percent the second year and 5 percent the third year for 356 percent average. Evidently the large increase from the second and third years was due to the fact that many clubs and groups found that horseback riding was enjoyable along the river trails in relation to farm youngsters horseback riding in the Arlington and Arlington Canal area.

ORV Use: The number of man-use days increased to 327 percent the second year and 42 percent the third year for 356 percent average. ORV groups had many gatherings along the river and seemed to enjoy the challenge of trails.

Swimming: The number of man-use days decreased 922 percent the second year and 85 percent the third year for a 503 percent decrease. Swimming has decreased remarkably since the first year due to decreased water quality.

Camping: The number of man-use days increased 41 percent the second year and 59 percent the third year for a 57 percent average. Almost all of the camping takes place at Buckeye Hills recreation area. This area has become popular with older couples who have found this an inexpensive place to stay overnight when traveling from the coast to the Phoenix area or vice versa. Some transients take up residence in this area during the mild winter months.

Fishing: The number of man-use days increased 6 percent the second year and 380 percent the third year for a 193 percent average. For some unknown reason the fisherman were attracted to the Gillespie Dam due to the abundance of fish during the third year. I have no logical explanation for this increase.

SPECIAL COMMENTS ON IMPORTANT SECTIONS OF THIS STUDY:

Total Rank for Vehicles by Site for Three Years (Table 12):

Buckeye Hills ranks first in the number of vehicles visiting any one site. This area was mainly used for camping (4,089 units).

Robbin's Butte ranks second in the number of vehicles. The area was used entirely for hunting (3,650 units).

Three Year Rank Order for Vehicles:

Rank	Site	Total Units
1	Buckeye Hills	4,089
2	Robbins Butte	3,650
3	Arlington	2,758
4	Gillespie Dam	2,527
5	Bullard	2,300
6	115th Avenue	2,164
7	91st Avenue	2,072
8	P.V. Road to 80	1,786
9	Power Butte	1,530
10	J. Rabbit Lane	1,452
11	Arlington Canal	1,429
12	Palo Verde Road	1,330

Three Year Site Ranks for Vehicles:

Site	Name	Site Rank by Year 1st 2nd 3rd	Average Yearly Rank - 3
1	91st Avenue	11 - 6 - 5	7.33
2	115th Avenue	9 - 4 - 7	6
3	Bullard Avenue	6 - 5 - 6	5.67
4	Jack Rabbit Lane	8 - 9 - 11	9.33
5	Robbins Butte	3 - 1 - 2	2
6	Buckeye Hills	1 - 2 - 1	1.33
7	Power Butte	4 - 10 - 12	8.67
8	Gillespie Dam	2 - 7 - 4	4.33
9	Arlington	5 - 3 - 3	3.67
10	Arlington Canal	10 - 11 - 9	10
11	Palo Verde Road	12 - 12 - 10	11.33
12	Palo Verde Road to 80	7 - 8 - 8	7.67

TABLE 10

Study Area Survey's
October 10, 1984 - August 1, 1987

	Week-end	Weekday	Opening day	Holiday	Total
1st Year					
July, Aug., Sept. '84	Contract approval delayed!				
Oct., Nov., Dec. '84	13	5	2	2	22
Jan., Feb., March '85	9	6	--	1	16
April, May, June '85	3	3	--	--	6
2nd Year					
July, Aug., Sept. '85	4	3	1	2	10
Oct., Nov., Dec. '85	11	7	4	2	24
Jan., Feb., March '86	6	4	--	1	11
April, May, June '86	3	3	--	--	6
3rd Year					
July, Aug., Sept. '86	8	5	1	2	16
Oct., Nov., Dec., '86	9	5	2	2	18
Jan., Feb., March '87	6	3	--	2	11
April, May, June '87	6	4	--	--	10
3 Year Totals	78	48	10	14	150

TABLE 11

	1984-85	1985-86	%	1986-87	%	3 Year Total	%
Vehicles	5,880 *2,313 8,193	9,072	54 11	12,134	33	27,086 *2,313 29,399	44 22
Hunting	12,038	15,328	27	16,882	10	44,248	19
Picnicking	13,714 *5,978 19,692	21,421	56 10	29,603	38	64,738 *5,978 70,716	17 24
Hiking	1,343 *546 1,889	3,045	120 61	4,705	55	9,039 *546 9,585	88 58
Motorcycling	1,756 *000	489	-72	1,857	280	4,102	208
Horseback	75 *45 120	969	1,192 707	1,020	5	2,064 *45 2,109	598 356
ORV Use	352 *94 446	1,903	441 327	2,697	42	4,952 *94 5,046	242
Swimming	251 *4 255	20	-920 -922	3	-85	274 *4 278	-503
Camping	2,018 *196 2,196	3,105	54 41	4,924	59	10,039 *196 10,235	57 50
Fishing	731 *38 769	774	5 6	3,737	38	5,242 *38 5,280	192 193

Note: These figures added to the totals were transferred from the 1st quarter of the second year in order to yield a more practical adjustment for the data. The study was approved and started on the second quarter of the first year.

TABLE 12

Rank of Number of Vehicles by Site Per Year

Rank	1984-85	Total	Rank	1985-86	Total	Rank	1986-87	Total
(1)	Buckeye Hills	980	(1)	Robbins Butte	1,307	(1)	Buckeye Hills	1,824
(2)	Gillespie Dam	716	(2)	Buckeye Hills	1,285	(2)	Robins Butte	1,657
(3)	Robbins Butte	686	(3)	Arlington Area	1,090	(3)	Arlington Area	1,174
(4)	Power Butte	527	(4)	115th Avenue	1,090	(4)	Gillespie Dam	1,133
(5)	Arlington Area	494	(5)	Bullard Avenue	799	(5)	91st Avenue	1,069
(6)	Bullard Avenue	437	(6)	91st Avenue	698	(6)	Bullard Avenue	1,064
(7)	P.V. Road to 80	430	(7)	Gillespie Dam	678	(7)	115th Avenue	976
(8)	J. Rabbit Lane	369	(8)	P.V. Road to 80	608	(8)	P.V. Road to 80	748
(9)	115th Avenue	350	(9)	J. Rabbit Lane	465	(9)	Arlington Canal	664
(10)	Arlington Canal	329	(10)	Power Butte	448	(10)	P.V. Road	652
(11)	91st Avenue	305	(11)	Arlington Canal	436	(11)	J. Rabbit Lane	618
(12)	Palo Verde Road	257	(12)	Palo Verde Road	421	(12)	Power Butte	555

Total Rank Order for Hunters by Site for Three Years (Table 13)

Robbins Butte ranks first in the number of hunters visiting the area (8,507 hunters).

The Arlington Area ranked second in the number of hunters visiting the area (5,649 hunters).

Three Year Rank Order for Hunter:

Rank	Site	Total
1	Robbins Butte	8,507
2	Arlington Area	5,694
3	Bullard Avenue	3,418
4	Gillespie Dam	3,335
5	Power Butte	3,343
6	Palo Verde Road to 80	3,178
7	115 Avenue	3,171
8	Arlington Canal	2,765
9	91st Avenue	2,538
10	Jack Rabbit Lane	2,369
11	Buckeye Hills	2,291
12	Palo Verde Road	2,189

Three Year Site Ranks for Hunters:

Site	Name	Site Rank by Year 1st 2nd 3rd	Average Yearly Rank - 3
1	91st Avenue	11 - 7 - 9	9
2	115th Avenue	9 - 3 - 4	5.33
3	Bullard Avenue	7 - 5 - 3	5.67
4	Jack Rabbit Lane	10 - 10 - 10	10
5	Robbins Butte	1 - 1 - 1	1
6	Buckeye Hills	3 - 12 - 12	9
7	Power Butte	4 - 9 - 5	6
8	Gillespie Dam	2 - 4 - 11	5.67
9	Arlington	5 - 2 - 2	3
10	Arlington Canal	8 - 8 - 6	7.33
11	Palo Verde Road	12 - 11 - 8	10.33
12	Palo Verde Road to 80	6 - 6 - 7	6.33

TABLE 13

Rank of Number of Hunters by Site Per Year

Rank 1984-85	Total	Rank 1985-86	Total	Rank 1986-87	Total
(1) Robbins Butte	1,586	(1) Robbins Butte	3,062	(1) Robbins Butte	3,859
(2) Gillespie Dam	1,377	(2) Arlington	2,426	(2) Arlington	2,254
(3) Buckeye Hills	1,318	(3) 115th Avenue	1,356	(3) Bullard Avenue	1,532
(4) Power Butte	1,243	(4) Gillespie Dam	1,229	(4) 115th Avenue	1,254
(5) Arlington	969	(5) Bullard Avenue	1,195	(5) Power Butte	1,203
(6) P.V. Rd to 80	968	(6) P.V. Rd to 80	1,034	(6) Arlington C.	1,186
(7) Bullard Avenue	754	(7) 91st Avenue	1,032	(7) P.V. Rd to 80	1,176
(8) Arlington Canal	661	(8) Arlington Canal	918	(8) P.V. Road	1,086
(9) 115th Avenue	561	(9) Power Butte	897	(9) 91st Avenue	1,071
(10)Jack Rabbit Ln.	511	(10) Jack Rabbit Lane	853	(10) Jack Rabbit L.	1,005
(11)91st Avenue	435	(11) P.V. Road	680	(11) Gillespie Dam	929
(12)P.V. Road	423	(12) Buckeye Hills	646	(12) Buckeye Hills	327

Total Rank Order for Picnicking Man-Use Days by Site for Three Years (Table 14)

Buckeye Hills ranks first in the number of man-use days (total 10,014).
Robbins Butte ranks second in the number of man-use days (total 9,292).

Three Year Rank Order for Man-Use Days:

Rank	Site	Total Man-Use Days
1	Buckeye Hills	10,014
2	Robbins Butte	9,292
3	Arlington	6,862
4	Gillespie Dam	5,936
5	Bullard Avenue	5,513
6	115th Avenue	5,126
7	91st Avenue	4,780
8	Palo Verde Road to 80	4,053
9	Power Butte	3,709
10	Arlington Canal	3,442
11	Jack Rabbit Lane	3,402
12	Palo Verde Road	3,225

Three Year Site Ranks for Picnicking Man-Use Days:

Site	Name	Site Rank by Year 1st 2nd 3rd	Average Yearly Rank - 3
1	91st Avenue	11 - 7 - 6	8
2	115th Avenue	8 - 6 - 7	7
3	Bullard Avenue	6 - 5 - 5	5.33
4	Jack Rabbit Lane	9 - 8 - 11	9.33
5	Robbins Butte	3 - 1 - 2	2
6	Buckeye Hills	1 - 2 - 1	1.33
7	Power Butte	4 - 9 - 12	8.33
8	Gillespie Dam	2 - 4 - 4	3.33
9	Arlington	5 - 3 - 3	3.67
10	Arlington Canal	10 - 11 - 10	10.33
11	Palo Verde Road	12 - 12 - 9	11
12	Palo Verde Road to 80	7 - 10 - 8	8.33

TABLE 14

Three Year Site Totals for Picnicking - Man-Use Days

Rank	1984-85	Total	Rank	1985-86	Total	Rank	1986-87	Total
(1)	Buckeye Hills	2,316	(1)	Robbins Butte	3,085	(1)	Buckeye Hills	4,641
(2)	Gillespie Dam	1,730	(2)	Buckeye Hills	3,057	(2)	Robbins Butte	4,022
(3)	Robbins Butte	1,566	(3)	Arlington	2,764	(3)	Arlington	2,916
(4)	Power Butte	1,243	(4)	Gillespie Dam	1,570	(4)	Gillespie Dam	2,636
(5)	Arlington	1,182	(5)	Bullard Avenue	1,951	(5)	Bullard Avenue	2,529
(6)	Bullard Ave.	1,033	(6)	115th Avenue	1,935	(6)	91st Avenue	2,446
(7)	P.V. Rd to 80	978	(7)	91st Avenue	1,622	(7)	115th Avenue	2,394
(8)	115th Avenue	797	(8)	Jack Rabbit Ln	1,061	(8)	P.V. Rd to 80	1,715
(9)	Jack Rabbit Ln	782	(9)	Power Butte	1,040	(9)	Palo Verde Rd	1,694
(10)	Arlington Canal	789	(10)	P.V. Rd to 80	1,360	(10)	Arlington Can.	1,625
(11)	91st Avenue	712	(11)	Arlington Can.	1,030	(11)	Jack Rabbit Ln	1,559
(12)	Palo Verde Road	585	(12)	Palo Verde Rd	946	(12)	Power Butte	1,426

Total Rank Order for Fishing by Site for Three Years (Table 15)

There were only 6 sites that had fishing activity. Gillespie Dam Area ranked first in use days (total 2,593). Ninety-first (91st) Avenue ranks second in the in-use days (total 1,043).

Three Year Rank Order for Use Days:

Rank	Site	Total Use Days
1	Gillespie Dam	2,593
2	91st Avenue	1,023
3	115th Avenue	804
4	Bullard Avenue	750
5	Arlington Area	42
6	Arlington Canal	10

The above relates the total use of fishing man-use days over the three year study. Only six sites had any activity during this period.

Three Year Site Rank for Fishing:

Site	Name	Site Rank by Year 1st	2nd	3rd	Average Yearly Rank - 3
1	91st Avenue	3 -	2 -	2	2.33
2	115th Avenue	4 -	3 -	3	3.33
3	Bullard Avenue	2 -	4 -	4	2.66
4	Jack Rabbit Lane	N/A	N/A	N/A	--
5	Robbins Butte	N/A	N/A	N/A	--
6	Buckeye Hills	N/A	N/A	N/A	--
7	Power Butte	N/A	N/A	N/A	--
8	Gillespie Dam	1 -	1 -	1	1.00
9	Arlington Area	5	N/A	N/A	only 1 year
10	Arlington Canal	6	N/A	N/A	only 1 year
11	Palo Verde Road	N/A	N/A	N/A	--
12	Palo Verde Road to 80	N/A	N/A	N/A	--

TABLE 15

Three Year Site Totals for Fishing

Rank 1984-85	Total	Rank 1985-86	Total	Rank 1986-87	Total
(1) Gillespie Dam	435	(1) Gillespie Dam	372	(1) Gillespie Dam	1,786
(2) Bullard Avenue	107	(2) 91st Avenue	170	(2) 91st Avenue	790
(3) 91st Avenue	83	(3) 115th Avenue	118	(3) 115th Avenue	632
(4) 115th Avenue	54	(4) Bullard Avenue	114	(4) Bullard Avenue	529
(5) Arlington Area	42				
(6) Arlington Canal	10				

Conclusion

This summary is a condensed report of the three year study reports. The succinct data is provided here with as few remarks as possible for the reader to draw his own opinion as to the results of the study.

My personal opinion of the wildlife area studied is that the large increase in activity is due to the management and direction by the Arizona Game and Fish Department. The hunters I have talked to have given me positive feedback on the direction of the area. The majority of opinion is that the hunters like the area and the help and supervision given by the Arizona Game and Fish Department.

I am sure that the use will continue to grow because there are no other wildlife areas as close to a major metropolitan area as Phoenix.

TABLE 15

FIR... EAR ...ULT... 84

October 1984 - June 1985

1984 | 1985

SITE:	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
VEHICLES	305.2	350.7	436.6	368.7	686.1	979.9	526.6	716.3	494.0	328.5	256.5	430.4	5,880
HUNTING	435.9	561.8	754.6	511.6	1586.3	1318.3	1243.1	1377.6	969.4	661.5	423.1	968.7	1,227* 10,812
PICNICING	711.9	797.8	1032.6	782.6	1566.3	2316.4	1243.1	1730.6	1182.4	787.5	585.1	978.1	13,714
HIKING	62.0	130.0	48.0	95.0		978.6		27.4				2.0	1,343
MOTOR-CYCLING	146,6	59.0	45.2	166.6	6.4	452.0	5.8	2.0	282.2	248.9	193.1	147.7	1,756
HORSEBACK		8.0								28.0	18.6	20.0	75
ORV USE	30.0	44.0		112.0		146.0					20.0		352
SWIMMING	32.0		127.0	32.0				20.0	40.0				251
CAMPING		14.4			10.0	1944.2	12.8	16.0	8.0	4.0			2,009
FISHING	83.4	54.0	107.0					435.2	42.0	10.0			732

* Added 1st dove season before project officially started. Data provided by Arizona Game and Fish Department

TABLE 17

SECOND YEAR RESULTS BY SITE
July 1985 - June 1986

1985 **1986**

SITE:	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
VEHICLES	698	835	799	465	1307	1285	448	678	1090	436	421	608	9,070
HUNTING	1032	1356	1195	853	3062	646	897	1229	2426	918	680	1034	15,328
PICNICING	1622	1935	1951	1061	3085	3057	1040	1570	2764	1030	946	1360	21,421
HIKING	311	200	457	95	496	1081	179	39	73	14	3	97	3,045
MOTOR-CYCLING	34	83	39	60	18	73		16	70	22		74	489
HORSEBACK	38	272	18	44	6				42	102	299	148	969
ORV USE	342	82	309	149	21	212	120	74	169	76	115	234	1,903
SWIMMING	4		16										20
CAMPING			34			2968	103						3,105
FISHING	170	118	114					372					774

TABLE 16

THIRD YEAR RESULTS BY SITE

July 1986 - June 1987

SITE:	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
VEHICLES	1069	976	1064	618	1657	1824	555	1133	1174	664	652	748	12,134
HUNTING	1071	1254	1532	1005	3859	327	1203	929	2254	1186	1086	1176	16,882
PICNICING	2446	2394	2529	1559	4022	4641	1426	2636	2916	1625	1694	1715	29,603
HIKING	147	96	130	47	160	3717	114	43	83	50	33	85	4,705
MOTOR-CYCLING	223	106	151	292		247	60		160	133	241	244	1,857
HORSEBACK	235	133	110	44					153	129	138	78	1,020
ORV USE	281	230	174	283		349	54	57	494	194	295	286	2,697
SWIMMING		3											3
CAMPING	266	8		5		4645							4,924
FISHING	790	632	529					1786					3,737

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Picacho Peak State Park. Photo by Josh Young

Special Issue

Biotic Communities of the American Southwest–United States and Mexico

David E. Brown
Editor

Contents

Acknowledger

In 1974 the Rocky Mountain Forest an
(USDA Forest Service) undertook a jo
Region-3 headquarters to compile a
information concerning wildlife spec
and New Mexico. David R. Patton accepte
Leader for the Forest Service, working at th
Arizona State University campus at
Arizona Game and Fish Departm
collaborator but agreed to author and
part of this effort the Arizona Game an
Mountain Station published a detailed
Communities of the Southwest by
Lowe.
The purpose of the map was to tie
meet local assessment needs and
regional level. As a result of the map th
document, in a publication, the physi
the identified biotic communities. T
started in 1977.
David E. Brown organized a gro
dealing with the various biomes and bec
for the unified work. He has authored o
chapters and filled in the gaps bet
Throughout *Biotic Communities of*
States and Mexico he is the aut
attributed to other authors. Aside from a
(David R. Patton and Charles P. Pase
Arizona State University (W.L. M
Desert Botanical Garden (Howa
Arizona (Charles H. Lowe), and the
M. Turner).

Sonoran Riparian Scrubland

In and along drainages within the Sonoran Desert are scrublands of low to medium height (1.5 to 3.0 m), too dense to be considered desertscrub or strand. Although these scrublands usually contain plant species also found in adjacent desertscrub (e.g., *Lycium brevipes, Acacia greggii, Celtis pallida,* and especially the highly facultative mesquite), the actual stream channel dominants are usually distinctive riparian species. Seepwillow (*Baccharis salicifolia*) is abundant nearest water, with Desert Broom (*B. sarothroides*) in drier places and Mule Fat (*B. viminea*) in desert washes. Arrow-weeds (*Tessaria sericea, Pluchea camphorata,* and *P. purpurascens*) and Burrobrush may dominate on sandy soils (Fig. 187). These and other evergreen shrubs have adapted to successional situations as befits their restricted occurrence to flood-prone areas. The deciduous Desert-willow (*Chilopsis linearis*) is a common arboreal component, as is the increasingly prevalent, deciduous Saltcedar.

Along the saline portions of the lower Colorado and Gila rivers and in the Salton Sea basin, are dense and taller (to 11 m or higher) "thickets" of introduced Saltcedar and the evergreen Athel (*Tamarix aphylla*). In the less disturbed sites, these may be accompanied by native Screwbean Mesquite, Lenscale, or Quailbush (*Atriplex lentiformis*), Arrow-weed, Western Honey Mesquite (*P. glandulosa* var. *torreyana*), and such purely salt-shrub species as *Suaeda torreyana, Atriplex polycarpa* and *Allenrolfea occidentalis* (Fig. 188). These communities are highly flammable because of deciduous and other properties of Saltcedar, and are now typically in a fire-succession stage. Each fire (or clearing) increases the prevalence of the root sprouting Saltcedar at the expense of more valuable native vegetation. Consequently, fire disclimax consociations of Saltcedar now exclusively occupy extensive areas along the lower Colorado River, its delta, tributaries, distributaries (e.g., Rio Hardy, Alamo, and New rivers), agricultural drains and sumps, and other poorly-drained, alkaline places (Fig. 189).

The value of these thickets to game species is well known, and such places often support a high density of Desert Cottontail (*Sylvilagus audubonii*) and Gambel's Quail (*Lophortyx gambelii*), and if of sufficient height (3+ m), nesting Mourning and White-winged Doves. Other birds well represented in Sonoran riparian scrub are the Crissal Thrasher, Abert's Towhee, Brown Towhee (*Pipilo fuscus*), Say's Phoebe (*Sayornis saya*), and Black-tailed Gnatcatcher (Anderson and Ohmart, 1977; Anderson et al., 1977). If standing water is present, such scrublands may also often be inhabited by the Yuma Clapper Rail (*Rallus longirostris yumaensis*).

Figure 187. *Sonoran riparian scrubland, strand, and woodland on the Verde River, Tonto National Forest, Maricopa County, Arizona. Scrubland composed largely of Burrobush* (Hymenoclea monogyra), *Arrowweed* (Tessaria sericea) *and Velvet Mesquite* (Prosopis velutina) *in scrub form. Elevation ca. 450 m.*

Figure 188. Sonoran ... *Saltcedar* (Tamarix ... (Prosopis pubescens ... with an occasional ... Colorado River. Elev...

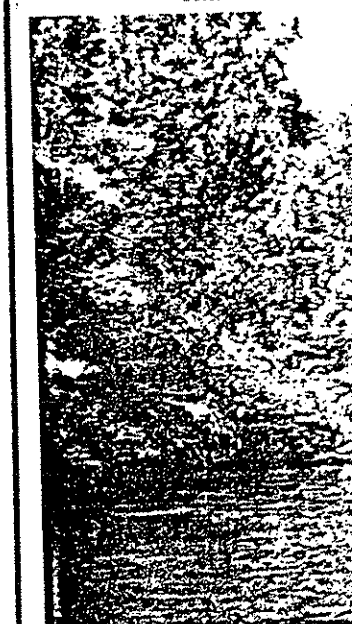

Figure 189. ... *Sonora, Mexico* ... mesquites (Prosopis ... increasing ...

n sandy soils (Fig. 187). These and other
adapted to successional situations as
occurrence to flood-prone areas. The
llow (*Chilopsis linearis*) is a common
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species as *Suaeda torreyana, Atriplex*
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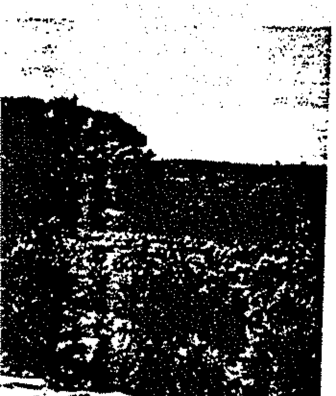

Tonto National Forest.
monogyra).
. Elevation ca. 450 m.

Figure 188. *Sonoran "lower Colorado River" scrub of Arrowweed* (Tessaria sericea, Pluchea camphorata). *Saltcedar* (Tamarix chinensis), *Western Honey Mesquite* (Prosopis glandulosa *var.* torreyana), *Screwbean* (Prosopis pubescens), *Lenscale or Quailbush* (Atriplex lentiformis) *and Seepweed* (Suaeda torreyana), *with an occasional willow* (Salix exigua, S. gooddingii), *near Cibola, Yuma County, Arizona, along the Colorado River. Elevation ca. 120 m.*

Figure 189. *Sonoran "lower Colorado River" riparian scrub in the Colorado River delta below Riito, Sonora, Mexico. A disclimax community dominated by Saltcedar* (Tamarix chinensis). *The remaining few mesquites* (Prosopis glandulosa *var.* torreyana, Prosopis pubescens) *will eventually be displaced with increasing incidence of fire brought on by the flammable properties of Saltcedar. Elevation ca. 5 m.*

ARIZONA WILDLIFE VIEWING GUIDE

John N. Carr

John N Carr

RIPARIAN HABITAT

In Arizona, riparian habitats comprise only one percent of the land area. Yet these narrow, fertile strips along streams and canyon bottoms harbor the greatest diversity of plants and animals of any habitat type. Riparian habitats are easily disrupted, and as a result only a small percent of these pristine areas remain.

This habitat, dependent upon adequate moisture from streams or springs, is very visible in Arizona since most of the surrounding area is dry upland desert. The classic cottonwood-willow riparian forests are evident along the Verde River in central Arizona and the San Pedro River in the southeast. At higher elevations, sycamores, alder, ash, Arizona walnut, canyon grape, and poison ivy can also be present.

Riparian habitats are not just cottonwood-willow or sycamore communities: they may take the form of a drier mesquite bosque (forest), a wet marsh, or a line of vegetation extending down a canyon bottom due to the cooler, wet conditions not found in the surrounding area. Arroyos—dry streams and channels—support more and larger plants that are common in adjacent areas. These "dry riparian" habitats are created from the extra moisture provided by runoff from seasonal rains, creating a haven for many insects, birds, and mammals. The largest paloverde and ironwood trees of the Sonoran Desert are found near these arroyos.

Many wildlife species are largely or totally dependant on the riparian deciduous forest. The Arizona gray squirrel, Apache fox squirrel, and raccoon are examples. Bats roost in riparian trees and feed upon the great number of insects produced there. Many bird species depend on riparian habitats. At the San Pedro River National Conservation Area, for example, 350 bird species have been identified, three-fourths of those recorded in Arizona. These riparian habitats provide the necessary requirements for bald eagles, gray hawks, yellow-billed cuckoos, great blue herons, Mississippi kites, and many other birds.

After a drive through the Bill Williams Delta National Wildlife Refuge, look at the surrounding hills: the difference in vegetation is remarkable and demonstrates how important this riparian habitat is to the wildlife of Arizona. To see wildlife in Arizona, go to the riparian areas—the animals do!

Riparian habitat along the San Pedro River near Fairbank.
RANDY A. PRENTICE

Riparian vegetation supports large numbers of insects, including the rainbow grasshopper. Insects are an essential food source for many birds during the nesting season.
ALEX KERSTITCH

~~Gila R.~~
Salt R

MAN AND WILDLIFE IN ARIZONA: The American Exploration Period 1824-1865

by
Goode P. Davis, Jr.

Edited by Neil B. Carmony
& David E. Brown

1982

April 18, probably near the head of Safford Valley, Pattie reported catching an otter in a beaver trap — one of the few references to river otters in Arizona. The hungry trappers ate the otter:

On my return from setting our two traps, I killed a buzzard, which disagreeable as it was, we cooked for supper. In the morning of the 18th, I found one of the traps had caught an otter. This served for breakfast and supper (Pattie 1833:71).

Proceeding up to the Gila, Pattie (1833:71) reported the killing of four deer and some turkeys during two days of hunting in the vicinity of the same creek where he had dispatched the grizzly on January 26. The exhausted trappers reached the Santa Rita Copper Mines on April 29, 1825.

James Ohio Pattie left his father at the mines and returned to Santa Fe to requisition horses and supplies for another trip to the Gila, this time to reclaim the pelts buried at two caches. The expedition reached its objectives, but only a few furs were recovered from the cache on the San Francisco River, and the larger cache on the Gila had been broken into and stolen, presumably by Indians. Financially broken, the Patties settled for the next few months at Santa Rita, where they attempted to work the mines.

Although his first trapping venture was a financial bust, James Ohio Pattie was undaunted. The next winter the younger Pattie joined a group of "French" trappers bound for the Red (Colorado) River. Leaving his father behind, Pattie and his companions left the Santa Rita mines on January 2, 1826[4] and traveled down the Gila River (Fig. 3).

The record of this second trapping expedition contains only meager bits of natural history as Pattie concentrates on detailing a particularly bloody battle with hostile natives which took place near the mouth of the Salt River.

[4]Weber (1971:123) cites evidence that indicates that this expedition may have actually taken place during the winter of 1826-1827 and been lead by Michel Robidoux.

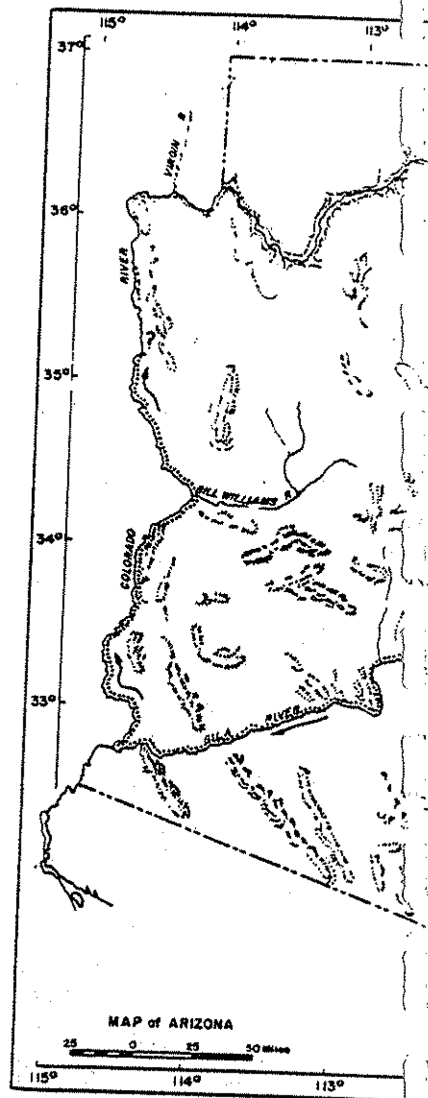

Figure 3. Route of James Ohio P…
January 1826 - April 18…

ead of Safford Valley, Pattie
p — one of the few refer-
hungry trappers ate the otter:

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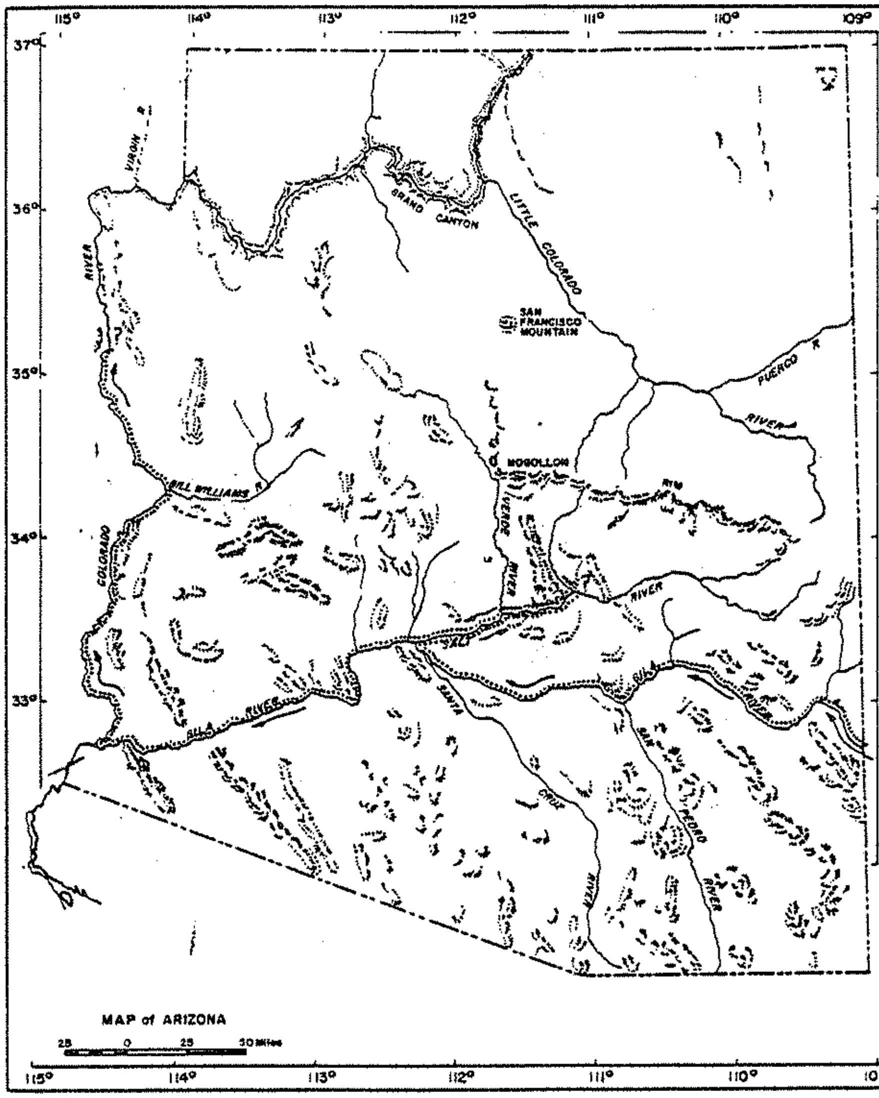

Figure 3. Route of James Ohio Pattie's 2nd trapping expedition in Arizona, January 1826 - April 1826.

Here, despite Pattie's remonstrances, the trappers camped at a "Papawar" village whose inhabitants showed more evidence of treachery than the hospitality they professed. Pattie and another trapper withdrew for the night and camped some distance away. Their fears were realized; the "Papawars" massacred the entire party except for the leader who escaped, badly injured, into the darkness. He eventually stumbled into the hiding place that concealed Pattie and his companion, and the three men successfully evaded the Indians.

Incredible good fortune now befell them. The next night the three fugitives spotted the campfires of another expedition of American trappers. They were made welcome and accepted the offer to continue trapping as part of the company.

The mountain men first exacted a successful revenge on the "Papawars": they killed most of the warriors in an ambush, then burned the village. They now settled down to the routine of trapping beaver, working their way up the Salt River, which Pattie called Black River.

It [Salt River] affords as much water at this point as the Helay.

In the morning of the 1st of February, we began to ascend Black River. We found it to abound with beavers. It is a most beautiful stream, bounded on each side with high and rich bottoms. We travelled up this stream to the point where it forks in the mountains; that is to say, about 80 miles from its mouth. Here our company divided, a part ascending one fork, and a part the other. The left fork [Verde River] heads due north, and the right fork [Salt River] northeast. It was my lot to ascend the latter. It heads in mountains covered with snow, near the head of the left hand fork of the San Francisco. On the 16th, we all met again at the junction of the forks. The other division found that their fork headed in snow covered mountains, as they supposed near the waters of Red River (Pattie 1833:91).

The trappers returned to the mouth of the Salt River and Pattie briefly described the next leg of their journey:

lley, north of Mount Graham, te nce of javelina:

9), one of my men discovered a ag weight of these animals is in riably light pepper and salt. if the musk which lies near the re oved (Emory 1848:69).

earny was forced by rugged ter- the Gila. The column returned edro. Dr. Griffin noted that as Hog River, probably because el wooded flood plain. Emory of he San Pedro:

te wide, and is covered with a m ood, and willow, through being unhorsed .... The San few yards wide, and only a foot

outh of the San Pedro, Johnston t dense riparian thickets. Lt. of his part of the Gila, the date

f e blue quail were seen, and t one.
a the San Pedro, was seamed e gns" of beaver and one trail

n absorbing aspects of the ady the ruins of a number of ab ndoned irrigation systems. ive, the expedition rested and

traded among the Maricopas and Pimas — peaceful farmers who grew crops of corn and cotton which they irrigated by diverting water from the Gila.

On November 14, Kearny resumed the march down the Gila. Dr. Griffin (1943:35) observed that below the Salt the Gila River was about 80 yards wide, three feet deep, and rapid. "We have seen more water fowl in the last two days than we have yet met with on the River — ducks, brant geese and swan." Below the great bend, Lt. Emory referred to the river bottoms being "wide, rich, and thickly overgrown with willow and a tall aromatic weed." The Gila was, in places, covered with waterfowl, particularly snow geese, which Emory called "white brant (wings tipped with black)." Signs of deer and beaver were abundant and one member of the party shot a "large buck," most likely a mule deer (Emory 1848:91).

In what is now western Maricopa County, Turner noted that the Gila was becoming much more like a real river. The width varied from 100 to 150 yards wide, with an average depth of four feet — "quite deep enough to float a steamboat." It flowed gently over a sandy bottom, while the banks, in Emory's terminology, were fringed with "cane, willow, and myrtle." Farther on, at the north end of the Mohawk Mountains in what is now Yuma County, Kit Carson shot a bighorn ewe.

We climb the table-bench again 30 feet, and travel until we gradually get into the bottom of the Gila again, at the point of Bighorn mountain, where Carson shot a doe of the Bighorn or mountain sheep. This animal had the face of the sheep, but with very short hair all over; its horns were like those of the common wether .... The animal probably weighed 70 pounds ... several of the males showed themselves on the cliffs, up which they climbed with great facility; their horns were very large, and their appearance much different from the female ... (Johnston 1848:606).

Emory states that he named the site "Goat's Spur," because of the bighorn. Near there, on November 18, Emory described the Gila bottom:

old beaver trapper Antoine Leroux acted as guide for the expedition, and Colonel Lewis S. Craig, later murdered by deserters in the Mohave Desert, commanded the military escort.

The Commission reached the Colorado River in June, 1852, and Lt. Whipple was detached to complete the survey of the Gila River, begun a year earlier but left incomplete because of a shortage of funds. Bartlett described the lands near the confluence of the two rivers:

The Colorado flows through a bottom or valley from two to four miles in width, thickly covered with cotton-wood and mezquit; ... the bottom land of the Gila was from three to four miles wide near the junction. The portion towards the river is thickly covered with cotton-wood, and with willows on the margin, while that further back has nothing but mezquit (Bartlett 1954, 2:159).

The Colorado was now so high as to cause the Gila to flow back a full fifteen miles. The Gila was still low, and, except near the junction, but a diminutive stream. It is doubtful whether it can ever be navigated ... (Bartlett 1854, 2:160).[4]

The main expedition, including Bartlett and the escort, left Fort Yuma on June 18 and worked its way up the Gila toward the Pima villages. Bartlett reported on June 21:

A number of fish were brought in today by the Mexicans resembling the buffalo-fish of the Mississippi. They drove them into a small nook in a laguna nearby, and then rushed into the water and killed them with poles. I ate of them at dinner, but found them soft and unpalatable (Bartlett 1854, 2:195).

[4]A year earlier, in June, 1851, Lt. Thomas W. Sweeny and nine men established Camp Independence, on the east bank of the Colorado. Travelers told him at the time that the Gila River had been completely diverted in the area of the Pima Indian villages, where extensive irrigation was practiced. See: Sweeny, T.W., 1956. *Journal of Lt. Thomas W. Sweeny, 1849-1853*; ed. Arthur Woodward, Westernlore Press, Los Angeles, 120 p.

In the vicinity of the Moha
tle army saw bighorn in 184
tailed deer." Deer and antel
Gila, but as Bartlett (1854,
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On June 23, a short dista
Bartlett described their camp

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2:199).

Just below the Pima villa
Gila completely dry — the In
to their fields. Three days later
miles north to the Salt River:

The river we found to be
three feet deep, and both rapi
sweet, and neither brackish n
name. We saw from the banks
caught several of the same sp
Along the immediate margin
grow (Bartlett 1854, 2:240-241).

About 12 miles above th
again found the Gila flowing

The river was here much
feet high, and completely over
woods, the latter from the opp
width was less than fifty feet, a
nine inches (Bartlett 1854, 2:260

In the vicinity of the Mohawk Mountains (where Kearny's little army saw bighorn in 1846) Antoine Leroux shot a "fine black-tailed deer." Deer and antelope were occasionally seen along the Gila, but as Bartlett (1854, 2:197) tells us, the wagons alarmed them, and the hunters had to go out well in advance of the train in order to succeed.

On June 23, a short distance below the great bend of the Gila, Bartlett described their campsite (see Fig. 9):

> *So thick was the wood[s], that it was found impracticable to force our wagons through. This was the most beautiful spot we had encamped in since leaving the little valley of San Isabel, in California.; We pitched no tents, finding a better and more agreeable protection in the thick and over hanging willows* ... (Bartlett 1854, 2:199).

Just below the Pima villages, Bartlett was amazed to find the Gila completely dry — the Indians had diverted the entire flow onto their fields. Three days later on July 3, Bartlett traveled about 15 miles north to the Salt River:

> *The river we found to be from 80 to 120 feet wide, from two to three feet deep, and both rapid and clear. ... The water is perfectly sweet, and neither brackish nor salt, as would be inferred from the name. We saw from the banks many fish in its clear waters, and caught several of the same species as those taken in the Gila. ... Along the immediate margin of the stream large cotton-wood trees grow* (Bartlett 1854, 2:240-241).

About 12 miles above the Pimas, on July 12, 1852, Bartlett again found the Gila flowing:

> *The river was here much contracted, with steep banks fifteen feet high, and completely overhung with willows and cotton-woods, the latter from the opposite banks, meeting at the top. Its width was less than fifty feet, and its greatest depth did not exceed nine inches* (Bartlett 1854, 2:260).

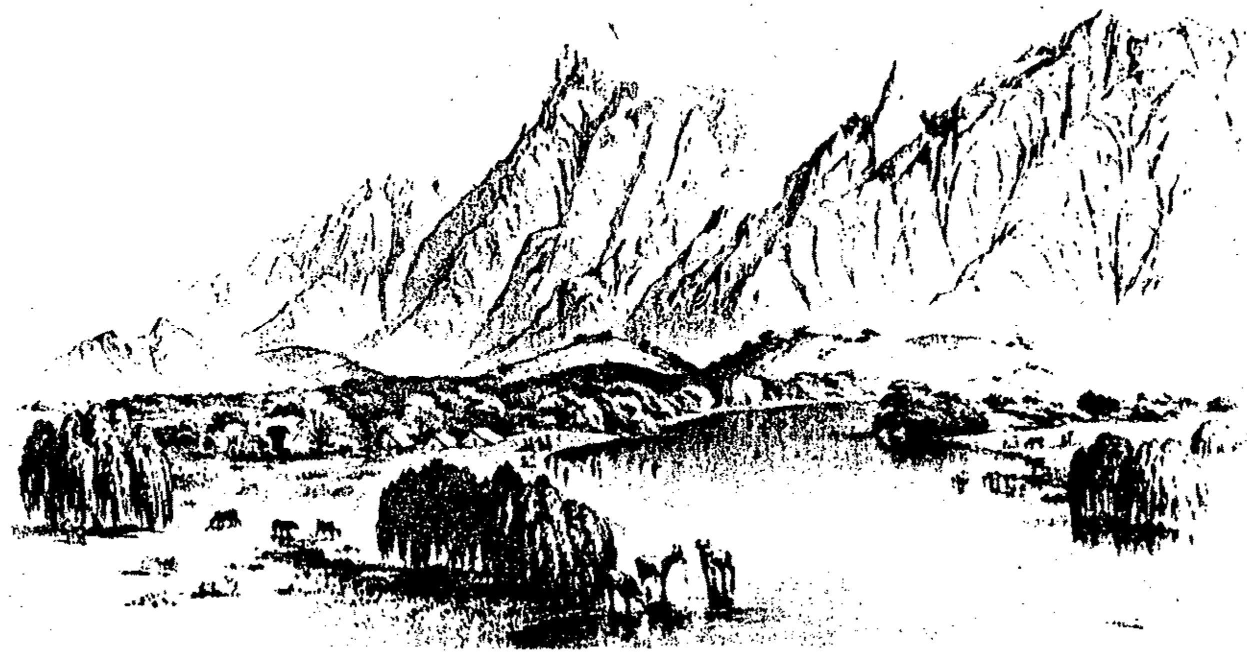

Figure 9. "Big Horn Mountain, River Gila." Reproduced from Bartlett (1854: opp. p. 198).

s companions killed several turkeys in
d stream now called Turkey Creek,
er (Conner 1956:110).

in the fall of 1863 the prospectors
a creek about five miles south of
ream, now called Wolf Creek, flowed
Conner also reported shooting a
e west of the Prescott town site. In
he upper Verde River country, Conner
ht by the howling of "wolf packs."
that Conner always distinguished
(Conner 1956:110, 118, 162).

eer hunting on a chaparral-covered
tt in 1864 when he heard the roar of
ded grizzly, following a rifle shot
two men trailed the bear by its
nal with the onset of darkness (Conner

of Conner's companions found a deer
with leaves and sticks. The men,
s to be a lion kill. The kill was so
er to camp for their own use (Conner

s deer and deer hunting many times in
deer were common in the Prescott
was a staple of the prospector's diet.
h between mule deer and white-tails,
er were what he encountered.

tion type in the vicinity of Prescott. It is
scrub oak, *Quercus turbinella* and other

Pronghorn: When Conner first approached the Prescott area in 1863, several of his comrades shot some pronghorn in a grassy prairie on Weaver's Creek, 25 miles southwest of the site of the future capital (Conner 1956:131). Later, while hunting in chaparral country near the upper Hassayampa, Conner met an Indian, presumed to be on his way to hunt pronghorn with his bow. The stuffed head of a pronghorn was tied to the small of his back as a decoy for stalking. When the Indian stooped, the head would be upright and visible (Conner 1956:108).

Bighorn: In 1864, Conner and some gold miners had just inspected a camp established by Mexican prospectors at the head of Date Creek. All had been killed by Indians. Conner looked up and saw a band of "mountain goats" on what he described as a "low, rocky ridge overlooking the narrow valley" (Conner 1956:217). This may have been the north flank of the Date Creek Mountains.

The Woolsey Expeditions

In April, 1864, construction began on Prescott, the first territorial capital of Arizona. Nearby Fort Whipple would be ready for occupation in a month. In the meantime, the task of containing Apache raids fell to the miners, ranchers, and other civilians. Until then, in the words of General William S. Rosecrans, "the whites lived on the reservations and the Indians occupied the country."

The leader of these civilian irregulars was a frontiersman from Louisiana named King S. Woolsey. In 1864, Woolsey led three punitive expeditions across central Arizona in pursuit of Apaches who had stolen livestock from ranches in the Prescott area. These excursions revealed the agricultural and mineral potential of the mountain valleys that formed the drainage of the Verde and Salt Rivers. The civilian volunteers who went along combined Indian-hunting with exploring and prospecting activities and the Apaches went largely unpunished.

Woolsey's second expedition, in March, was described by a participant, Henry Clifton, in a two-part report in the *Arizona Miner*, published as a semi-monthly in Prescott. One hundred miners left Woolsey's ranch on the Agua Fria and struck off in three parties to raid Apache rancherias. Clifton's contingent headed east, then south. The volunteers found a stream emptying into the Agua Fria which they called Ash Creek, because of "the abundance of fine ash timber that grew on its banks." Clifton went on: "The creek at this place is some ten feet in width and crossed by innumerable beaver dams, making it quite deep. We caught some very fine fish, of the same species as are found in the ... Colorado and Gila" (Woody 1962:165).

In June a third expedition headed east across the Verde River and into Tonto Basin. On June 14 a party that included a chronicler named F.A. Cook was working its way down Tonto Creek when it came to the Salt River. Cook reported:

We made a willow drag and caught about 200 fish. The largest ones looked verry much like Cod but had no teeth, and would weigh from 10 to 20 lbs. This kind of fishing was new to many of us but was verry fine sport for we had to go into the river and in some places it was up to our necks but the weather is verry hot and the waters warm (Reeve 1949:102).

The irregulars moved up the Salt River a few miles and camped at "Grapevine Springs." In his diary entry for June 21, Cook states:

Made 4 or 5 hauls with our willow drag & caught about fifty fish all suckers, but verry sweet. I think the best I ever tasted. Perhaps it is because we have no meat for we have nothing but flour & coffee (Reeve 1949:104).

The next day Cook commented:

For the past five or six days about half our living has been fish. Our only trouble is that we have not got lines strong enoug[h] for the large fish which weigh from 10 lbs. to 40 lbs., neither can we ı, in March, was described by a t ɔ-part report in the *Arizona* ıt y in Prescott. One hundred Agua Fria and struck off in three C ton's contingent headed east, nı a stream emptying into the Creek, because of "the abundance ts anks." Clifton went on: "The et ı width and crossed by innu- quite deep. We caught some very te ound in the ... Colorado and

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catch many of them in our willow drag (Reeve 1949:104).

The Apache-hunters traveled back up Tonto Creek for a few miles and then turned east into the Sierra Ancha Mountains. "Jacob Snyder killed a fine deer here. We ate it all but 1 ham which we saved for breakfast next morning" (Reeve 1949:105).

The party returned to the Salt River and headed south up Pinal Creek into the Pinal Mountains. In his official report to Governor Goodwin, Woolsey commented that his hunters kept the volunteers "well supplied with venison and turkey" (Woody 1962:173).

Woolsey and his men continued south to the Gila River and traveled upstream, probably to Bonita Creek. While camped about three miles up Bonita Creek on July 18, Cook wrote: "Killed a large brown bear abo 1/2 mile below here" (Reeve 1949:112).

The roving volunteers then struck out to the east again and reached Eagle Creek which they mistook for Black River. Cook described the area:

Went in an easterly direction across the hills ... to a creek or river 15 to 20 ft. wide, good water & plenty of fish also some Bear, Bever & Turkey (Reeve 1949:113).

The expedition finally turned west, passing north of the Gila Mountains, and approached the San Carlos River when Cook wrote, "Killed a bear" (Reeve 1949:115). Woolsey also mentioned the bear hunts in his report. He described traveling west through Antelope Flat toward San Carlos River:

We travelled ... some twenty miles over a level country covered with grass and shaded by cedar trees forming a most excellent stock range. Among these cedars we found an abundance of "bear sign," and one evening just before camping we had some excellent sport in killing a bear, our second, as we had killed one on the Gila about 15 miles above Fort Goodwin. Both of them were of the species known as the Cinnamon bear (Woody 1962:174).

on is ordinarily more than a match for f traps. The most certain, as well as the them, is by poisoning the carcass of a fal, with strychnine. ...

cies, as is well known, does not differ ies. It brings forth in May or June, in er or among rocks. Five or six puppies birth. A variety of absurd stories re- ss current, among even the best in- ny affirming that the pups are born to be afterwards licked into proper

ous Foxes of North America, but one, an inhabitant of the Territory. Two ox and the little Kit or Swift Fox, may itself, though generally distributed, nt. I procured a number of fine skins hem as articles of dress, for pouches, es.

nce of [otters], I am unable to speak , however, that Otters do exist in the

cies are found, and are not uncom- d, and particularly the mountainous vicinity of the San Francisco and Bill erly noted for the numbers of these they appear to have somewhat de- Rocky Mountains, and the ranges of ularly the home of the huge Grizzly rous farther north. A variety ... ex- mon Black Bear ... also includes ange. ...

The most characteristic, as well as most abundant species of Squirrel, is the Tuft-eared ... [Abert squirrel] discovered by Dr. Woodhouse in the San Francisco Mountains. It is one of the largest, and certainly the very handsomest of all our North American species. Besides very beautiful and harmonious colors, it rejoices in the possession of long pointed ear-tufts, extending an inch or more from the edge of the conch of the ear, which give it a peculiarly sprightly and truly elegant appearance.

The pine-clad mountains of northern and central Arizona are the chosen home of this Squirrel; and it rarely, if ever, quits these woods for other situations. It is there a resident species, breeding in abundance, and braving the rigors of winter. Its food is chiefly pine and other seeds. ...

In addition to the preceding, a true Gray Squirrel inhabits Arizona, which I am inclined to think is a species new to science. It must be quite rare, as I never saw or obtained but a single one — a female, shot December 20, 1865, at Fort Whipple.[4]

... [the beaver] is found abundantly on all the streams of the Territory. Judging from the accounts of old trappers, its numbers seem even to have increased of late; owing, doubtless, both to the diminished value of its fur, of which so many articles now take the place, and to the Indian difficulties, which prevent the penetration of the hunter to its abodes. Particularly upon the Rio Salado [Salt River] and San Francisco [Verde River] as it is very abundant; and its dams occur, in some places, every few hundred yards. The almost unbroken seclusion of these retreats gives the animals such a sense of security, that they are less strictly nocturnal in working or

[4]This squirrel, now known as the Arizona gray squirrel, was indeed then unknown to science. Coues described the species, naming it *Sciurus arizonensis*. The squirrel is still found in the vicinity of Fort Whipple in the Bradshaw Mountains. The specimen described by Coues was not collected by him but sent to him by Willard Rice from the headwaters of the Hassayampa River shortly after Coues left the Territory (Mearns 1907:275).

nprecise, and sometimes contradic-
e: lorers definitely suggest that the
a : luxuriant than even the early
hardly surprising when it is remem-
r were taken at the height of the
e d other livestock were at record

s ten were described as "parklike"
arly Arizona is of a more open coun-
Nonetheless, even within the grass-
o er desertscrub species were pres-
d the upper San Pedro Valley as "a
rg mezquit bushes but destitute of
sh saltbush, and other scrub species
Valley in 1854. Clearly, species of
o lly dominant even at these early
as ands to mesquite-grassland and
ot so much an invasion as a gradual
n

t s replacement of grasses by nox-
as due to the cessation of range fires
ie argue that livestock removed the
y fire; in the absence of fire the
outcompeting the palatable grasses
th scrub precluded the establish-
th protection from grazing. Only
o fuel a fire can the grasslands be

ic hypothesis, it usually has been
a supposition that fires occurred
ti s. This latter supposition is not
There are eight references to fire in
hese fires were caused by travelers'
unexplained origin. There are
fires or to burned areas in northern

Arizona where there were fewer travelers. If lightning fires were frequent, the explorers should have noted some evidence of their occurrence.

Nowhere is there anything to indicate that lightning fires were frequent or widespread. Although fire well may have played an important role in the maintenance of grasslands, the advocates of such a position should consider that fire may have been only an occasional event.

Rivers and Other Wetlands

The few perennial streams and rivers in Arizona were highways for the early American explorers and pioneers. These streams and their riparian forests were linear oases in an arid land, a haven for man and wildlife. The region's few natural wetlands and watering holes were of an importance to wildlife far out of proportion to their geographical extent.

The destruction of Arizona's rivers and the desiccation of its wetlands without doubt are the most important changes in Arizona wildlife habitats to have taken place since settlement. These changes are depicted graphically by Brown et al. (1981) and show that large reaches of formerly perennial streams are now intermittent or ephemeral in character. All of the rivers mentioned by the early explorers — the Gila, the Santa Cruz, the San Pedro, the Salt, the Verde, the Colorado, the Little Colorado, the Bill Williams — all have had their waters impounded, regulated, diverted, or intercepted by groundwater pumping. Such changes are of course devastating to aquatic species, and it should come as no surprise that many of Arizona's native fishes are now endangered.

Less obvious are changes to those waters and riparian habitats still existing. Although much has been written on the phenomena of channel cutting (e.g., Bryan 1925, Hastings and Turner 1965, Cooke and Reeves 1976), the causes remain elusive. The early travelers generally describe streams and wetlands as more marshy and boggy than in later accounts. Obviously, in many areas groundwater levels were higher and, with local exceptions, stream channels on many rivers were less incised than now. Sloughs and backwaters were present, even on some minor drainages. No mention of floods appears in Davis' study other than a reference to flood trash lodged high in trees on the lower Gila.

Numerous descriptions of large trees in the stream-side forests and the frequent mention of wild turkeys suggests taller-structured and more extensive riparian forests along the Gila, lower San Pedro, and upper Santa Cruz Rivers than in photographs taken in the 1890's (see, e.g., Hastings and Turner 1965). Photographs of the Gila River taken in the early and mid-1880s are presented by Turner (1974) and show extensive forests of large trees. Turner (1974) states that these stands were not present in photographs taken in 1909, and many of the gallery forests of the lower rivers probably were destroyed by the cycle of floods and erosion cutting that took place in the period 1885-1890 (Hastings and Turner 1965). Dynamic, and subject to change, these communities since have shown various stages of recovery but have not attained their former grandeur.

The Wildlife

Many of us have pondered on the status of Arizona wildlife in their original environments — especially the game animals. The accounts in this work of these and other species of note permit some conclusions to be drawn on wildlife abundance and distribution in presettlement Arizona. A number of species mentioned have since been extirpated; several others are now decidedly rare. Still others now appear to enjoy a wider distribution than formerly. An interesting question is posed: Why has the distribution of some animals remained essentially the same while the areas occupied by others have contracted or expanded? This question will, we predict, be debated for some time to come.

Pronghorn (antelope; prong-horned antelope)

Pronghorn were reported by the American pioneers from almost all open and level parts of Arizona. Like the mule deer,

pronghorn occupied a wide vari
them in montane parks, meado
cisco Mountain, the grasslands an
Little Colorado River, the grass
zona, and in the lower Colorado
along the lower Gila River and
Wherever there was relatively
countered, and this species was
by travelers.

The coming of civilizatio
Arizona. By World War I, hon
overhunting, and probably oth
"antelope" population to small
for all practical purposes, bee
strongholds in the valleys south of
Santa Cruz. In the 1920s a per
pronghorn regained much of its f
bers. Beginning in the early 1940's
transplants to southeastern Arizo
by 1965 the outlook for this speci
since then, rural subdivisions, low
scrub encroachment, overgrazin
determined, factors have plague
outlook is for a continued reductio
and an increased dependence up
horn numbers, now estimated at

Mule Deer (black-tailed deer; de

Most Americans did not spec
tered, but some did use the term
clearly show mule deer as found
Arizona explored during the 182
changes in distribution from tha
pronghorn were the two large
regularity by travelers prior to 1865

ag as much game as they could have
p expedition encountered bighorn
n hwestern Arizona, but try as they
ul in killing one for a specimen or
re deer in southern Arizona in 1864
s f the more settled regions in the

is l in this study rarely reported kill-
animals on a single hunt. Usually a
camp with a single animal. The early
mals whenever possible, but they
y the wagonload.
tions of hunting in frontier Arizona
in 858. It is interesting that his deer
kably similar to those of deer hunters
y. He wasn't successful on every trip,
p is considered a satisfactory bag.
can explorers contains little informa-
ethods and use of large mammals in
la e game animals is demonstrated
bon, and others observed deer skins,
Americans often attempted to trade
o Indian groups that they encoun-
ers was offered jerked mule meat by
r and Audubon purchased desert
er, the accounts surveyed here do
the whites obtaining deer or prong-
s. vidently Indians in Arizona did
n s with the efficiency required to

iv suggested that Arizona Indians
as tool for hunting large game.
declare that fire drives were carried
t ignificant influence on the com-
it ommunities. The evidence that

Dobyns cites in support of his "fire drive" theory is absurdly feeble. How the firing of natural vegetation would facilitate the capture of such animals as deer and pronghorn is never detailed, nor are any eyewitness accounts of game being captured by this method cited. The sources reviewed in this study contain no information suggesting that Indians used fire in the hunting of big game in Arizona.

Fish and Fishing

There are a number of references to fish collecting and fishing. Unlike game, which was often scarce, fish in the Gila drainages were usually described as abundant, although there were various opinions on the quality of the native fishes as food. None of the expeditions reported true native trout, but then few, if any, trout streams were visited. There were no bass, catfish, bluegill, carp, or other of the introduced species so common today.

The Mormon Battalion reported large fish of up to three feet in the San Pedro River. These so-called "salmon-trout" were also reported from the Gila and Salt Rivers and were almost certainly Colorado River squawfish (*Ptychocheilus lucius*), now extirpated from the state (Minckley 1973).

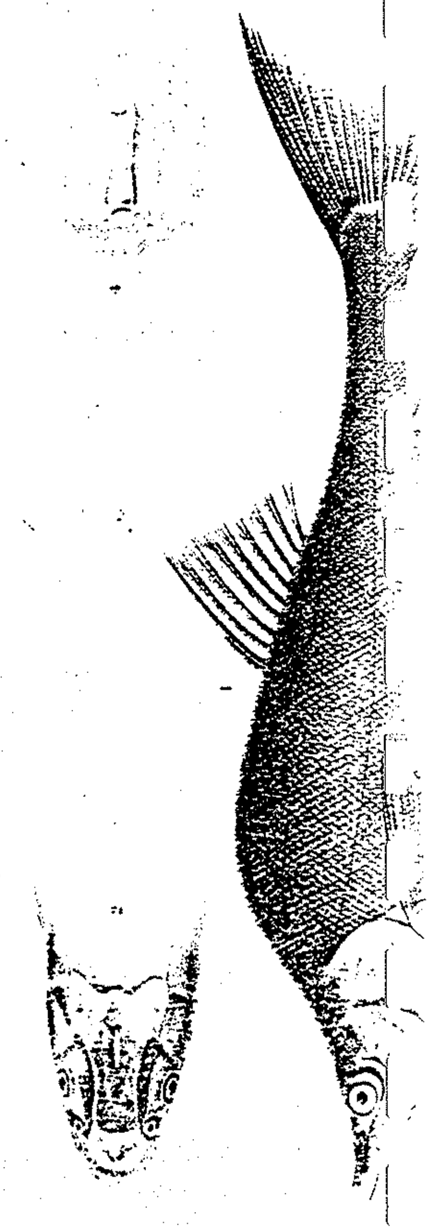
Fish of edible size caught from the Gila and its tributaries by early travelers were most likely various closely related chubs of the genus *Gila* (Verde "trout," Gila "trout," bonytail, etc.) and suckers such as the Gila sucker (*Catostomus insignis*), flannelmouth sucker (*Catostomus latipinnis*), Gila mountain sucker (*Pantosteus clarki*), and the razorback sucker (*Xyrauchen texanus*).

Bartlett's men caught small, but edible, "trout" in Sonoita Creek, and Bartlett later tried a "type of buffalo fish" (razorback sucker) from the lower Gila River, which he found soft and unpalatable.

Bartlett also reported many fish in the clear waters of the Salt River and caught several. F.A. Cook related that a company of volunteers seined 200 fish from the Salt — the largest being between 10 and 20 pounds. Later this same detachment lived on 50 suckers that were "verry sweet."

Chamberlain reported his companions caught enough "finny strangers" on the upper Gila in July to supply "all hands" for both supper and breakfast. One measured four inches between the eyes and weighed "30 pounds."

Plate 18



ARIZONA'S NATURAL ENVIRONMENT

Landscapes and Habitats

CHARLES H. LOWE

THE UNIVERSITY OF ARIZONA PRESS
Tucson, Arizona

UNIVERSITY OF ARIZONA PRESS
From *The Vertebrates of Arizona*

I. S. B. N.-0-8165-0349-4

CONTENTS

Shreve (1915:40-41) concluded that:

"It will be impossible to summarize the floristic relationships of the Santa Catalinas in a thorough manner until very much more is known of their own flora and also of the floras of the many adjacent mountain ranges and desert valleys, both in the United States and Mexico. For the explanation of these relationships a closer acquaintance is needed with the actual mechanisms of transport which are effective in the dispersal of the seeds of desert and mountain plants. *A fuller knowledge is also required of the fluctuations of climate within recent geological time, and of the consequent downward and upward movements of the Encinal and Forest belts of all southwestern mountains* [italics mine]. Such movements would alternately establish and break the connections between the vegetation of the various mountain ranges and elevated plains, thereby permitting the dispersal and subsequent isolation of species which might find no means of movement across the desert valleys under existing conditions."

Shreve wrote this at the former Carnegie Desert Laboratory, on Tumamoc Hill at Tucson. Today Shreve's many far-sighted leads in environmental biology are being enthusiastically followed by several investigators at the University of Arizona where, for example, in the same buildings on Tumamoc Hill, the Geochronology Laboratory of the University is investigating physical, biological, and cultural aspects of arid lands (see "The Last 10,000 years" by Martin, Schoenwetter, and Arms, 1961).

AQUATIC HABITATS

The aquatic fishes and semi-aquatic frogs, turtles, beavers, and other "amphibious" species in Arizona live in either warm-water or cold-water rivers, streams, lakes, or ponds. The major localities in Arizona's warm-water and cold-water fisheries are shown on maps provided in Mulch and Gambel's useful pamphlet (1954) on game fishes in Arizona.

Figure 57 is a drainage map of Arizona (Miller, 1951) which includes those waters supporting permanent populations of native fishes. While there was additional disturbance of some of these waters during the past decade, they remain today largely as shown. The major drainage basins in Arizona are outlined on this map, which also accompanies the check list of fishes (Miller and Lowe, part 2 of this work, 1964).

Figures 58 and 59 show parts of the Colorado River, Arizona's largest, as it courses through the deep gorge that is Grand Canyon. The aquatic fauna of this sizeable Arizona section of the Colorado, which drops 2,000 feet in elevation from *ca.* 3,200 at Lee's Ferry in the Great Basin Desert near the Utah line to *ca.* 1,200 at Hoover Dam (Boulder Dam) in the Mohave Desert in Nevada, is an immensely interesting fauna that has been little studied and is consequently little known.

Figures 65 and 66 are photographs of Aravaipa Creek, a desert stream in the Galiuro Mountains of southern Arizona that is partially canopied by a well-developed riparian woodland climax dominated by cottonwood, willow, and ash (cottonwood-willow gallery association). The desert

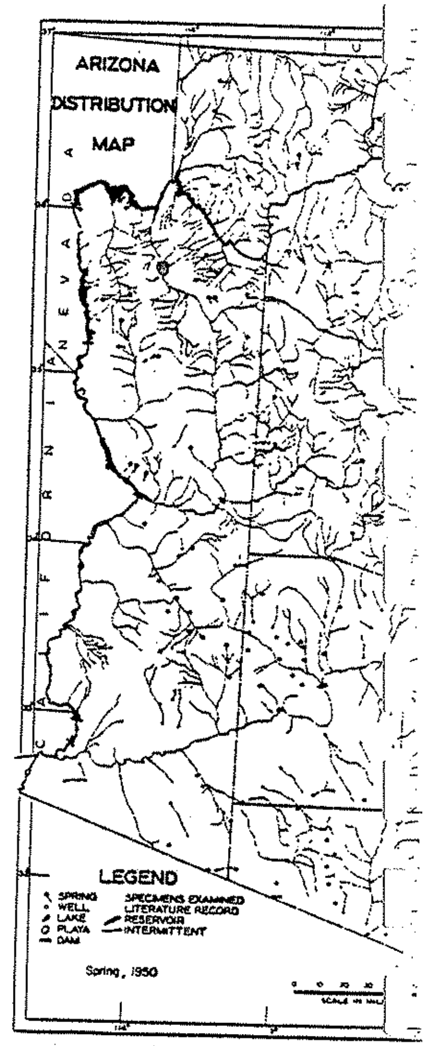


Fig. 57. A drainage

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ins t which are effective in the dispersal
A fuller knowledge is also required of the
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d subsequent isolation of species which
desert valleys under existing conditions."

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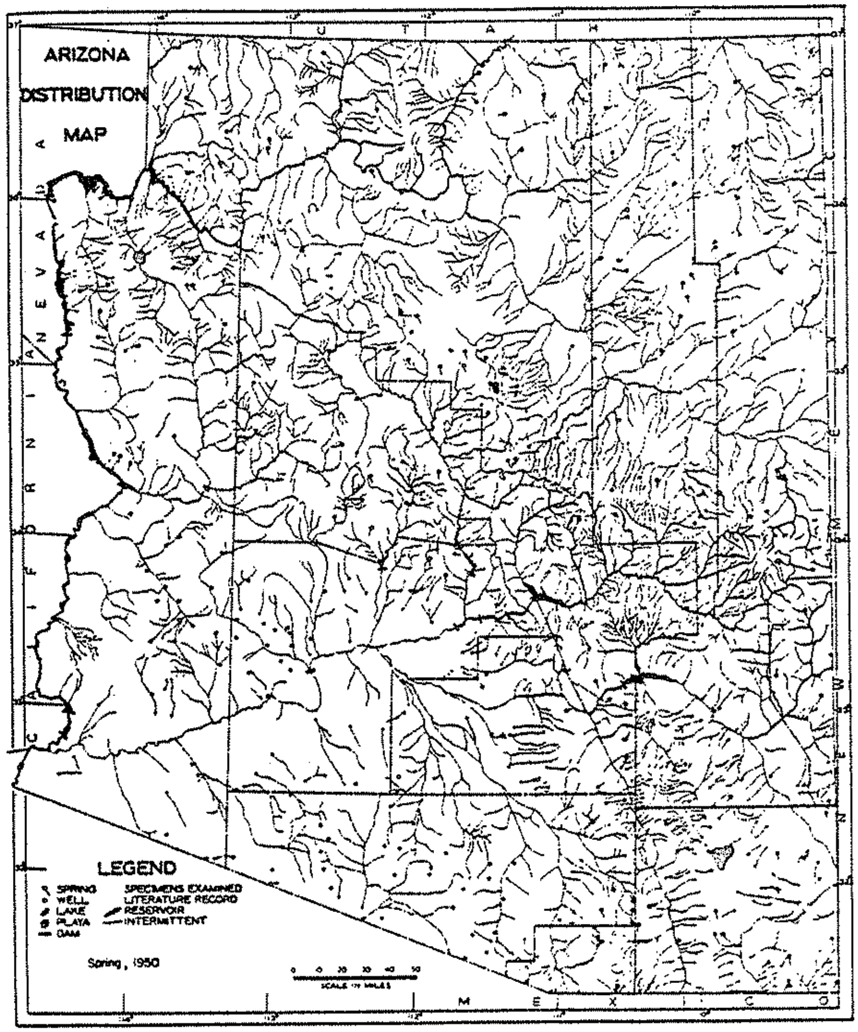

Fig. 57. A drainage map of Arizona (Miller, 1951).

climax here, at 2,600 feet elevation, is paloverde-sahuaro. This fast-flowing, spring-fed stream still supports seven species of native southwestern fishes.[27] These species are now isolated in Aravaipa Creek as remnants of the former and larger fish fauna of San Pedro River (which was formerly a major tributary to Gila River) which is now a dry river bed at the mouth of Aravaipa Creek (north of Mammoth, Pinal County) except at times of flood or run-off.

The high mountain stream habitat of the vanishing Arizona native trout (*Salmo gilae*) is shown in Figure 64.

The ranch pond is a characteristic aquatic habitat in Arizona and is a focal point for vertebrate wildlife. Figure 63 shows a ranch pond (represo, or dirt tank) made of earth, and with a depth of four to five feet. It was successfully planted with the popular bass-bluegill combination at the time the photograph was taken, November 8, 1952. The locality is at 5,000 feet elevation, on the J. A. Jones Ranch in Parker Canyon, south side of the Huachuca Mountains, Cochise County.

The wide variety of Arizona's sport fishing lakes, from the desert near sea level to coniferous forest at over 9,000 feet elevation, are indicated in Figures 59-62. It is of interest that the most widely fished trout in Arizona, rainbow trout (*Salmo gairdneri*), is stocked and taken in each of these lakes where they are associated with cold-water game species in Big Lake in the White Mountains (*ca.* 9,000 feet, Fig. 61), and with warm-water game species in mid-elevation Peña Blanca Lake in southern Arizona near Nogales, Sonora (*ca.* 4,000 feet, Fig. 62), as well as in low-elevation lake Mohave (*ca.* 700 feet, Fig. 60) and other desert area impoundments in the lower Colorado River near sea level.

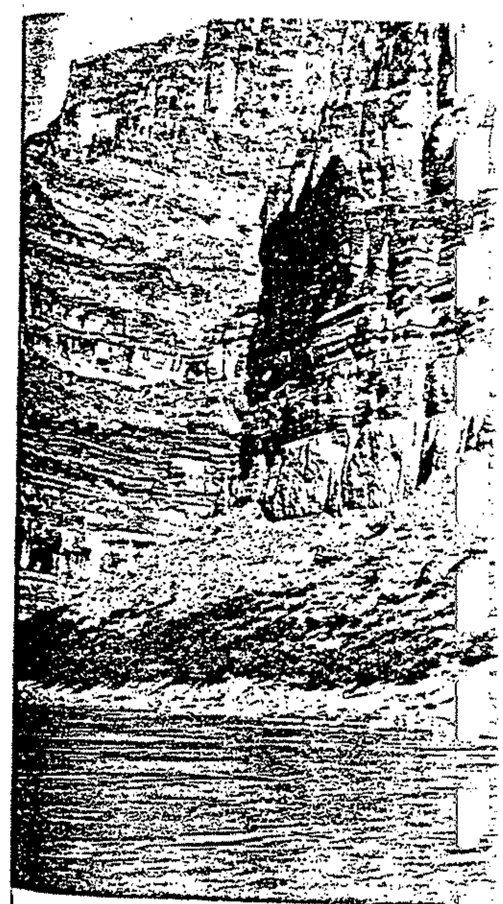

Fig. 58. The Colorado River in Grand
Mead. The shrubby riparian border of mes
river in the lower part of the gorge, w
well into the canyon. Photo by E. T

[27] Longfin dace (*Agosia chrysogaster*), spikedace (*Meda fulgida*), Gila sucker (*Pantosteus clarki*), Sonora sucker (*Catostomus insignis*), loach minnow (*Tiaroga cobitis*), Colorado chub (*Gila robusta*), and speckled dace (*Rhinichthys osculus*).

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THE NATURAL VEGETATION OF ARIZONA

This manual describes and illustrates Arizona's natural biotic communities and accompanies the map "Natural Vegetative Communities of Arizona." 1973(c).

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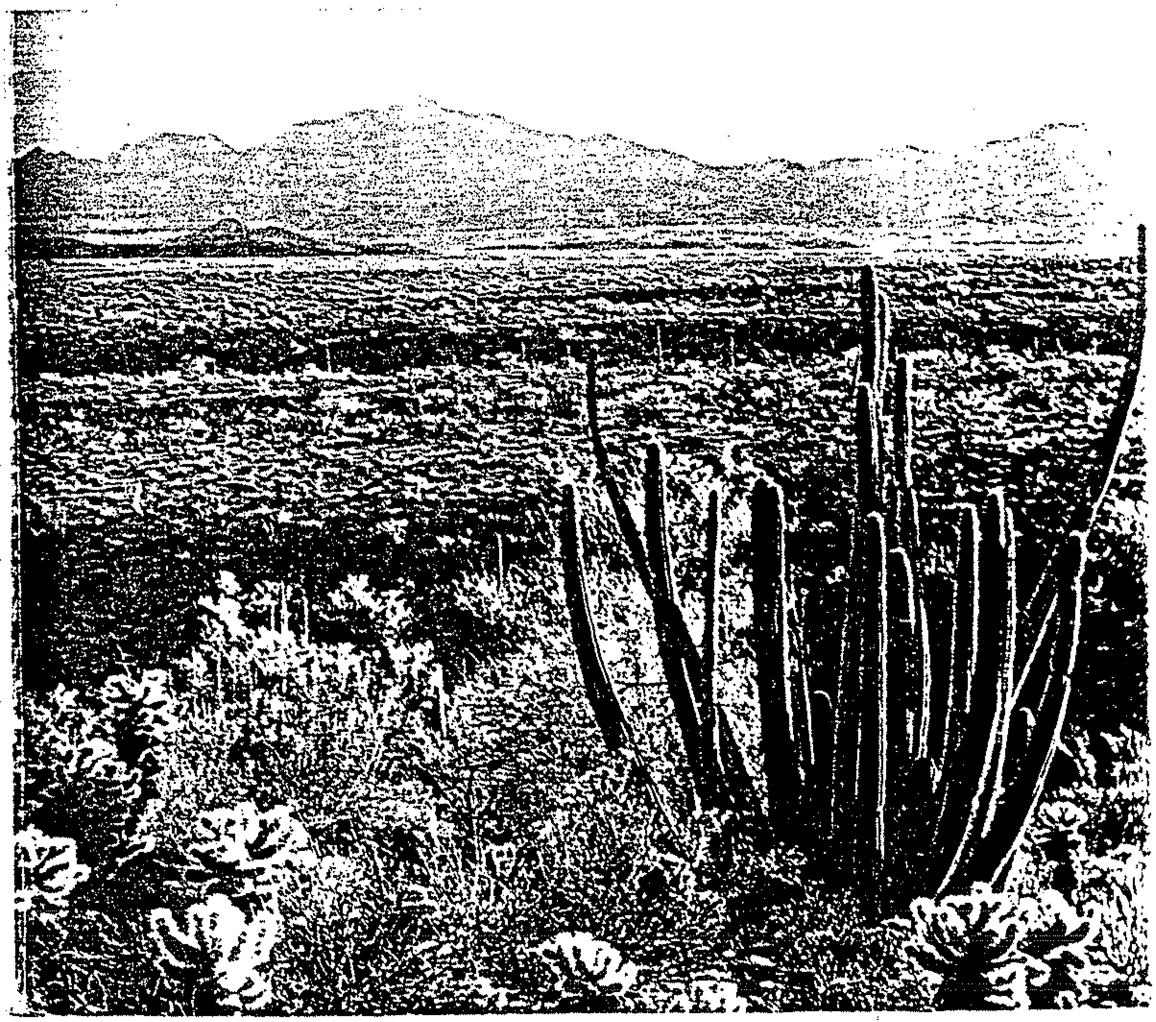

porcupines, deer mice, turkeys, bandtail pigeons, stellar jays, mountain chickadees, yellow-eyed juncos, purple martins, short-horned lizards, mountain king snakes, green treefrogs, and tiger salamanders.

RIPARIAN DECIDUOUS FOREST

(Riparian Deciduous Woodland)

The riparian communities are not shown on the color map. In total they comprise a limited geographic area that is entirely disproportionate to their landscape importance and recreational value, and their immense biological interest. Whether called forest or woodland, they are comprised of tall, winter-deciduous broadleaf trees that are the same species and/or genera as in the eastern deciduous forest of the United States. In the arid and semi-arid Southwest, these remnants of earlier widespread forests are restricted to our streamways and drainageways, and at some lakes and ponds, that provide the necessary stream flow or underflow to support broadleaf forest species. These canyon and arroyo forests are principally located in the sub-Mogollon region of the state (Figs. 7 and 8).

Both their distinctive life-form and their riparian habitat distinguish these biotic communities from the evergreen western woodlands and the coniferous forests through which they course fingerlike from our highest spruce-fir forests throughout woodland and chaparral into the grasslands and deserts below. Often the canopy is widely open as in a woodland aspect. Also, as the trees are large with some species reaching heights of 50 to 100 feet, they occasionally form a high-canopied gallery forest with a more or less completely closed cover.

The composition and form of the riparian forest changes with elevation. Higher, in high evergreen woodland and in the coniferous forest, major broadleaf riparian trees are mulberry, elderberry, alder, narrowleaf cottonwood, boxelder, cherry, maple, and mountain willows. Lower, in the lower woodland, chaparral, and grassland into desertscrub, the riparian "big-five" are cottonwood, willow, sycamore, walnut, and ash.

Fig. 7. Riparian Deciduous Forest—summer aspect. Along Wet Beaver Creek in Yavapai County, 5000 ft., June 1971. A mixed broadleaf community of deciduous forest trees. Representatives are sycamore *(Platanus wrighti)*, alder *(Alnus oblongifolia)*, walnut *(Juglans major)*, willow *(Salix bonplandiana)*, and cottonwood *(Populus fremonti)*, with abundant native grape vines *(Vitis arizonica)* in the understory.

Fig. 8. Riparian Deciduous Forest—winter aspect. Aravaipa Creek, Graham County, 3200 ft., February 1971. Sycamore *(Platanus wrighti)*, willows *(Salix spp.)* and Fremont cottonwood *(Populus fremonti)* are the principal dominants along the watercourse.

Many of the associated animals are found either wholly or primarily in riparian habitats. Here is the home of the great host of vanishing species in Arizona's heritage, that include the utterly unexpectable and hardly believable water ouzel (or dipper) and water shrew. Here is the large *aquatic* fauna that includes the fishes and a diverse aquatic group of water insects and other small invertebrate animals; a *semi-aquatic* animal group that includes beavers, racoons, river otters, garter snakes, mudturtles, and treefrogs; and a large number of wholly *terrestrial* species such as the rose-throated becard and Mexican black hawk, orioles, vireos, warblers, flycatchers, tanagers, gray squirrels, and ring-tailed cats.

It should not go unnoticed that in Arizona these riparian woodlands and stream forests have been rapidly dwindling just as the water table has been rapidly lowering, and our broadleaf trees are now the native phreatophytes of the water users. With present plans for increasing dams, flood control, water salvage, water

Fig. 9. Juniper-Pinyon Woodland. At Arizona-New Mexico state line near northwest corner of Zuni Indian Reservation, ca. 6700 ft. elevation. Colorado pinyon *(Pinus edulis)* with the shorter statured one-seed juniper *(Juniperus monosperma)*. Some blue grama *(Bouteloua gracilis)* remains and was once abundant on the floor of the woodland openings. Photo by M. D. Robinson.

delivery, and numerous new development projects these magnificent forests are now truly endangered. Unless those concerned with projects such as the above do not quickly reassess their commitments, it will not be long before our riparian forests are destroyed forever in Arizona. They cannot be replaced.

JUNIPER-PINYON WOODLAND

In Arizona, juniper ("cedar") is more prevalent than is pinyon pine in the overall Pinyon-Juniper Woodland matrix, hence the name Juniper-Pinyon Woodland. This structurally simple woodland occurs predominantly in northern Arizona where it reaches greatest development on plateaus and mesas at elevations between 5500 and 7500 feet. The pinyon pines reach greatest size and density above 6500 feet (Fig. 9). Below 6000-6500 feet,

FISHES OF ARIZONA

By

W. L. Minckley

Pp. i-xv + 1-293, frontispiece, 127 numbered figures, 42 maps

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and
Lower Colorado River Basin Research Laboratory
Arizona State University
Tempe, Arizona

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INTRODUCTION

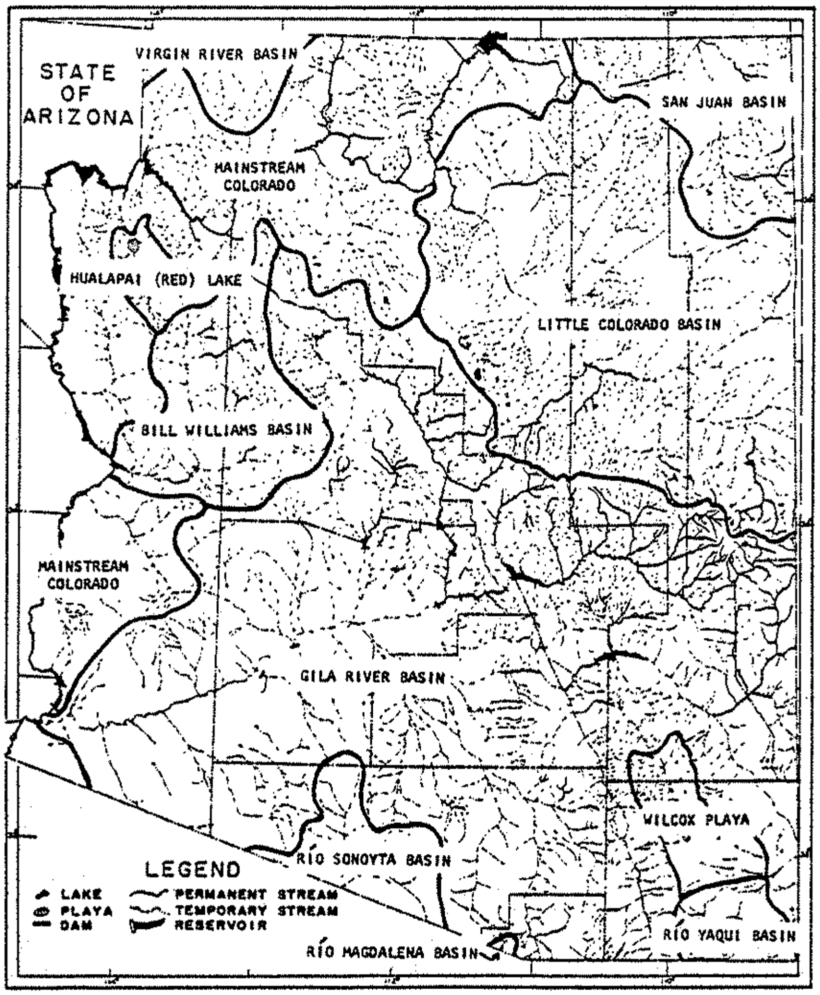
Habitats of Arizona Fishes

Arizona is known throughout the world for its picturesque scenery, and principally for its rugged topography which has obviously been shaped and maintained mostly by waters in which fishes live, or were formerly present. Arizona is one of the most diversified areas in the Continental United States, with climate ranging from arid and hot at lower elevations in the southwest, to cold, treeless tundra on the highest peaks of major, north-central mountains. Intervening areas include almost all conceivable kinds of habitat, from grassland through deciduous forest to conifers (reviewed by Lowe, 1967). Since waters are profoundly influenced by the climate and habitats in which they occur, or through which they flow, the habitats of fishes in Arizona are almost equally diverse. Development of the water resources, however, a necessity if man is to use and flourish in the lower elevation, highly-productive desert regions, has changed fish habitats severely, and has destroyed or vastly modified most native fish environments in one manner or another.

Most fish habitats in Arizona, prior to modifications, consisted of flowing streams. Springs, which are so important in adjacent states such as Nevada and California, were (and are increasingly) uncommon and small in size. Closed basins, also common in adjacent regions (Miller 1946a; Hubbs & Miller, 1948), were essentially absent in times past (such as during Glacial periods). Only two major areas of internal drainage are now present, the Wilcox Playa (Pluvial Lake Cochise) in the southwest, and the Hualapai (Red) Dry Lake in the northwest (Map 1). The former now supports a few introduced fishes in artificial tanks, isolated springs, and tributary streams, and appears to have had only a few native species in the past. The latter was apparently fishless (Hubbs & Miller, 1948), but now has a few introduced species living in artificial tanks within its basin. A few other small areas, such as the closed-basin lakes along the Mogollon Rim (Cole, 1963), were also fishless prior to their general development for recreational purposes and stocking of trouts and associated game and forage species.

Most of the state is drained by the Colorado River and its tributaries. The largest tributary is the Gila River in the south. Second largest is the basin of the Little Colorado River, in the northeast. The Bill Williams River system, north and west of the Gila, is third in size of drainage area. Artificial impoundments created on these rivers, plus those on the mainstream of the Colorado River, now make up the major surface waters of Arizona, and provide living space for enormous numbers of fishes, most of which are introduced from elsewhere. A number of smaller systems (Map 1), such as Havasupai Creek, and the Paria, San Juan, and Virgin systems, have insignificant drainage areas, or enter Arizona from an adjacent state. They are nonetheless important since they provide different kinds of habitats, which are in part inhabited by different kinds of fishes.

To the south, headwaters of three Mexican drainage basin contribute to the native Arizona fish fauna. These are the Río Yaqui system, which drains the extreme southeast corner of the state east of Douglas, Cochise County (including the west and southwest sides of the Chiricahua Mountains, the Río Magdalena, which in part heads in Sycamore (or Bear) Canyon a few miles west of Nogales, Santa Cruz County, and Río Sonoyta near Lukeville, Yuma County, which adds to the fish of Arizona in its former tributary, Quitobaquito Springs, Organ Pipe Cactus National Monument (Map 2).



Map 1. Drainage basins of Arizona; base map modified from that of Miller (1954).

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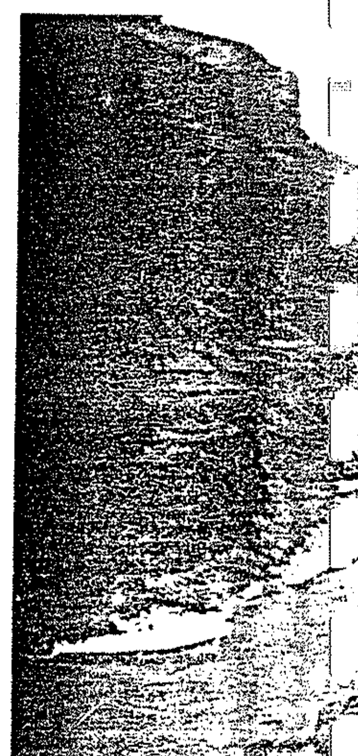

Figure 1. Colorado River mains

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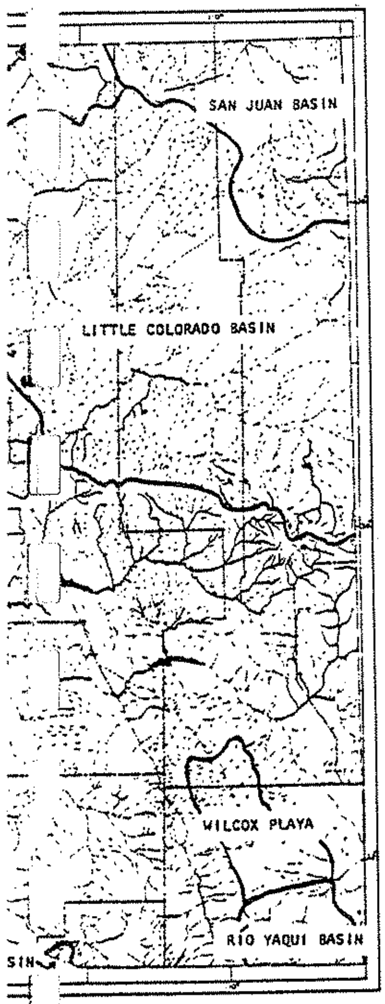


ap modified from that of Miller (1954).

At one extreme the large, through-flowing Colorado River provided an impressive, special fish habitat prior to damming. This river was highly turbid, strongly-flowing, swift and turbulent, and on the other hand subject to long periods of low flow during drought (Sykes, 1937; Miller, 1961b). Almost all physical and chemical conditions of the primitive river must have fluctuated quickly and radically, and a special fish fauna, which is to be detailed later, had become adapted to its vagaries. Damming results in relative stabilization of many features of any riverine environment (Moffett, 1949; Neel, 1963; Vanicek, et al., 1970). Temperatures become colder in summer since water is released from the depths of reservoirs for generation of power or other downstream uses; winter temperatures become relatively warmer and more stable. Turbidities decline since silts and debris become deposited in the quiet waters above dams. Chemical conditions become stabilized because of mixing and other phenomena in the upstream lakes. Despite such changes, the Colorado River remains an exceedingly unique habitat in its more inaccessible and unimpounded segments in the state (Fig. 1), but none of the stream may be considered undisturbed or pristine.

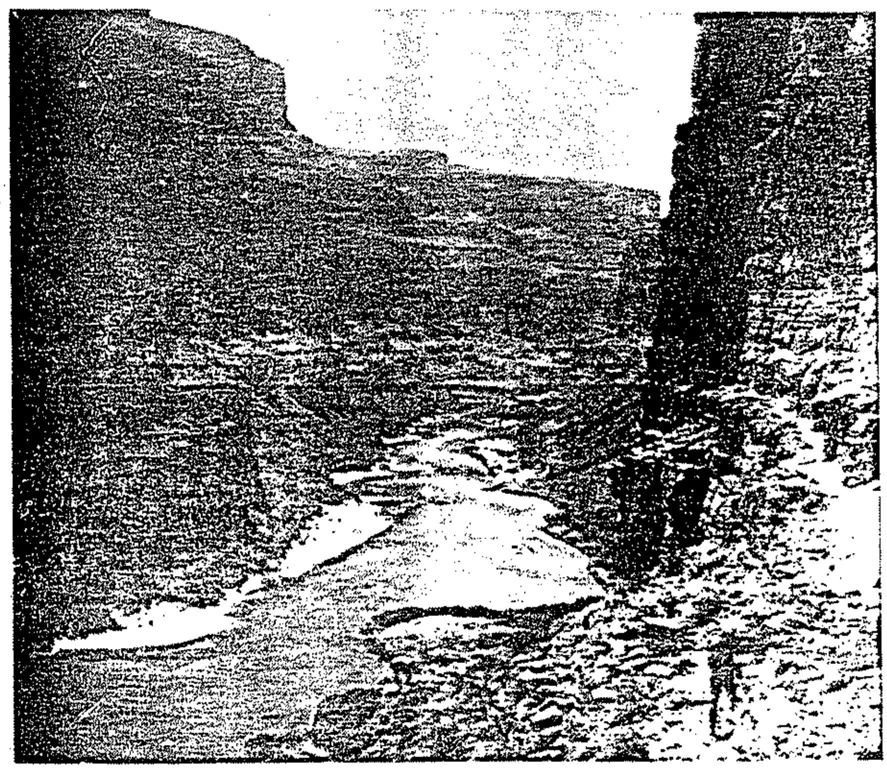
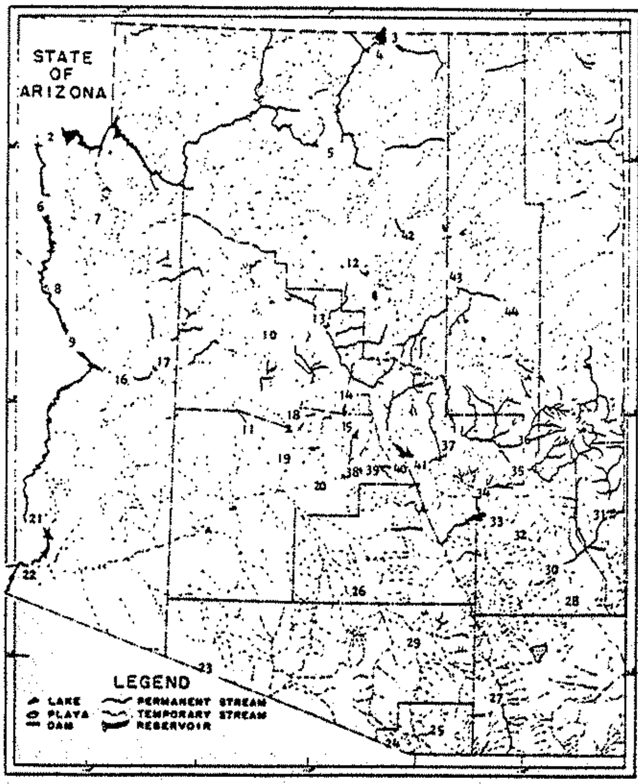


Figure 1. Colorado River mainstream in Grand Canyon National Park, Arizona.



Map 2. Some place names used in text: 1 — Virgin River; 2 — Lake Mead (Hoover Dam); 3 — Lake Powell (Glen Canyon Dam); 4 — Page; 5 — Grand Canyon of the Colorado River; 6 — Lake Mohave (Davis Dam); 7 — Kingman; 8 — Topock Marsh; 9 — Lake Havasu (Parker Dam); 10 — Prescott; 11 — Hassayampa River; 12 — Flagstaff; 13 — Verde River; 14 — Horseshoe Reservoir and Dam; 15 — Bartlett Reservoir and Dam; 16 — Bill Williams River; 17 — Alamo Reservoir and Dam; 18 — Carl Pleasant Lake and Dam; 19 — Agua Fria River; 20 — Phoenix metropolitan area; 21 — Imperial Reservoir and Dam; 22 — Yuma; 23 — Quitobaquito Spring, Organ Pipe Cactus National Monument; 24 — Sycamore (Bear) Canyon; 25 — Monkey Spring; 26 — Santa Cruz River; 27 — San Pedro River; 28 — San Simon River; 29 — Tucson metropolitan area; 30 — Safford; 31 — San Francisco River; 32 — Gila River; 33 — San Carlos Reservoir (Coolidge Dam); 34 — San Carlos River; 35 — Black River; 36 — White River; 37 — Salt River; 38 — Saguaro Lake (Stewart Mountain Dam); 39 — Canyon Lake (Mormon Flat Dam); 40 — Apache Lake (Horse Mesa Dam); 41 — Roosevelt Lake and Dam; 42 — Little Colorado River; 43 — Winslow; and 44 — Holbrook.

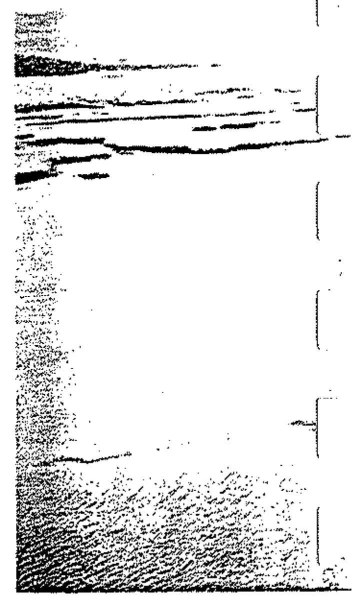


Figure 2. Topock Marsh, one o

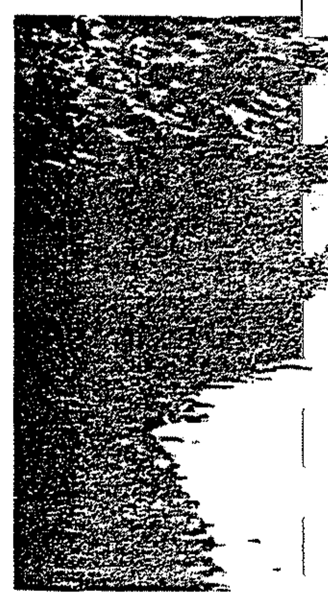


Figure 3. Salt River w

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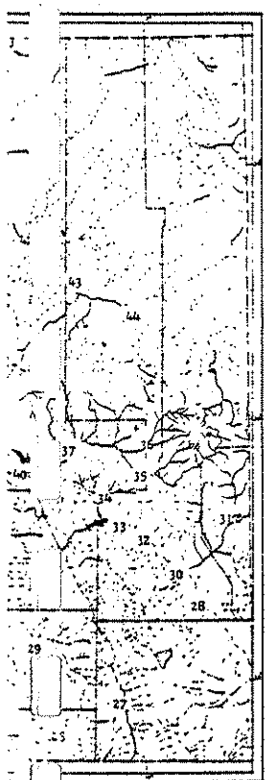

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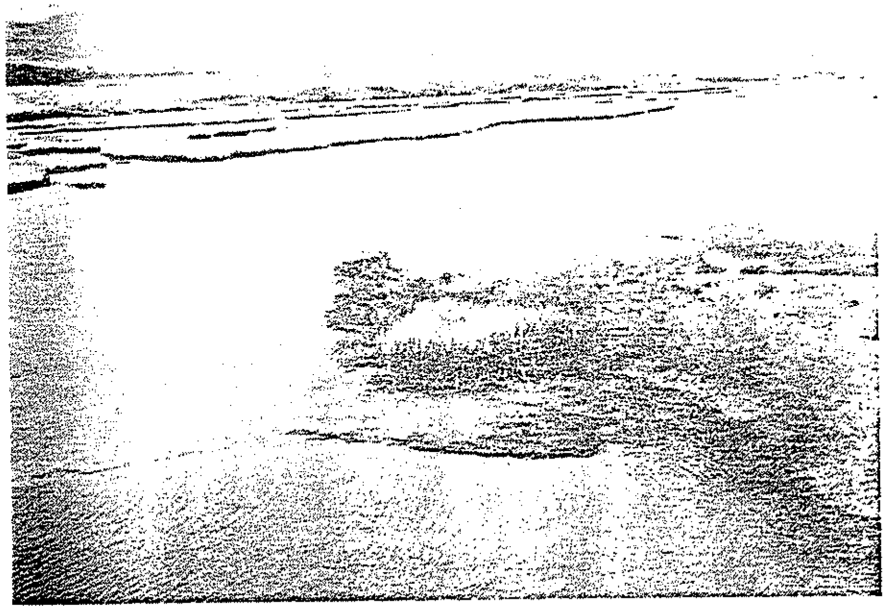

Figure 2. Topock Marsh, one of the last great desert marshes, Mohave County, Arizona.

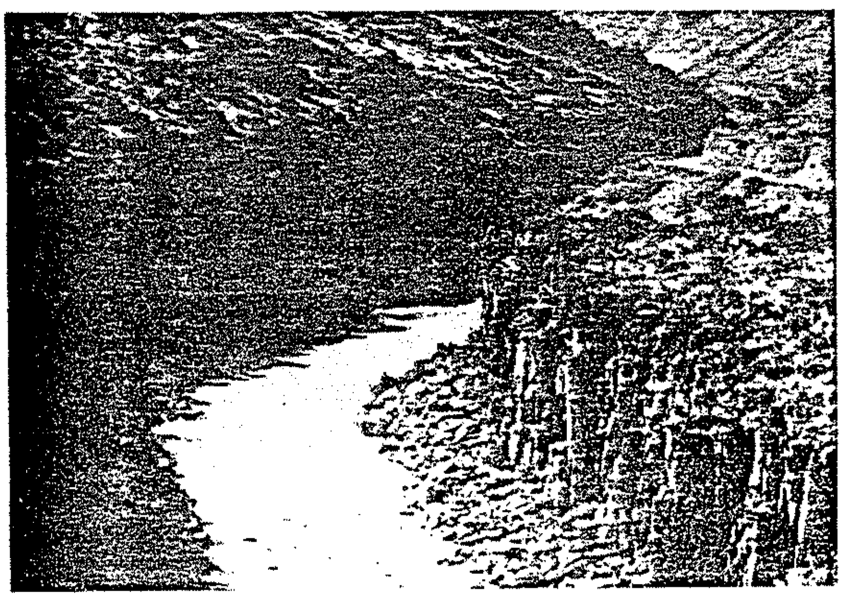

Figure 3. Salt River within the Salt River Canyon, Gila County, Arizona.

Containment of the lower Colorado River, which at one time flowed through multiple, braided channels, bordered by extensive marshes and oxbow lakes (Fig. 2), has produced essentially a sluice-way or large canal, and operations for power and irrigation create a habitat that cannot be considered similar to the natural condition in any way. Many fishes live throughout the lower mainstream, but the native fauna is essentially gone, and also appears on the decline in upstream reaches. Almost all large rivers of the state have suffered modifications that resulted in over-all effects similar to those occurring in the lower Colorado. A few segments, however, such as the Salt River in its canyon (Fig. 3) provide superficial glimpses of the past in its fauna and to the eye.

Artificial canals and ditches, results of man's development of the waters just discussed, now constitute major aquatic habitats in Arizona and elsewhere in the arid west (Pennak, 1958; Cole, 1963). These range

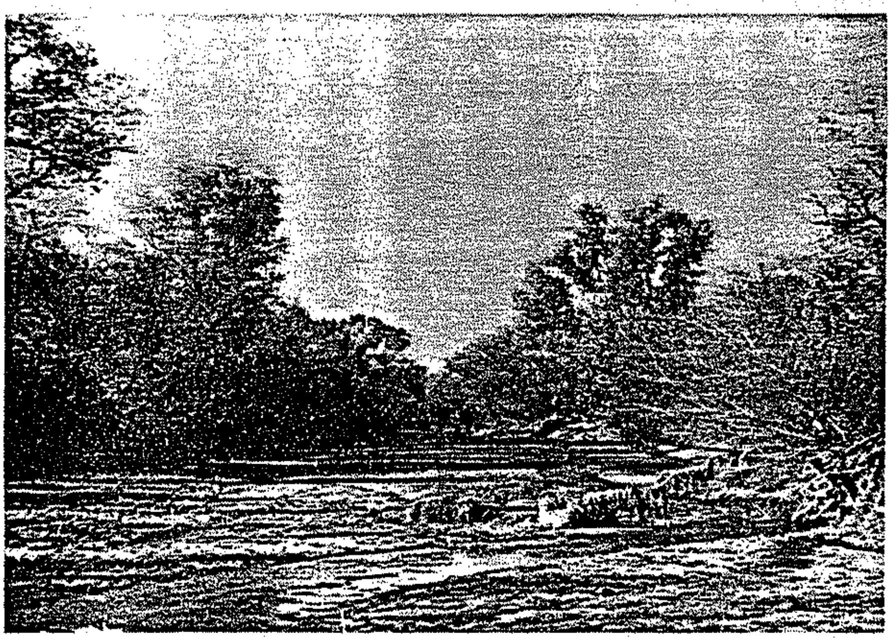

Figure 4. Santa Cruz River, Santa Cruz County, Arizona, a few miles north of the U. S. and Mexican Boundary.

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from small laterals, a meter (m)[1] or less across or deep, to major waterways that may be many meters wide, deep, and with swift currents. Again, operational problems exist insofar as fishes are concerned, such as periodic drying for repair or cleaning, application of herbicides to control aquatic vegetation, or dredging operations, and populations are rarely large under present conditions. Little research has been done on the ecology of these habitats, but they do allow fishes and other aquatic organisms to live in many parts of Arizona that would otherwise be devoid of such life. With increasing pressure of human populations on recreational waters of the state, I expect modifications of canals and other such water-transport systems soon to include extensive planning for fisheries development.

Figure 5. Lower Sabino Creek, Pima County, Arizona; a ciénega-like pool at the lower end of the flowing portion of the stream.

[1]Conversion factors for various metric units of measurements to inches, feet, pounds, etc. are given on page xi

Many smaller rivers and creeks of Arizona now are dry except in periods of snow-melt or heavy precipitation. This has resulted from diversions, impoundments at their headwaters, pumping of underground aquifers, or perhaps a natural climatic trend toward drought. Many such habitats support fishes in their permanent headwaters, and sometimes downstream where water moving through the coarse-grained sands and gravels of the stream bed is forced to the surface in canyons or elsewhere where the channel is crossed by stony dikes. In the recent past, when the lower-elevation grassland or desert streams were more permanent, they often flowed through broad, marshy floodplains in multiple channels (Hastings, 1959; Hastings & Turner, 1966), and were repeatedly dammed by beaver (Emory, 1857; Pattie, 1905; Lockwood, 1929). Dark, organic sediments form parts of the walls of many present-day "washes" in the American Southwest, remnants of marsh or "*ciénega*" deposits (Martin & Mehringer, 1965, and references cited). Great galleries of cottonwood trees, so conspicuous at present along many waterways (Fig. 4), were most likely absent or localized in places of relatively good drainage, or were perhaps suppressed by beaver cutting and/or lack of great success in reproduction. Areas of entrenched channel doubtless were present, bordered by mesquite "*bosques*" on terraces. Under such conditions, much of the stream bottoms must have been of mud and debris, currents would have been slow, impeded by debris, beaver dams, and the tortuous nature of channels, and flooding effects would have been minimal (Fig. 5). The present aspect of many desert and grassland streams therefore, with a tendency for broad channels bordered by cut banks (Figs. 4, 6), originated in the later 1880s with a cycle of arroyo cutting. Similar erosional activity was recorded in or around this period over a large area, and the uniformity "points toward operation of a broad regional factor like climate (Hastings & Turner, 1966)." However, in southern Arizona at

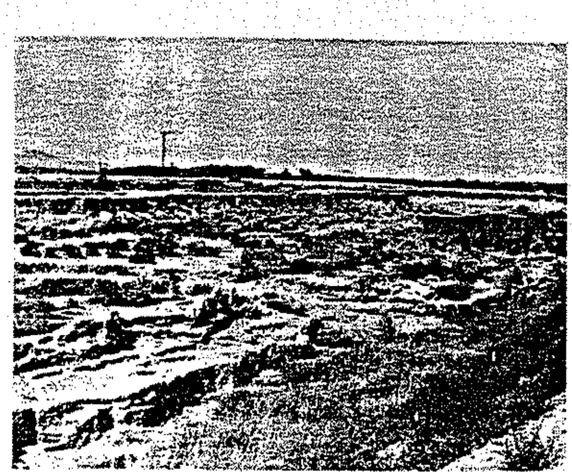

Figure 6. Santa Cruz River and associated washes, Pinal County, Arizona, down-stream from Tucson; a now-dry stream bed obviously greatly incised and eroded.

Figure 7. Tributary to the White
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Figure 7: Tributary to the White River, Apache County, Arizona; high-elevation ciénega conditions interspersed with riparian gallery forests of conifers and various deciduous trees, ca. 2,500 m above mean sea level.

least, severe over-grazing by domestic livestock in the period 1870-90 resulted in death of about 75 per cent of the herd when prolonged drought grasped the region in 1891-94. Effects of this catastrophe on the land and the terrestrial vegetation are vividly documented by paired photographs published by Hastings and Turner, which contrast the late 1800s with the 1960s. There can be little doubt that aquatic habitats, and fishes, also were severely influenced (Hastings, 1959; Miller, 1961b; Minckley, 1969a).

Streams at intermediate and higher altitudes in Arizona, except in the south, remain far less disturbed than larger rivers and the other, lower-elevation waters. This is a result, at least in part, of lesser damage by man to the surrounding terrain, on Indian lands where developers are just beginning to encroach, and on public lands that must be maintained as the watershed to supply needs of the exploding human populations of lower elevations. Also, because of their higher gradient and the seasonality of precipitation and flood, the riparian or stream-side vegetation along such watercourses may well be more resilient to disruption, undergoing a perpetual succession (Campbell & Green, 1968) of sorts. In addition, much intermediate- to higher-elevation waters in Arizona are intensively managed for recreational purposes, principally sport fishing and some of the more "natural" streams therefore persist. The highest elevation brooks and creeks support trouts. They are cold, swift, and turbulent, relatively infertile, and clear, surrounded by coniferous forest and in some areas extensive galleries of deciduous trees (Fig. 7). At intermediate elevations the creeks are more similar to those

Figure 8. San Carlos River, Gila and Graham counties, Arizona; an intermediate-elevation stream with considerable pool-riffle development.

of parts of eastern United States, with pronounced pool-riffle development, gravelly bottoms, and slow to moderate currents (Fig. 8).

Major reservoirs, lakes, and ponds (the last including innumerable permanent or semi-permanent stock-watering tanks), as stated earlier, constitute a quiet-water habitat rare in Arizona prior to caucasoid man's development of the region. As with the streams, lake habitats range from cold bodies of water in montane situations, to hot, shallow, saline, desert pools, and the predominately-introduced fishes that live in them are similarly diversified. Cole (1963, 1968) summarized much of the available information on physical, chemical, and biological features of standing waters in Arizona, and should be consulted for further details.

The largest standing bodies of water in Arizona, lakes Powell, Mead, Mohave, and Havasu (the first of which is mostly in Utah; Map 2), all are formed by impoundment of the Colorado River mainstream. These are used for power generation and irrigation, plus domestic water supplies and ever-increasing recreational activities. Four impoundments on the Salt River are similarly used (Roosevelt, Apache, Canyon, and Saguaro lakes). Major features of these reservoirs at present include marked fluctuation in water levels, strong summer stratification in temperature, and very complex chemical attributes resulting from factors of input from the streams, evaporation, and currents resulting from inflows and from withdrawal from the deeper strata of the lakes. Other large reservoirs, on the Verde, Gila, and Bill Williams rivers, are even more fluctuant, or are relatively new, and have hardly been studied.

Small reservoirs are generally most common at intermediate and high elevations, and have been developed in many instances specifically

for recreational purposes (fo
Riggs Flat, Wood's Canyon
these support trouts and
as largemouth bass, bluegill,
tions are often too severe in
ment of fisheries, although
Eastern Hemisphere, has be
Above the deserts, smaller p
of fishes. Examples of lentic
9 through 12.

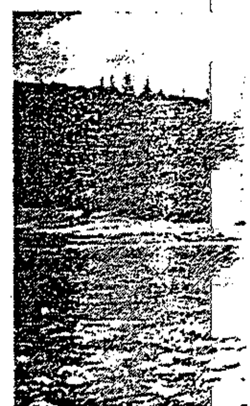

Figure 9. Natural depression "la
County, Arizona. Such habitats
provide substantial breeding habita

Figure 10. Roosevelt Dam and R
of a chain of lakes which impoun

TO

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m....

nc nced pool-riffle develop-
a: currents (Fig. 8).

e last including innumerable
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an lake habitats range from
to hot, shallow, saline, desert
ishes that live in them are
na ed much of the available
ol cal features of standing
ed for further details.

A ona, lakes Powell, Mead,
n tly in Utah; Map 2), all
River mainstream. These are
plus domestic water supplies
F impoundments on the
pa e, Canyon, and Saguaro
a present include marked
stratification in temperature,
ng om factors of input from
lt from inflows and from
lakes. Other large reservoirs,
, are even more fluctuant, or
died.

o non at intermediate and
in many instances specifically

for recreational purposes (for example, Peña Blanca, Parker Canyon, Riggs Flat, Wood's Canyon, and many lakes on Indian lands). Most of these support trouts and in some instances warmer-water fishes such as largemouth bass, bluegill, and catfishes. Smaller ponds at low elevations are often too severe in temperature or some other factor for development of fisheries, although *Tilapia*, an introduced cichlid genus from the Eastern Hemisphere, has been used near Tucson (McConnell, 1965, 1966). Above the deserts, smaller ponds or tanks often produce spectacular yields of fishes. Examples of lentic habitats in Arizona are pictured in Figures 9 through 12.

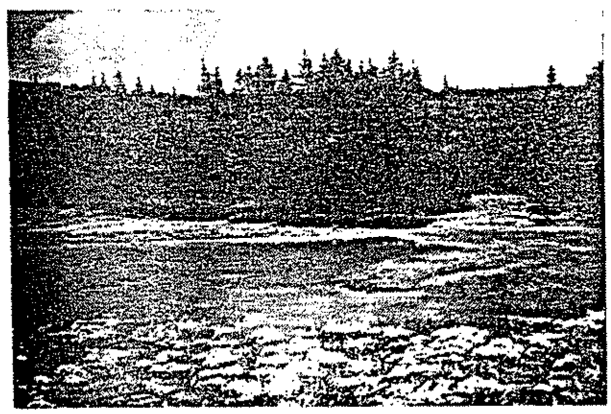


Figure 9. Natural depression "lake" at about 3,000 m above mean sea level, Greenlee County, Arizona. Such habitats rarely support other than introduced salmonids, but provide substantial breeding habitat for native frogs and other amphibians.

Figure 10. Roosevelt Dam and Reservoir, Gila County, Arizona, on the Salt River; first of a chain of lakes which impound the lower portion of the Salt River Canyon.

ACCOUNTS OF SPECIES

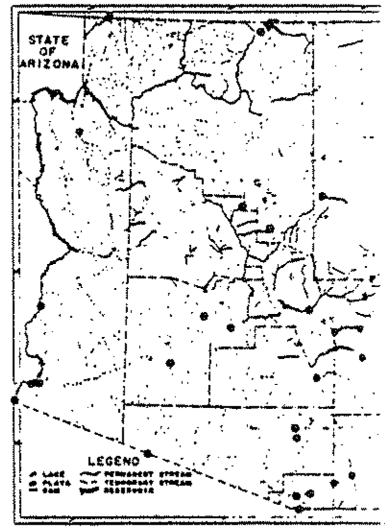
Most accounts which follow include a photograph(s) of the fish discussed, a listing of previous records from Arizona, giving the scientific names historically applied to the species, additional descriptive information that is intended to supplement the keys, and a general discussion of the status of the fish in the state and its general biology. Also, a map of the distribution of each fish in Arizona is included when appropriate. Maps were compiled from the literature and from collections made mostly by Carl L. Hubbs, Robert R. Miller, myself, and associates and students, and deposited principally at the University of Michigan Museum of Zoology and in the Collection of Fishes, Arizona State University. Personnel of the Arizona Game and Fish Department and U. S. Bureau of Sport Fisheries and Wildlife also made substantial contributions of collected specimens and unpublished records, especially of game fishes. Many data from the Colorado River were obtained from California Fish and Game Department field biologists. A listing of the personnel and agencies that have contributed to the over-all project is provided in the acknowledgements.

Coverage of the state has been relatively intensive (Maps 3-6), and fortunately includes early collections made prior to the onset of massive modifications of aquatic habitats. Additional samples are needed from the Colorado River, which, because of relative inaccessibility (in Grand Canyon, for example), and the size and complexity (the lower river and its mainstream impoundments), has been sorely neglected.

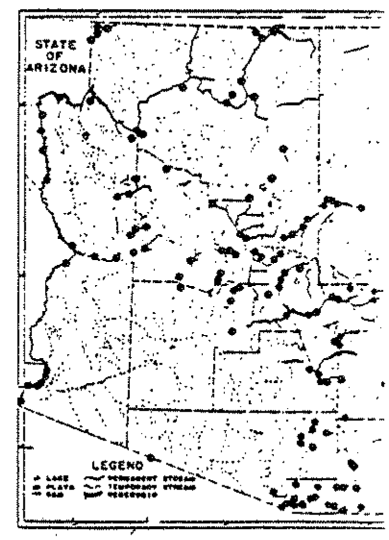
In the maps depicting the distributions of various species of fishes in Arizona (Maps 7 through 42), open circles denote localities where the particular kind formerly was present, as based on literature records or recent collecting, and dots represent localities where the species was known to persist in the period 1963 through 1972. Half-darkened circles indicate introduced populations of native species, moved in attempts to maintain them in nature.

Family ACIPENSERIDAE, sturgeons

Sturgeons are generally large fishes that enjoy a circumpolar distribution, occurring throughout much of northern Europe, Asia, and North America. They are of considerable commercial value in large rivers and estuaries, especially in Eurasia, and of increasing value as sport fishes in the United States. All species spawn in fresh waters, but many of them live and grow mostly in the sea, or in estuaries of large rivers. They are remnants of an ancient group of fishes. The skeleton is mostly cartilage, there are five rows of bony scutes ("bucklers") arranged along their bodies, one dorsal, two dorso-lateral, and two ventro-lateral. The underside of their conical or flattened, elongated snouts bears four, variably-elongated, fleshy barbels. The jaws are highly protactile, toothed in young and toothless in the adult. One species has been introduced, with as-yet-unknown success, into the Colorado River, Arizona—California.



(Map 3)



(Map 5)

Maps 3-6. Localities in Arizona fr
time in the literature, or have bee
preserved specimens or identific
fishes are not included, see Map
5 — 1941-1960; and Map 6 — 196

ECIES

a photograph(s) of the fish
Arizona, giving the scientific
dditional descriptive informa-
s, and a general discussion of
neral biology. Also, a map of
included when appropriate.
from collections made mostly
and associates and students,
of Michigan Museum of Zoolo-
a State University. Personnel
t and U. S. Bureau of Sport
ial contributions of collected
lly of game fishes. Many data
om California Fish and Game
the personnel and agencies
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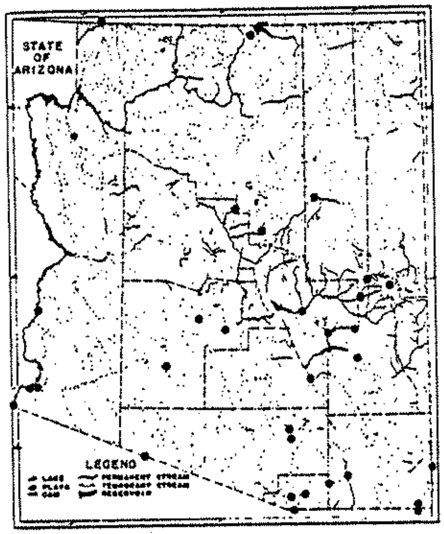
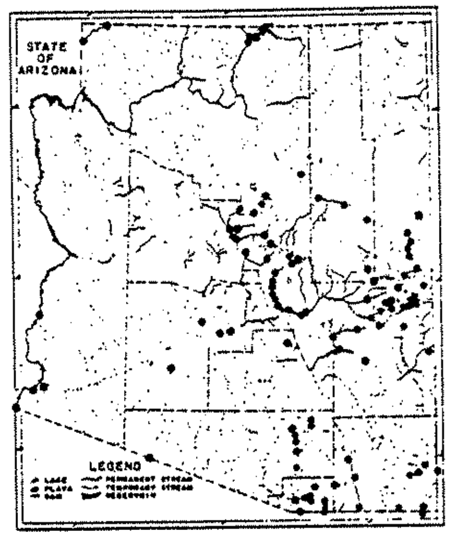
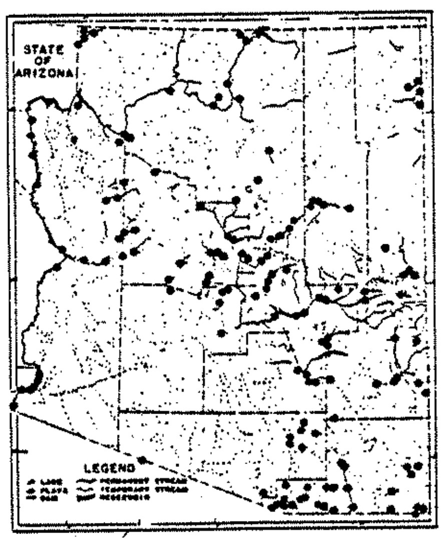
California.



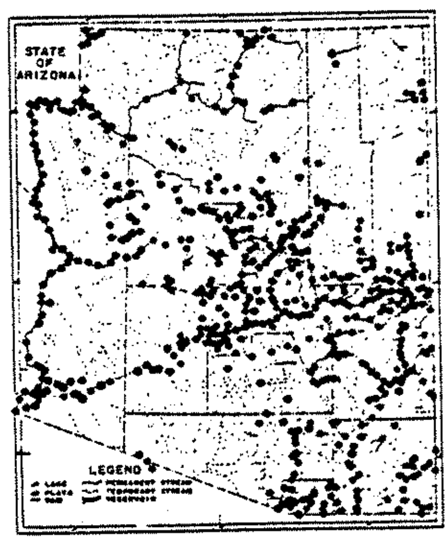
(Map 3)



(Map 4)



(Map 5)



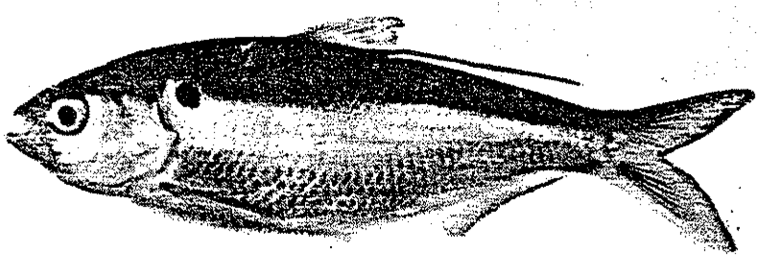
(Map 6)

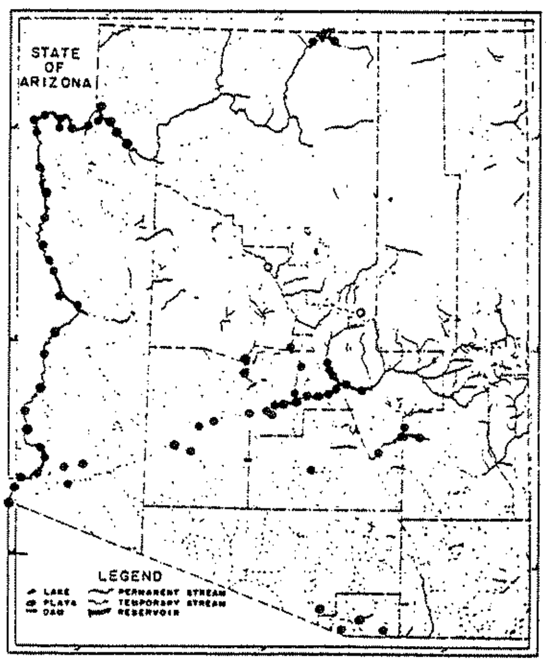
Maps 3-6. Localities in Arizona from which fishes have been recorded within historic time in the literature, or have been collected and/or observed and are documented by preserved specimens or identifiable photographs (localities for introduced salmonid fishes are not included, see Map 10): Map 3 — pre-1900; Map 4 — 1901-1940; Map 5 — 1941-1960; and Map 6 — 1961-1972.

Colorado River in the late 1800's by the old U.S. Fish Commission (Taggart, 1885), but was not seen again. According to recent reports another clupeid, the alewife, *Alosa pseudoharengus* (Wilson), is now introduced into the extreme headwaters of the Colorado River basin, in Colorado, as have been smelt (Family Osmeridae; *Osmerus mordax* Mitchill) (Anonymous 1971), and I have been informed by personnel of the Colorado Department of Game and Fish that the gizzard shad, *Dorosoma cepedianum* (LeSueur), has been on the "west slope" in Colorado for some time, but obviously has not moved downstream.

Threadfin shad, *Dorosoma petenense* (Günther)

(Fig. 29; Map 7)





Dorosoma petenense atchafay

Signalosa petenensis, Chance,

Dorosoma petenense, Shapov Miller, 1961b: 374. Walker, e and McConnell, 1963: 113. McC nell, 1966: 71. Burns, 1966a: 48 43. Johnson, *et al.,* 1970: 47. J 1970: 338. Minckley, 1971: 183.

Dorosoma petenensis (sic), Mi

Body compressed, deep an highly serrate, with 14 to 17 pr fin with 14 or 15 soft rays, the when deflected downward. Anal terminal and oblique. Eye large, well developed. Stomach gizzar voluted, and bearing many pylor

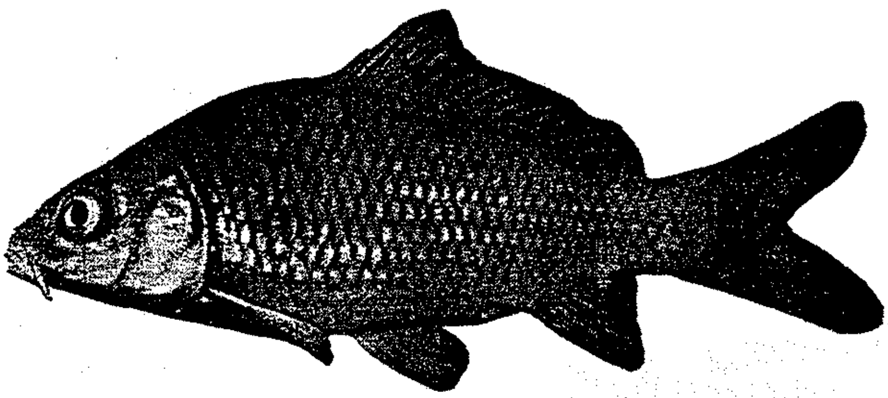
Color dark slate-gray to b Post-opercular spot smaller than suffused with yellow, especially

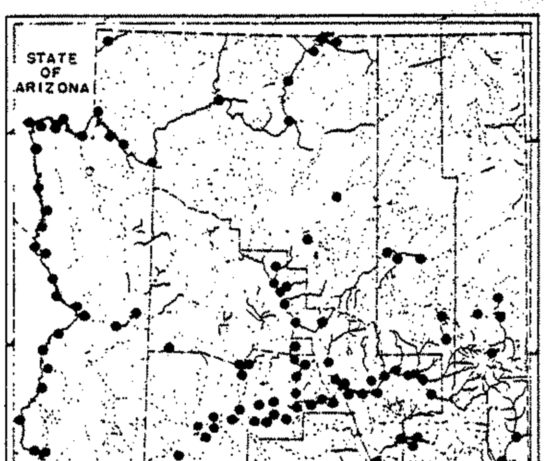
Threadfin shad were in Tennessee, into the Overton A and into Lake Havasu in 1954 years the fish had spread to system, from Lake Mead to th 1959 the species was transferr to lakes of central Arizona (were spread to inhabit almo elevation. They seem unable are generally absent from Tor Roosevelt Reservoir, from the Grand Canyon. They were i over-wintered there presumab springs. The species is gener below 9.0° C, or so, in winter times occur when temperature Parsons & Kimsey, 1954). At cold reservoirs may occur ne plants that are positioned ne States (Dryer & Benson, 1957 range of salinity tolerance, be than the ocean except near i the Pacific Ocean and Gulf of

J. E. Johnson (1969); et ecology of threadfin shad in references for the information situations the threadfin shad quently congregating below flowing pools. In the Gila River

Carp, *Cyprinus carpio* Linnaeus

(Fig. 43; Map 11)





Cyprinus carpio, Gilbert and Scofield, 1898: 493. Moffett, 1942: 82/ 1943: 182. Dill, 1944: 151. Wallis, 1951: 89. Douglas, 1952: 150. Miller, 1952b: 17/ 1961b: 374/ 1963a: 1. Hemphill, 1954: 41. Miller and Hubbs, 1960: 31. Follett, 1961: 227. LaRivers, 1962: 448. Miller and Lowe, 1964: 138/ 1967: 138. Minckley, 1965a: 50/ 1971: 184. Burns, 1966b: 510. Bradley and Deacon, 1967:

229. Johnson, 1968: 209. Min
son, 1968: 8. Johnson, *et al.*, 1

Body compressed. Ve
fin long, with 19 to 22 ra
Anal fin with six rays, the f
oblique, thin-lipped with two
teeth molariform and in th

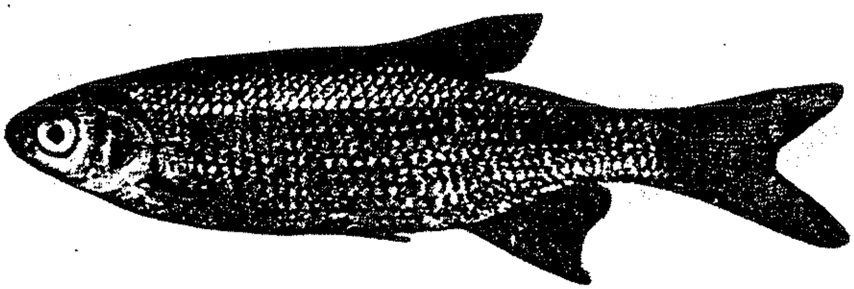
Color basically brass
yellow, yellow-orange, to
proximally.

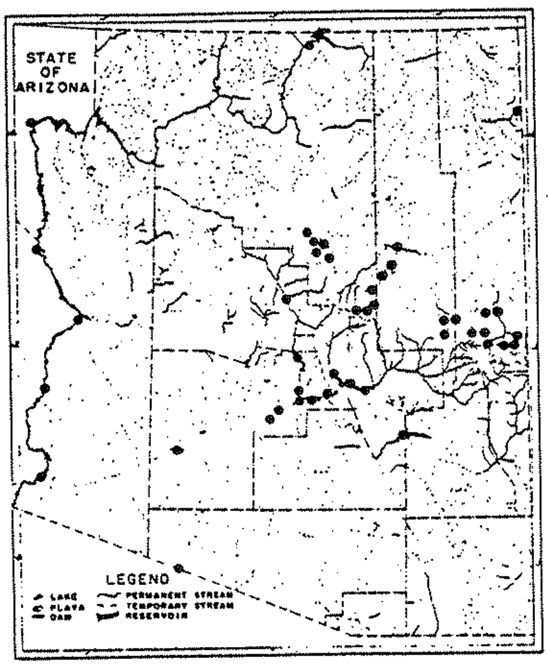
Carp arrived in
Taggart (1885) and Rul
in the rivers by Everman
(1898). Since then they h
below an elevation of 2
as well. They were in
(Forbes & Richardson, 1920
escaped from ponds in wh
they rapidly began to
commonest large fish in
fishes appear to have decl
either an interaction betwe
ation of habitat that wa
European (originally As
fishes declined as transporta
competitive at inland loca
value of any fish taken
Valley (Cross, 1967). In
were costly (and almost inv
detracted substantially from
ploitation of the fish.

The effects of ca
remarkably adaptable anir
chemical conditions, ter
dition, and therefore p
directly) with which they
small, although they somet
carnivorous on benthic i
carp in lakes, mostly cr
it is abundant, and fishe
of carp include a detailed
often causes turbid wa
(Sigler, 1958). In Arizo
River, the now-abundan
food item at some times o
indicates that it has an
if the concentration of
eat, the excess is bound

Golden shiner, *Notemiqonus crysoleucus* (Mitchill)

(Fig, 46; Map 12)





Notemigonus crysoleucus, Miller, 1952b: 33. Hemphill, 1954: 42. Miller and Hubbs, 1960: 31. LaRivers, 1962: 423. Miller and Lowe, 1964: 138/ 1967: 138. McKechnie, 1966a: 488. Bradley and Deacon, 1967: 273. Minckley and Carufel, 1967: 291. Minckley and Deacon, 1968: 1427. Minckley and Johnson, 1968: 9. Minckley, 1971: 184.

Notemigonus crysoleucus seco, Miller, 1952b: 33.

Notemigonus crysoleucus auratus, Miller, 1952b: 33.

Body thin, deeply compressed, head relatively small and acute. Mouth small and oblique. Lateral line deeply decurved, with 47 to 54 scales. Dorsal fin high, acute, originating behind insertion of pelvic fins. Fin-rays 8 in dorsal, 11 to 17 in anal, 15 in pectorals, and 9 in pelvics. Pharyngeal teeth in a single row, 5-5. Intestine short, peritoneum dusky. Belly between anus and pelvic fin-bases scaleless and produced into a soft, fleshy keel.

Color olivaceous dorsally,
sometimes white on breast anc
darker dorsally, especially if frc
lateral band. Fins colorless, or
ing adults.

Golden shiners are pop
have been present in Arizo
Lowe 1967). They enjoy a
of eastern United States,
México. There is a tendenc
in central and northern Arizc
(11 to 14), corresponding g
tained by some as the subs
numbers of anal fin-rays in fi
often have greater numbers
N. c. seco (Girard). These tw
along the lower Colorado Ri
(McKechnie, 1966a). The Ariz
introduced population(s) to c
ple, cooler above 1,000 m, w
ential survival of bait fish
vice versa at lower elevatio

Golden shiners became
zona, at least in the higher
and almost immediately w
(Borges, in Miller, 1952b), cc
species, principally salmonic
programs. This was discuss
Fisheries of innumerable lake
rupted by the eradication p
for the desired fishes to att
with increasing severity. The
this minnow and an attempt
reasonable success, but the
abundant enough to essential
Canyon Lake, and probably
Hawley Lake suffered a simil
abundant, and spreading thr
Rim country. Use of the fish
and is rigorously opposed. T
be occurring only through th
and thoughtless emptying of

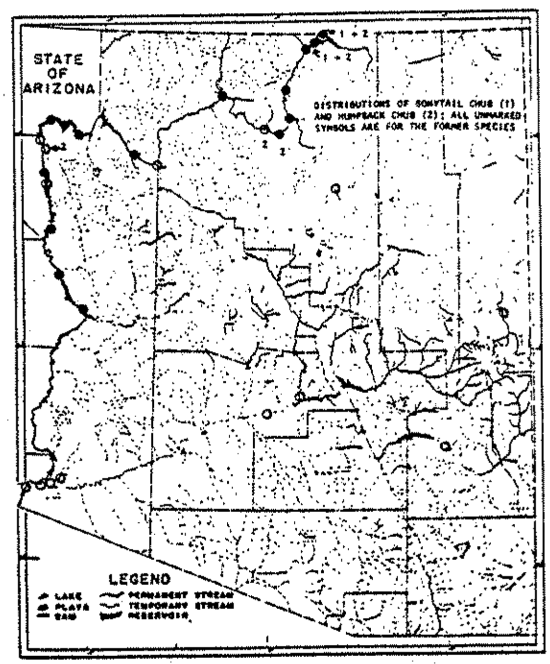
Minckley & Carufel (19
with a native, endemic spin
in Chevalon Creek at least,
consistent at the present wr
shiner (see below) now are k

the number of eggs varies with
an 10,000 to more than 50,000.
ge; females generally spawn for

predominating within its native
2,800 meters. It occurs in cool
bject to radical seasonal variation.
atic vegetation along the shore,
least 20 meters) at some times
r, abundantly at times, in saline
om surface connections to other

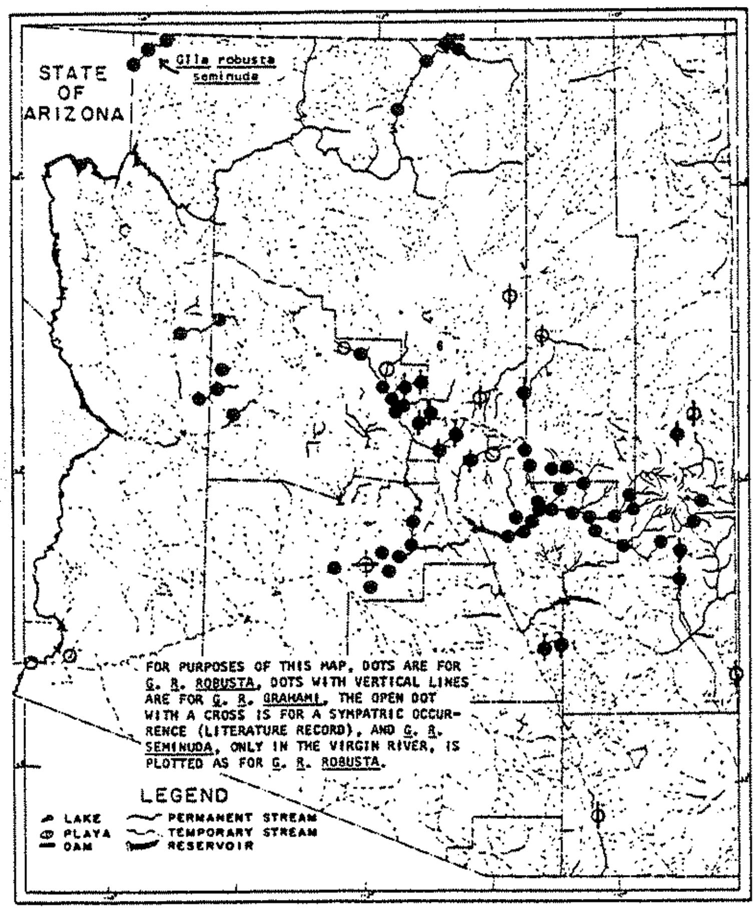
Bonytail chub, *Gila elegans* Baird and Girard[8]

(Fig. 48; Map 13)



[8]As with some of the trouts, the synomicon of the "*robusta* series" of the minnow genus *Gila* is complicated. *Gila elegans* has been considered as a full species, a subspecies, and an "ecotype," in the last two cases as a form of *G. robusta*. Many records of the last therefore include *G. elegans* and *G. intermedia* (to be discussed later), in part at least. These are not included in the listing of previous records unless especially pertinent.

Gila robusta grahami Baird and Girard, (Fig. 50, Map 14)



Gila grahami, Baird and Girard, 1853b: 389. Girard, 1856: 191/ 1859a: 61. Cope, 1871: 441. Cope and Yarrow, 1875: 665. Jordan and Gilbert, 1883: 228.

Gila robusta, Lowe, 1967: 102.

(?) Richardsonius gibbosus, Snyder, 1915: 582.

Gila robusta robusta, see records for that subspecies, p. 100, many of which include *G. r. grahami* in general statements of distribution.

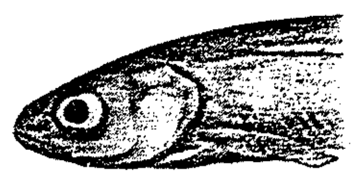
Gila robusta: robusta X intermedia, Barber and Minckley, 1966: 317.

This subspecies, diagnosed in the key (p. 100), tends in many respects to be intermediate between *G. r. robusta* and the Gila chub (*Gila intermedia*, discussed later). Rinne (1969) dealt with the systematics of the

"*robusta* complex" in the
of temporal and spatial sta
interpretation of probable
the progenitor of *G. r. grar*
isolated in the Gila River s
smaller tributaries and int
Mexico), by re-invasion of
A number of populations o
of creeks tributary to the G
invaded the Little Colorad
hybridization between G. r
ancient. The parallel betw
native Arizona trouts was

In Aravaipa Creek, sc
position of "top carnivore
smaller fishes of that stre
algae and aquatic insects.
presumably in pools, and
oranges on their lower chee
of the paired fins. I know
of this form, other than the

Gila robusta seminuda Co



Gila seminuda, Cope and
Jordan and Gilbert, 1883: 23
1930: 114.

Gila robusta seminuda, E
100. LaRivers and Trelease, 19
and Minckley, 1970: 15.

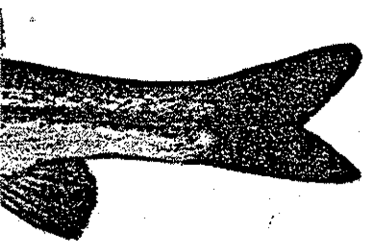
Gila robusta robusta see
include *G. r. seminuda* in gene

Gila r. seminuda is res
system in Utah, Arizona, a
"middle Colorado River fau
somewhat more streamlined
G. elegans, although it has
more turbid (abrasive), rive
LaRivers & Trelease (1952),
an intergrade between robu
consider it a valid subspecies
is allopatric to any other G
presently is inundated by L

iricahuas), in an attempt to
al species in the United States.
as a success.

nia Miller

5)



5: 581.

949: 148. Miller and Lowe, 1964:
ckley and Deacon, 1968: 1428.
ckley, 1970: 12.

. Scales relatively small, 63 to 75
lds. Dorsal, anal, and pelvic fins
5-4, 2.

lateral bands above and below
ng colors red at bases of paired
other ventro-lateral areas, basi-

b occurs in only a very limited
anyon west of Nogales, Santa
scribed in a number of papers
961), since it supports a rich
nts and animals that otherwise
therwise rare. In periods of
are maintained by underflow,
canyon walls. Amazingly, in
tion continues to inhabit the
s, a behavior that has caused
ct at the locality since they
ats in periods of above-normal
rarely grows larger than 125
hieve 250 mm farther down-

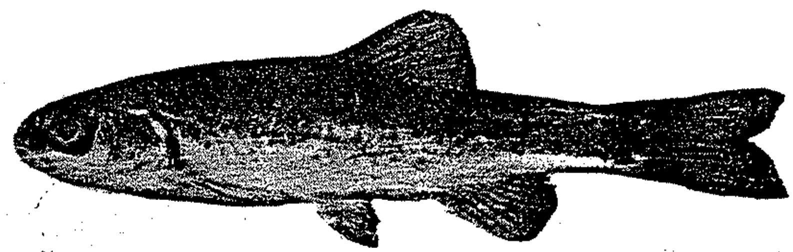
occur only downstream from
Bear Canyon (L. Miller, 1949);
ed individuals was discovered

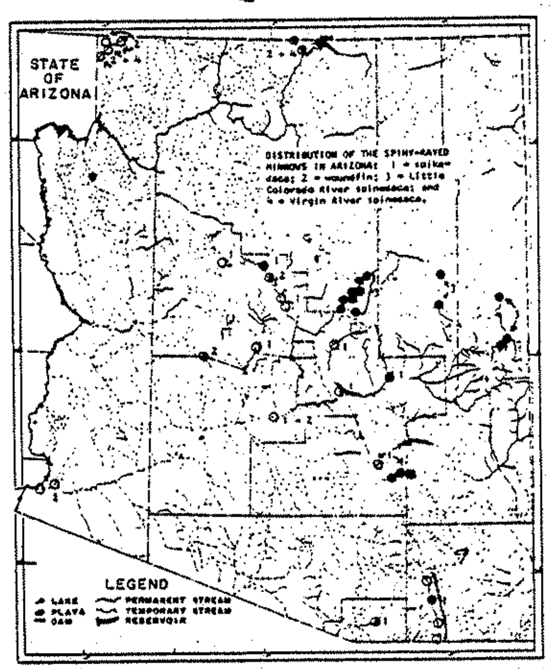
about 2 km north, in a seep that contained only a few liters of water. This serves to illustrate the tenacity of *G. ditaenia*, and its marked capability for maintaining populations in small habitats under severe environmental conditions. The seep had a foul, black, reducing bottom, and was almost totally overgrown by plants in places where cattle had not trampled it into a quagmire.

Foods of a few individuals of *G. ditaenia* from Arizona, taken in early summer, consisted of aquatic and terrestrial insects, and algae, in decreasing order of volume. Spawning appears to occur in early spring, on the basis of dates of occurrence of young in collections.

Little Colorado River spinedace, *Lepidomeda vittata* Cope

(Fig. 55; Map 16)

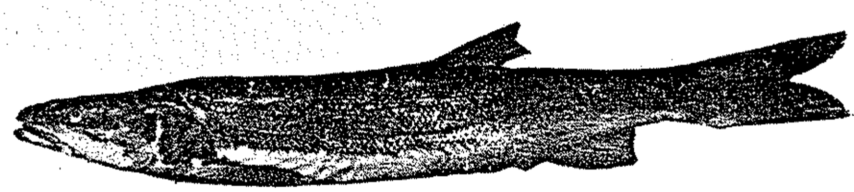


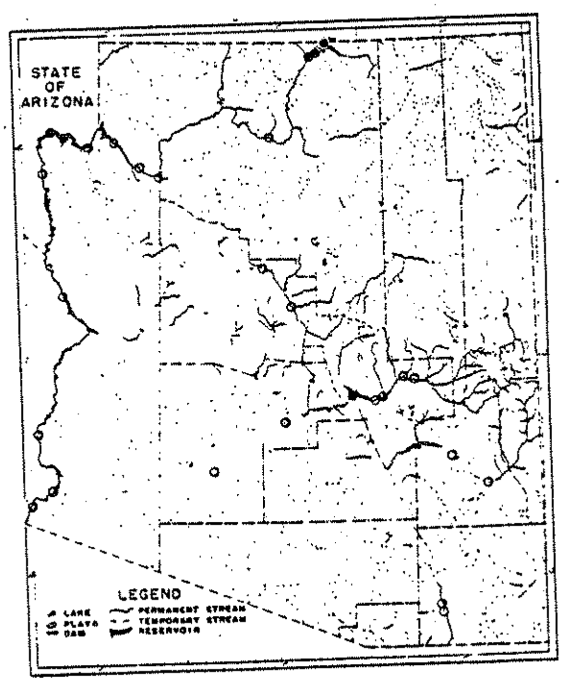


s s wn repeatedly over a period
od e about 2,000 eggs apiece.
g upon water temperatures, and
atching.

ve ebrates from the bottom, ter-
othe fish species and their own.
redside shiners were thought by
ita o the fisheries of the lower
t species and trout (Larkin &
d suppression of trout growth
owth (which compensated for the
e ugh to feed upon the shiner
la e trout was also indicated in
decline in a related shiner (*R.*
decline in trout production (Mc-

Colorado River squawfish (Colorado salmon or white salmon),
Ptychocheilus lucius Girard
(Frontis.; Figs. 60-61; Map 17)





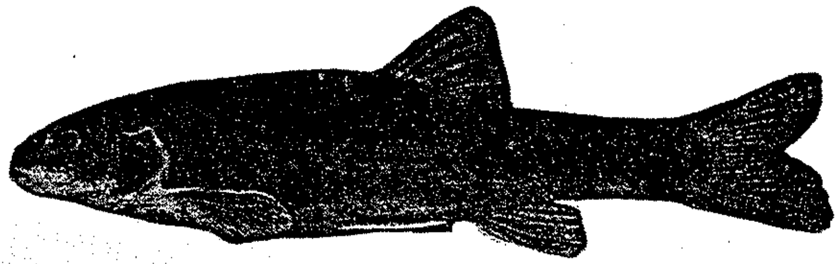
tures exceed 25° to 28° C, but
peratures from 28° to as high
nortalities of *A. chrysogaster*
sities and drying of the dorsal
reams, inflict physical damage.
ndary infections and often by
ammals is high on populations
nd also seems high in periods
ndency for *Agosia* to remain
of the day. In smaller pools,
algae *(Hydrodictyon)*, when
(Minckley & Barber, 1970), and
or other minnows in eastern

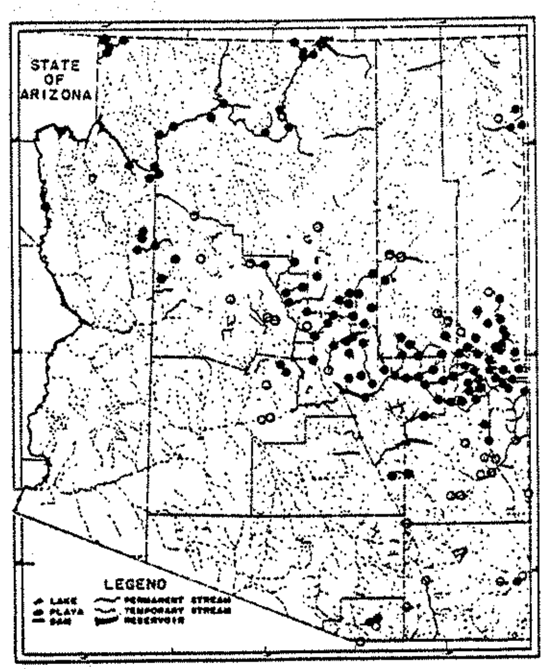
eriod, from December through
desert habitats. Saucer-shaped
These range from 15 to 25 cm
gins raised about a centimeter
etimes are quite concentrated,
rculate males move randomly,
any obvious territoriality. Fe-
ately flanked by 1 to 4 males
y to wander through the area.
ves postero-laterally to the fe-
sely followed by the male(s),
the actual spawning act. The
ve rapidly away, the males to
f the area, usually into deeper
ber, 1970). Eggs were readily
he depressions and removing
atch in less than four days in
yolk sacs are almost totally
. Growth is rapid and young
to spawn (about 45-50 mm
o evidence for a late summer
Few individuals live more than
een by me have been less than

, detrital materials, and algae.
but the major item in those
atic insects were noted, along

Speckled dace, *Rhinichthys osculus* (Girard)

(Fig. 63; Map 19)





Argyreus osculus, Girard, 1856: 186/ 1859a: 47.

Argyreus notabilis, Girard, 1856: 186 (Santa Cruz River, México).

Rhinichthys henshawii, var. III, Cope, 1874: 133.

Ceratichthys ventricosus, Cope, 1874: 136.

Apocope oscula, Cope and Yarrow, 1875: 647. Jordan and Gilbert, 1883: 211. Jordan, *et al.*, 1930: 141.

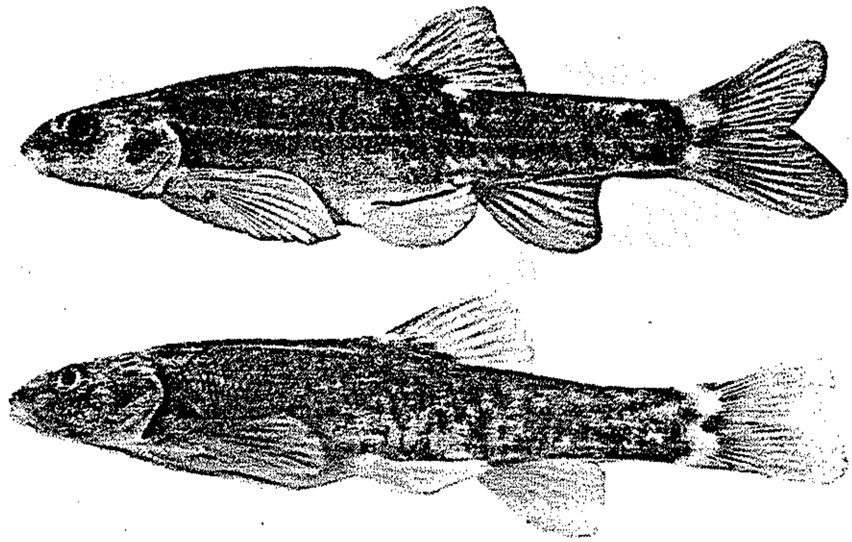
Apocope couesii, Yarrow, in Cope and Yarrow, 1875: 648. Jordan, *et al.*, 1930: 1411.

'c: is or any other native fish
runoff have been recorded,
uring years of low discharge,
ig reproductive success and
e' , this did not apparently
r.

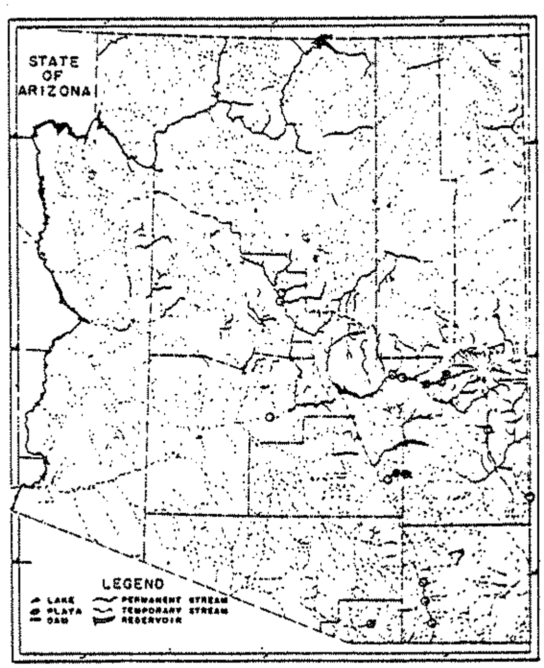
pa' 'e of maintaining position
a carried downstream, often
ol.., 1964). On the other hand,
time in intermittent pools, al-
rv' g.

Loach minnow, *Tiaroga cobitis* Girard

(Fig. 64; Map 20)

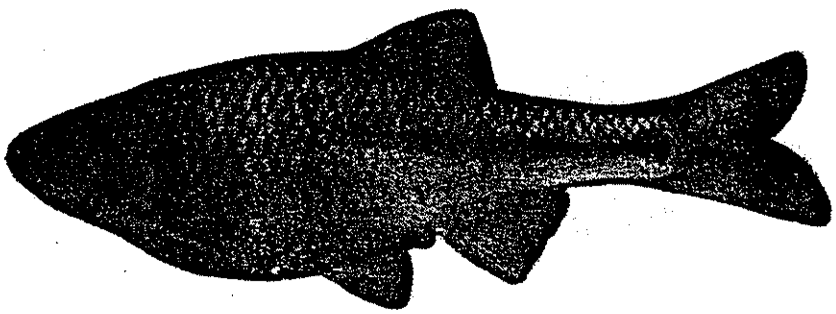


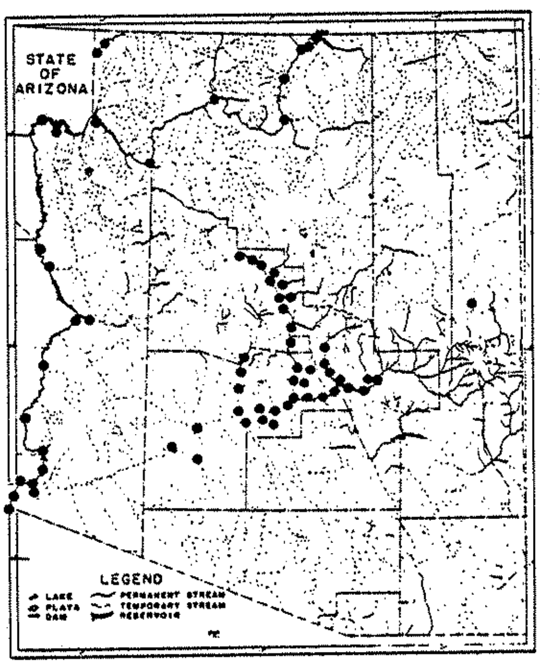
Male above, Female below.



Red shiner, *Notropis lutrensis* (Baird and Girard)

(Fig. 65; Map 21)





Notropis lutrensis lutrensis, Miller, 1952b: 21.

Notropis lutrensis, Hubbs, 1954: 287. Shapovalov, *et al.*, 1959: 167. Follett, 1961: 227. Miller, 1961b: 374. Miller and Lowe, 1964: 142/ 1967: 142. Koehn, 1965b: 462. Koehn and Minckley, 1965: 151. Bradley and Deacon, 1967: 229. Minckley and Carufel, 1967: 301. Minckley and Deacon, 1968: 1427. Minckley and Johnson, 1968: 9. Moore, 1968: 83. Minckley, 1971: 185/ 1972: 101.

Notropis lutrensis: lutrensis X suavis, Hubbs, 1954: 292.

Body highly compressed, its greatest depth greater than length of head. Snout blunt. Mouth terminal and oblique. Dorsal and pelvic fin-rays eight. Anal fin-rays 8 to 10, usually 9. Lateral line decurved, with 33 to 36 scales, most often 34 or 35.

Pharyngeal teeth usually in a
in one or both minor rows.

Color tan to olivaceus
Dorsolateral scales moderate
dition with caudal and all low
milky-white in life. Body pale
on body directly behind ope
pink.

This minnow is one o
of the western part of the
1967), thriving under c
temperatures, and so
numerous in clear streams
populations of other minn
component of the faun
abundance when drough
the species composition
tion of his species into th
where extremes in phys
in exactly what might b
lower elevations (below ab
by physical barriers such as
and even has moved into
Some of this dispersal ha
introductions from elsewhe
aggressive, colonizing natur

Hubbs (1954) referr
to intergrades, N. lutr
of a relatively slim body, ar
cause the original stock
such intergrades prevai
deep-bodied, and closely
(Baird and Girard), especial
more than one introductio

Reproduction by N
often in riffles over bould
Spawning activities have be
submerged roots, aquat
bottoms of aquaria and
Cross, 1967). In the large re
gations are active along co
period March through J
males, a rapid, zig-zag
contact by the male with hi
function in stimulation of tr
flurry, in which the mal
the female, with his bo
during emission of gametes

e, snout projecting and somewhat
hin jaws. Dorsal and anal fin-rays
at---l line. Breeding males with
ch . Nuptial tubercles large and

lateral band variously developed.
a blotched appearance. Breeding
ic ipanied by an orange basal

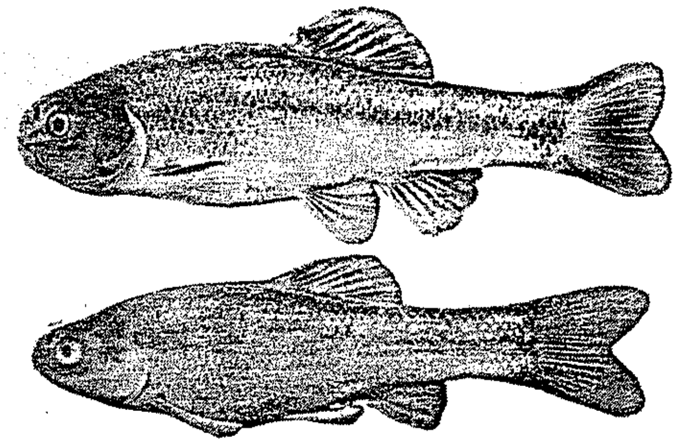
Canyon, and was found only
Chiricahua Mountains. Other
ur in tributaries of the
northern México. It most
ne upper Río Yaqui basin of
Rucker Canyon, despite con-
ct of camp sites, impound-
a , and so on until 1971.
that the fish now is extinct.
irbed beneath boulders and
h leepest places. Little was

similar habitats in smaller
os in pools over sand or
e g principally on detritus
plants. Invertebrates also are

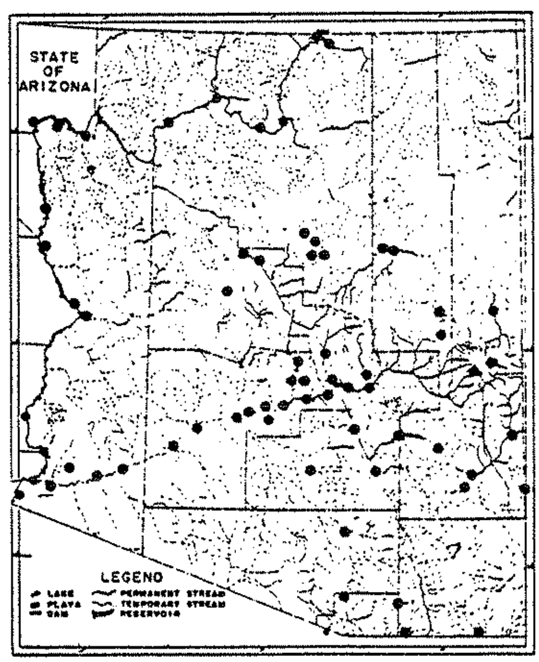
ves into smaller creeks
fl ing shallows over fine
d most often near a pool or
en is practiced by the males
h shing and plowing with
ou , to accomplish the task.
ike nest, usually by a single
and simply lodge in crevices
ir that occurring in trouts
Mo tains National Park, the
n known to disturb the eggs
year in the same gravels

Fathead minnow, *Pimephales promelas* Rafinesque

(Fig. 70; Map 22)



Male above, Female below.

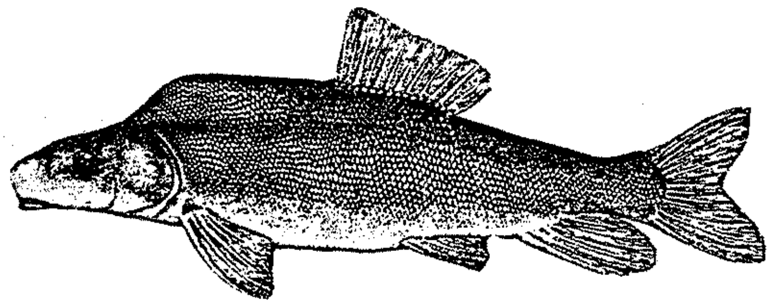


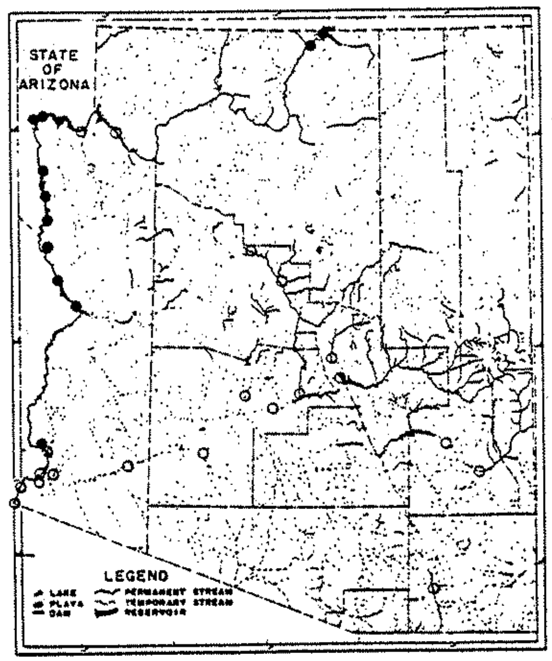
Pimephales promelas confertus, Shapovalov and Dill, 1950: 389. Evans and Douglas, 1950: 435. Miller, 1952b: 21. Shapovalov, *et al.*, 1959: 167.

nd was present. They also fed
n the other species, which may
e more diversified, shallower,
a substantial part of the diet in
dividual clams that were eaten
sh (Minckley, *et al.*, 1970). This
na impoundments, with maxima

Razorback (humpback) sucker, *Xyrauchen texanus* (Abbott)

(Fig. 74; Map 23)





Catostomus texanus, Abbott, 1860: 473.

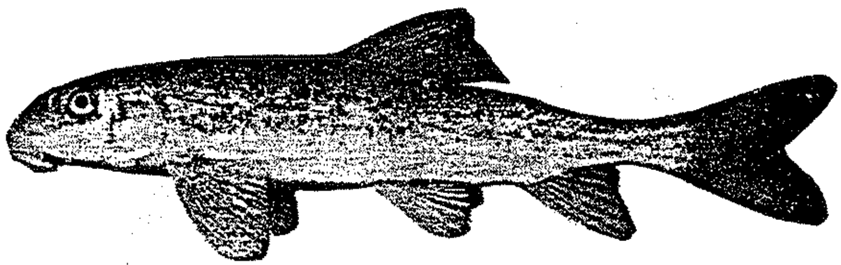
Catostomus cypho, Lockington, 1881: 237. Jordan and Gilbert, 1883: 129.

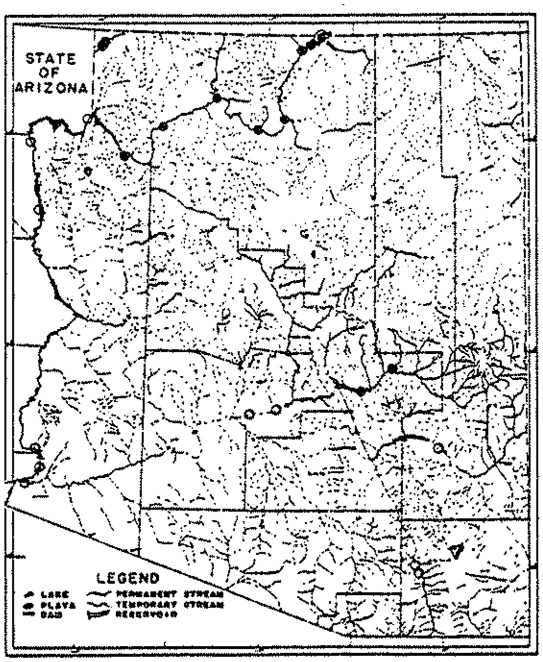
Xyrauchen cypho, Eigenmann and Kirsch, in Kirsch, 1889: 556. Evermann and Rutter, 1895: 482. Jordan and Evermann, 1896: 184/ 1937: 57. Gilbert and Scofield, 1898: 491. Meek, 1904: xxxix, 33.

Xyrauchen texanus, Fowler, 1913: 54. Ellis, 1914: 31. Snyder, 1915: 579. Jordan, *et al.*, 1930: 108. Evermann and Clark, 1931: 62. Moffett, 1942: 82/ 1943: 182. Dill, 1944: 150. Miller, 1946c: 410/ 1955: 127/ 1958: 202/ 1961a: 544/ 1961b: 373/ 1964a: 7/ 1964b: 28. Wallis, 1951: 89. Douglas, 1952: 149.

Flannelmouth sucker, *Catostomus latipinnis* Baird and Girard[14]

(Fig. 75; Map 24)





Catostomus latipinnis, Baird and Girard, 1853b; 388. Jordan, 1878a: 409/ 1878b: 153/ 1886: 120. Kirsch, 1889: 555. Jordan and Gilbert, 1883: 125.* Evermann and Rutter, 1895: 481.* Jordan and Evermann, 1896: 174.* Gilbert and Scofield, 1898: 489. Ellis, 1914: 28. Jordan, *et al.*, 1930: 107.* Miller, 1946a: 49/ 1946c: 415/ 1952b: 13/ 1955: 125/ 1961a: 544/ 1961b: 374/ 1964a: 7. Wallis, 1951: 90. LaRivers, 1952: 96/ 1962: 351. LaRivers and Trelease, 1952: 115. Rostland, 1952: 264.* Winn and Miller, 1954: 274. Eddy, 1957: 77.* Koster, 1957: 43. Kimsey and Fisk, 1960: 467. Miller and Hubbs, 1960: 20.

[14]The sucker discussed next, *Catostomus* species, has long been confused with *C. latipinnis*; references that include the two forms under the latter name are marked with an asterisk.

Sigler and Miller, 1963: 97. ... and Minckley, 1966: 323. Bra- Deacon, 1967: 229. Minckley Minckley, 1971: 186.

Acomus latipinnis, Girard,

Catostomus latipinnis discob

Catostomus (Catostomus) la and Koehn, 1971: 283.

Body elongated, thicker but thick. Lower lips marked Dorsal fin falcate, with 10 to small, sometimes embedded c

Coloration typically light scales sometimes markedly c colors have been noted in Ari upper Colorado basin. Fins-ra Young often silvery over-all.

The flannelmouth sucke streams of the Colorado Rive markedly reduced in range. paralleled that of squawfis species only in the Salt Rive mainstream Colorado River, to do poorly in impoundme the area below Lake Mead, Gila rivers, but they are not formed.

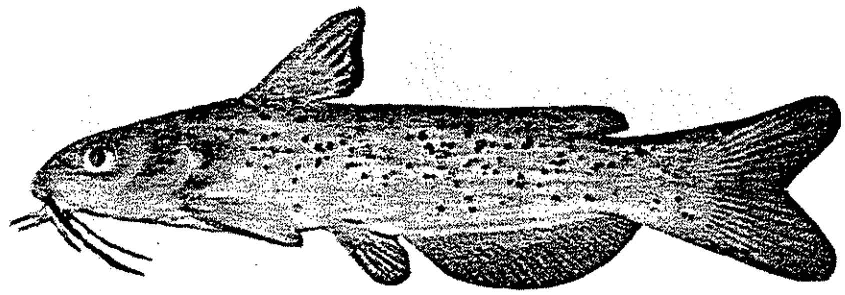
The species was utilize & Miller, 1963), and attains part of the Colorado basin (is a vegetarian (Ellis, 1914), on bottom invertebrates. So moving along the shoreline shallows along the margins from the Salt River Canyon and were associated with th (*G. r. robusta*).

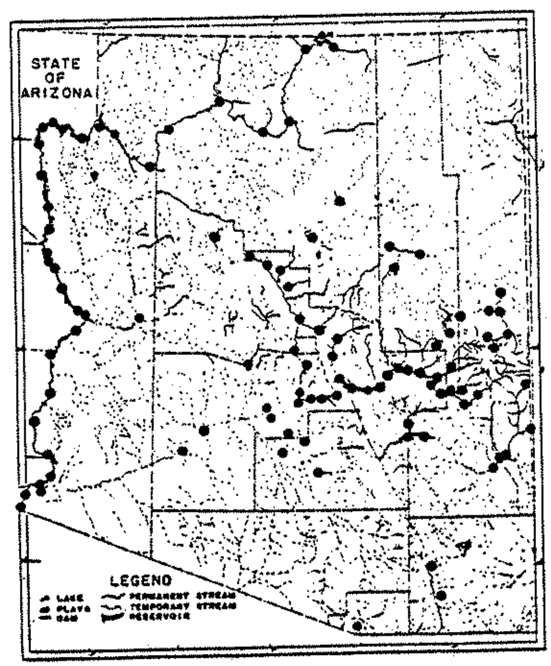
In the Santa Clara River River, *C. latipinnis* appears ably-introduced *Catostomus* None of these hybrids have pected in the near future.

with the item in its stomach, or
ving, and lies motionless for a
n in deep water when hooked,
rectly into brush or debris when
, and of an excellent flavor. In
le commercial importance, and
elopment in some parts of the

Channel catfish, *Ictalurus punctatus* (Rafinesque)

(Fig. 83, Map 29)





Ictalurus lacustris, Mulch and Gamble, 1954: 15.

Ictalurus lacustris punctatus, Dill, 1944: 155. Miller, 1946c: 415. LaRivers and Trelease, 1952: 118.

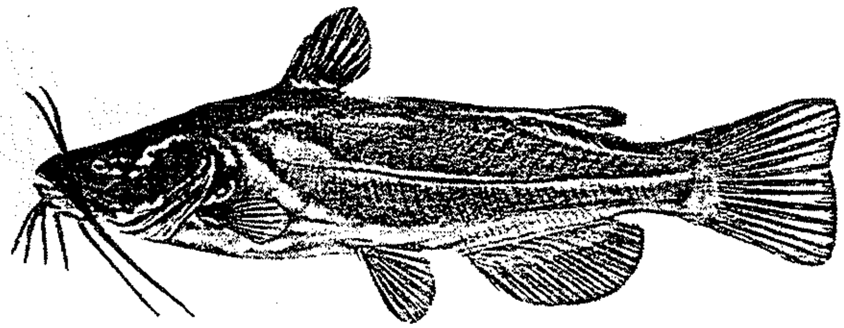
Ictalurus punctatus, Moffett, 1942: 82/ 1943: 182. Wallis, 1951: 90. LaRivers, 1952: 91/ 1962: 483. Miller, 1952b: 7/ 1961b: 374/ 1963a: 1. Beland, 1953a: 137. Lowe, 1960: 171. Miller and Hubbs, 1960: 31. Sigler and Miller, 1963: 109. Miller and Lowe, 1964: 145/ 1967: 145. Beers and McConnell, 1966: 71. Bradley and Deacon, 1967: 229. Minckley and Deacon, 1968: 1427. Minckley and Johnson, 1968: 6. Johnson, *et al.*, 1970: 46. Minckley, 1971: 186.

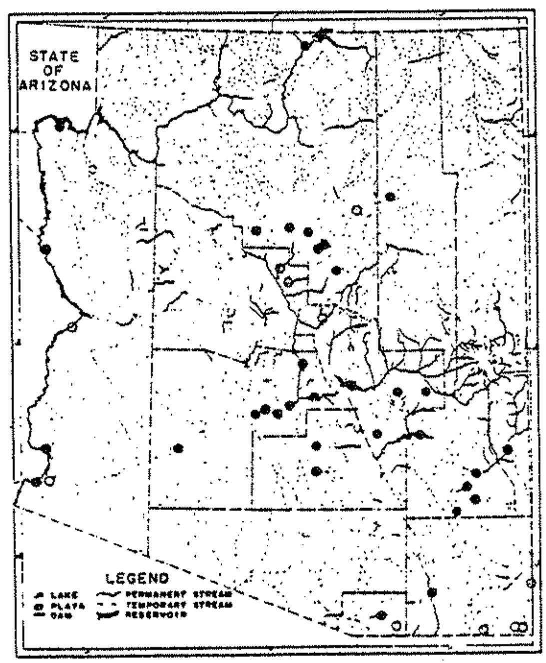
taxonomy or life histories of
arities of this species to the
le l by similarities in ecology
ri iative to the Pacific Slope

a Cruz River basin, in the
n :99. The stock reportedly
n me basin of the Río Sonora
re until the 1950s, providing
; ording to their testimony,
A ınd once fed by Monkey
mei bottom littered with skel-
o a formerly-large population.
ei rdino Creek, just south of
ıc likely moved into Arizona
the state year-around, when
herefore be considered native,
te I. *pricei* in Arizona or in

Black bullhead, *Ictalurus melas* (Rafinesque)

(Fig. 85, Map 30)





Ameiurus melas, Dill, 1944: 160. Miller and Winn, 1951: 83. Wallis 1951: 90. LaRivers, 1952: 92. LaRivers and Trelease, 1952: 118.

Ameiurus melas melas, Miller and Winn, 1951: 84.

Ameiurus melas catulus, Miller and Winn, 1951: 84. Shapovalov and Dill, 1950: 389. Shapovalov, *et al.,* 1959: 176.

Ictalurus melas, Miller and Hubbs, 1960: 31. Miller, 1961b: 374. LaRivers, 1962: 495. Miller and Lowe, 1964: 145/ 1967: 145. Barber and Minckley, 1966: 321. Bradley and Deacon, 1967: 273. Minckley and Deacon, 1968: 1427. Minckley and Johnson, 1968: 7. Moore, 1968: 104. Minckley, 1969a: 4/ 1971: 186. Barber, *et al.,* 1970: 10.

m-dwelling populations. Caudal
Jaws about equal in length.
oft-rays longest. Posterior serrae

usually black. Caudal-fin base
dark-gray, white to dirty-white

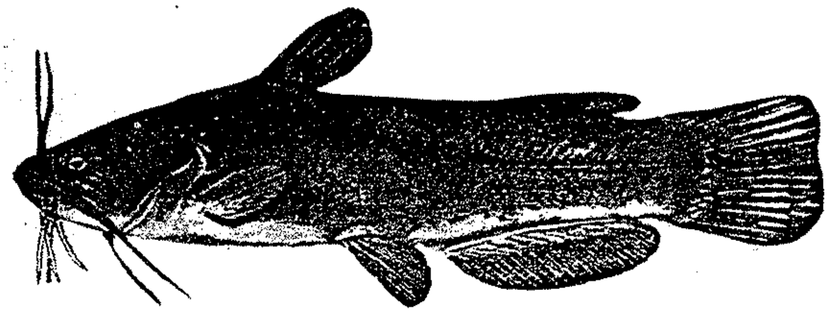
red a pest in Arizona waters.
nd more often than not forms
pete with more suitable fishes
n the high-elevation lakes of
a number of costly and time-
necessary over the past few
ons, small populations persist

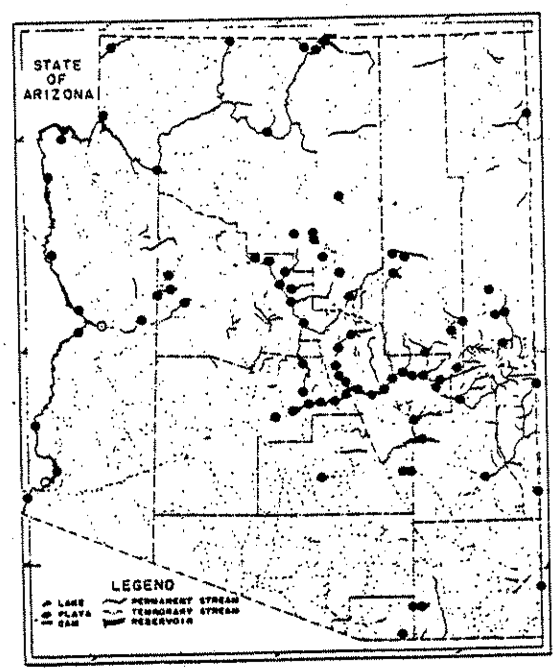
latively quiet, turbid waters,
ned habitats. They also seem
other species, occurring most
to 5 other species of fishes.
rnivorous when animal foods
g is mostly in early evenings
night. Bullheads, as with the
visions.

bullhead catfishes have been
pawning occurs in spring and
and channel catfishes, or in
of gravel, sand, or vegetable
time prior to the actual spawn,
d both sexes are involved in
e from intruders. Both sexes
young for a time, protecting
bout in shallow waters.

Yellow bullhead, *Ictalurus natalis* (LeSueur)

(Fig. 86, Map 31)





Ameiurus natalis, Dill, 1944: 159.

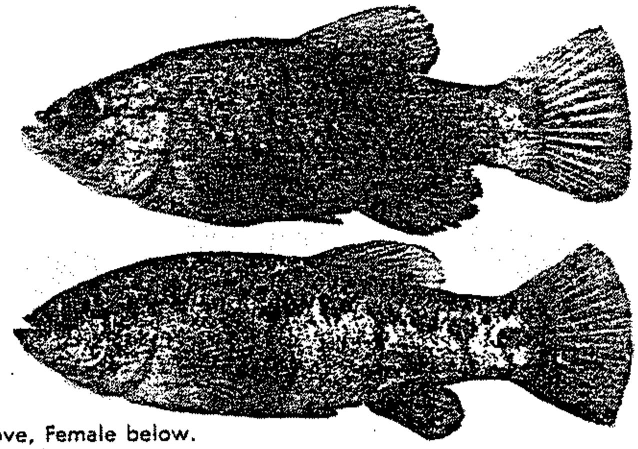
Ictalurus natalis, Koster, 1957: 178. Miller, 1961b: 374/ 1963a: 1. Miller and Lowe, 1964: 146/ 1967: 146. Minckley and Deacon, 1968: 1427. Minckley and Johnson, 1968: 6. Minckley, 1971: 186/ 1972: 102.

Body stockier than ***I. melas***. Caudal fin square to slightly convex distally. Lower jaw included. Most anal fin-rays about equal in length, distal margin almost straight.

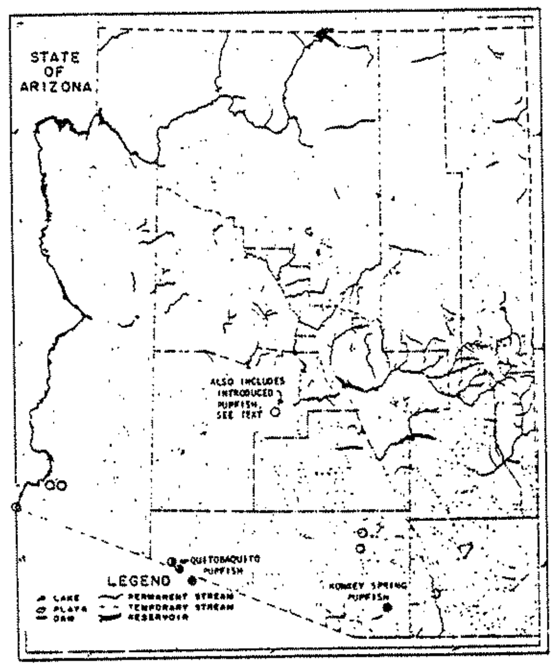
Chin barbels white or cream-yellow. Caudal fin-base without light bar. Body typically brassy- to brownish-yellow, belly lemon-yellow to milky-white. Inter-radial membranes generally lacking melanophores.

Desert pupfish, *Cyprinodon macularius* Baird and Girard[16]

(Fig. 90, Map 32)



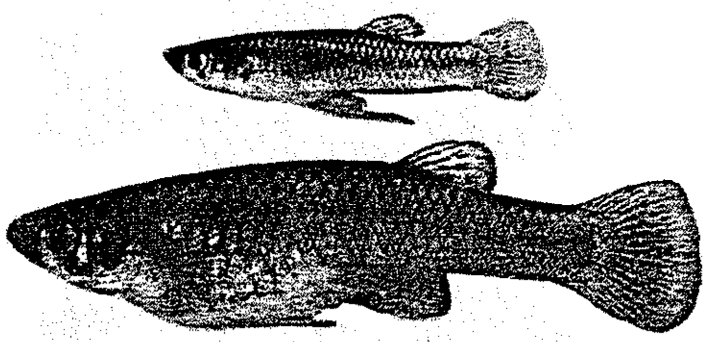
Male above, Female below.



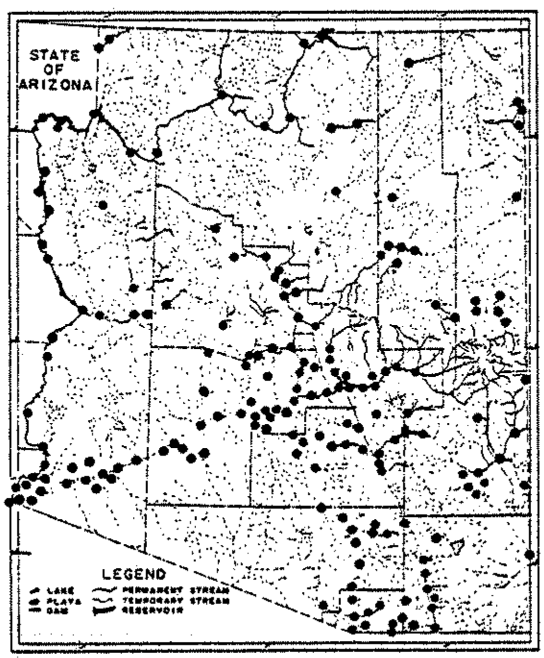
[16]All Arizona pupfishes have been considered, to date, under the name ***Cyprinodon macularius.*** A second species now is recognized, included below without a formal scientific name (as "*Cyprinodon* species"), and those references which combined the latter in a general statement of range for the desert pupfish are marked with an asterisk.

Mosquitofish, *Gambusia affinis affinis* (Baird and Girard)

(Fig. 92, Map 33)



Male above, Female below.



Gambusia affinis affinis, Hubbs and Miller, 1941: 3. Miller and Alcorn, 1946: 184. Shapovalov and Dill, 1950: 387. Wallis, 1951: 90. LaRivers, 1952: 89/ 1962: 534. LaRivers and Trelease, 1952: 119. Miller, 1952b: 12/ 1961b: 374. Follett, 1961: 227. Miller and Lowe, 1964: 147/ 1967: 147.

Gambusia affinis, Moffett
187.

Body somewhat elon
rounded. Gonopodium of male
in copulatory position. Males s
smaller; females to 50 mm

Body olivaceous or d
Scales usually outlined on do
fins typically with one to
sub-orbital bar ("tear-drop"

This species was fir
1967); it was introduced
(Rees, 1934). It has sin
water habitats in the s
succeeds in almost any con
through turbid, hot, st
voracious appetite for la
enjoyed by the species
destroy mosquito populat
duced into waters of vi
oceanic islands.

Predatory activities of
insects. Its own young a
after being born, and
In some instances mos
population sizes of much
mouth bass, through fe
cated in the disappeara
native fishes in the south
1961b; Myers, 1965; Min
livebearer discussed ne
where *G. affinis* has r
& Clark (1931) reported
appeared "to be drivin
than 10 years after its

Growth of female mo
males cease to grow w
its final, mature form (
to the female, and she may
repeated broods of young.
is about 24 days, brood
a single female may pr
1948).

lis (Baird and Girard)

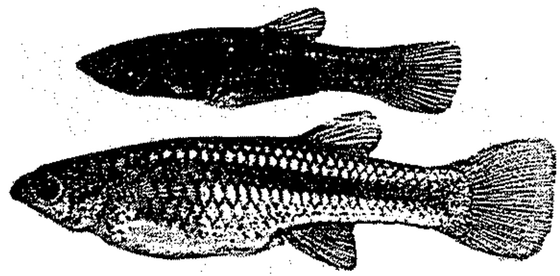
ubspecies, in Arizona, and
key will serve to identify

orbit. Mouth sub-superior, almost
iding from opercle to caudal
River basin. *Poeciliopsis occi-*
topminnow.
of orbit. Mouth superior. Lateral
pelvic fin-bases, diffuse.
Yaqui basin. *Poeciliopsis*
nnow.

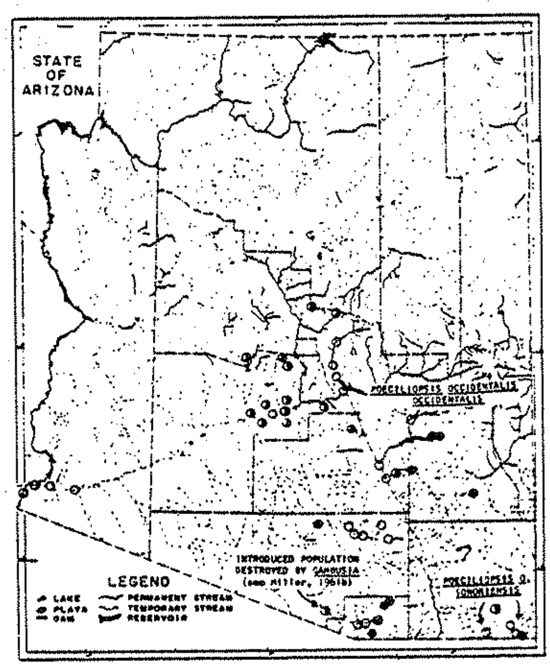
Gila topminnow,

Poeciliopsis occidentalis occidentalis (Baird and Girard)[17]

(Fig. 93, Map 34)



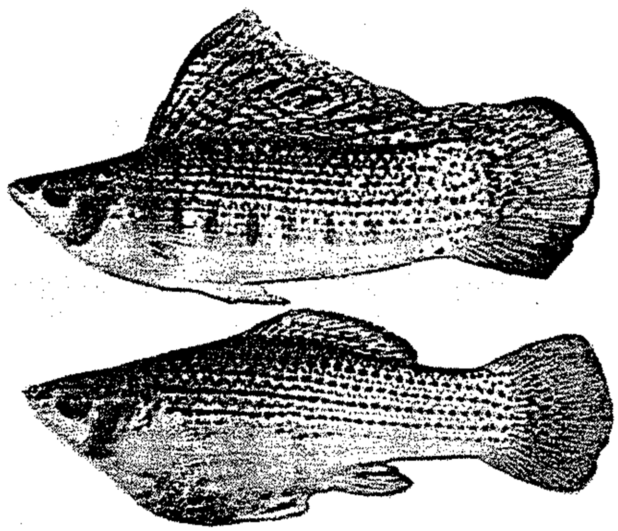
Male above, Female below.



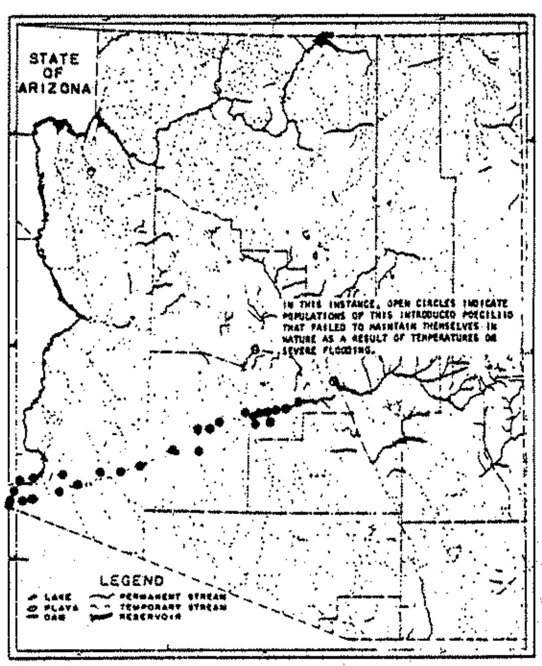
[17]References which include *P. o. occidentalis* plus *P. o. sonoriensis* are marked with an asterisk. Many data on the biology of these fishes in Arizona were provided by Allen Schoenherr, Department of Zoology, Arizona State University, who has been studying their ecology with special emphasis on the interactions of native live-bearers with the introduced mosquitofish, *Gambusia affinis.*

Sailfin molly, *Poecilia latipinna* (LeSueur)

(Fig. 97, Map 35)



Male above, Female below.



Mollienesia latipinna,

Poecilia latipinna, M

Female body short origin to snout. Female fins body short, deep, laterally c serrate. Male dorsal fin caudal fin greatly expand

Basic coloration olivac dorso-lateral scale bases an with rows of dark spots, vertically-elongated spots margin blackened, especi oped in caudal and someti

According to loca Salt and Verde rivers, where they were int aquarium fish for sale in and now occur through ponds, and in the lowe viduals were taken in 1 in Miller & Lowe, 1967), All the specimens I coloration, as in the ill Nevada (Deacon, *et al.*, expected in Arizona.

Tremendous popu enriched wastewater pi of a five-meter seine may many thousands of ind than those usually sold females of 120 mm, to at home in salty waters, s Bend, and it seems to b

Mollies are princip sometimes feeding on lea entirely filled with organ They often travel in lar and ponds, seemingly a most common in cut-off pits, where few other s before receptive femal and posing stiffly to Young are produced in s greatly distended and p brood. Young grow ra autumn if born early in

sa vhere I was familiar with the
in streams that drained limestone
and were small and spring-fed,
u ner and periods of drought

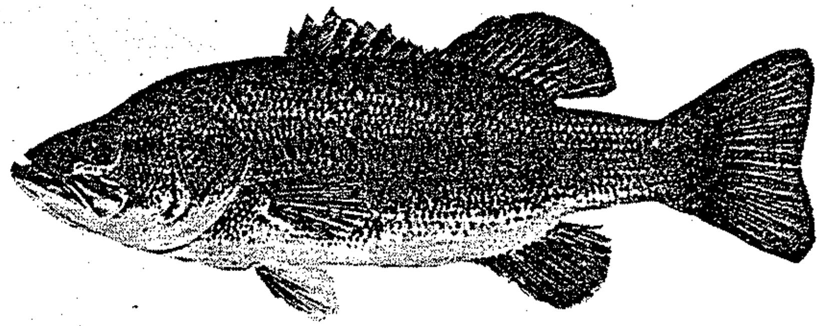
civorous later in life than other
i foods with increases in size,
c terrestrial insects to crayfish,
& Page, 1969). They tend to seek
n the smallmouth, and sometimes
d 932). Spawning behavior is
ha in 4 or 5 days, and the fry
he nest but does not apparently
they move to an independent

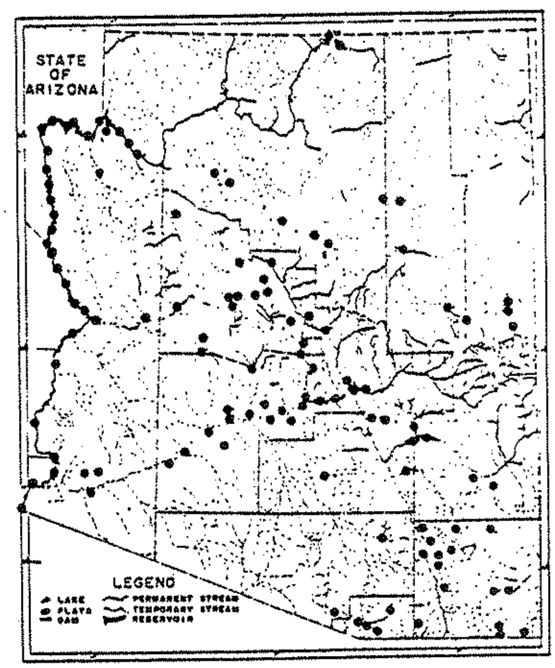
sh for, and collected, spotted
y rarely attain more than a kilo-
pc nt on light tackle.

en named (Hubbs & Bailey,
material to identify those from
to be the northern form, *M. p.*
t provenance of the original
re is in California (McKechnie,

Largemouth bass, *Micropterus salmoides* (Lacépède)

(Fig. 105, Map 37)





Lowe, 1964: 148/ 1967: 148. Lanse, 1965:
nd Johnson, 1968: 13. Minckley, 1971: 188.

latively shallow and chunky. Spines in dorsal
ver than 45 scales. Best distinguished from
h on tongue and general body configuration.

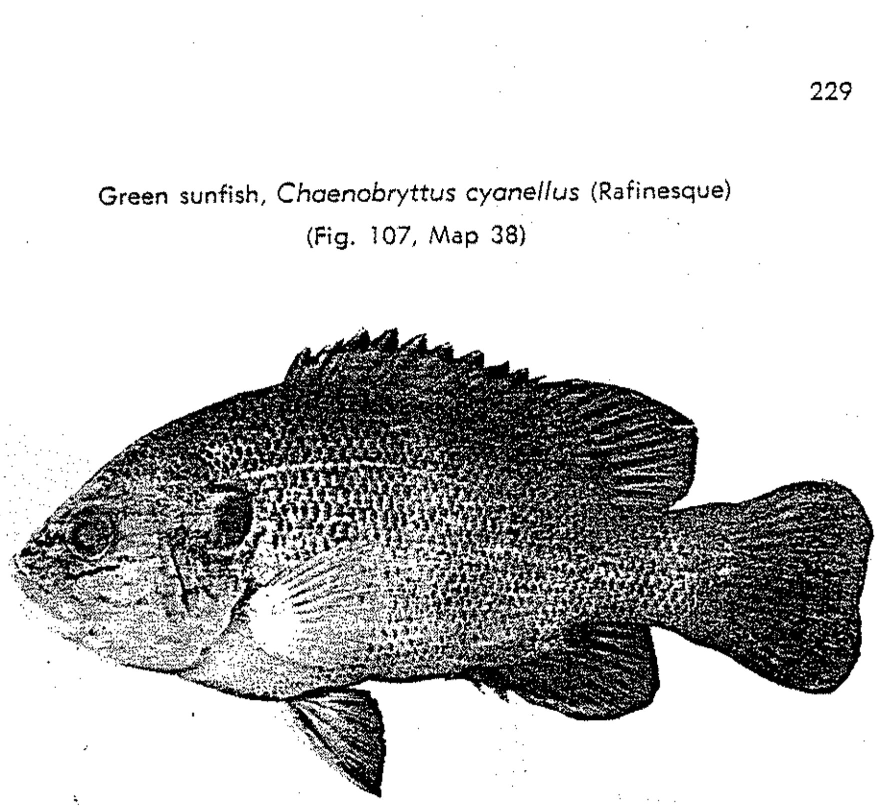
yellowish to brown and/or olive-green on
with lighter. Back and sides with chain-like,
netimes obscure in fish from warm, turbid
diating streaks. Soft dorsal, caudal, and anal
ppearing multi-oscellated.

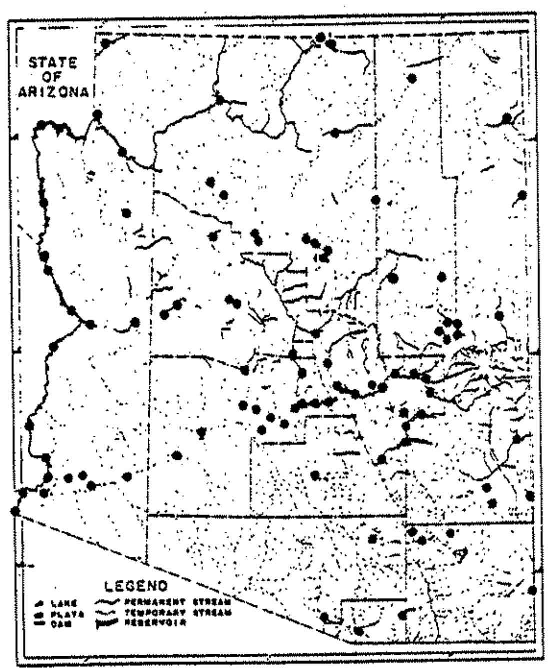
as a species of *Lepomis* by Bailey, *et al.*
nnot agree (see Branson & Moore, 1962,

Arizona from the lower Colorado River
ng the mainstream, in backwaters, and
pache, Canyon, and Saguaro lakes of the
ne natural distribution of this pugnacious,
hough somewhat more southern, to the
cies presumably gained access to Arizona
als being mixed with a stock of other,
ss or bluegill. The species is predaceous
smaller fishes. Breeding occurs in May
nilar to those constructed by other cen-
n the bottom, and the eggs and young
(1957) provided a detailed, authoritative
species in Illinois; little is known of its
st.

Green sunfish, *Chaenobryttus cyanellus* (Rafinesque)

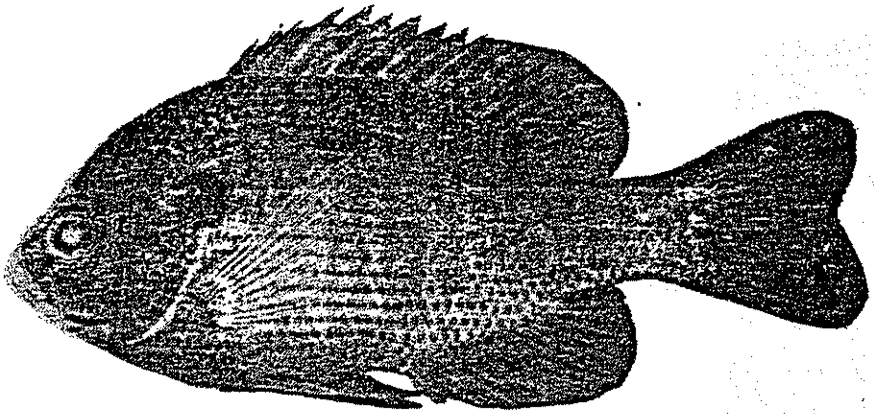
(Fig. 107, Map 38)

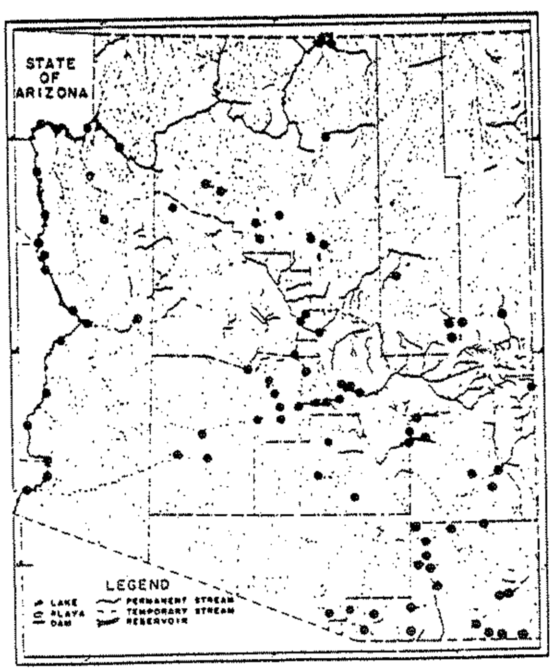




Bluegill, *Lepomis macrochirus* Rafinesque

(Fig. 108, Map 39)





Lepomis macrochirus purpurescens,

Lepomis macrochirus macrochirus,
1952: 120. Miller, 1952b: 37. Mulch

Lepomis macrochirus speciosus, Shap

Lepomis macrochirus, Moffett, 1943.
Miller, 1952b: 7/ 1961b: 374. Belanc
1960: 171. Miller and Hubbs, 1960:
1964: 149/ 1967: 149. Beers and Mc
and Deacon, 1967: 229. Minckley and
1968: 13. Minckley, 1969a: 5/ 1971:

Body deep and laterally compresse
posteriad to anterior margin of eye.
fimbriate posteriad. Pectoral fins long
high as, and broadly confluent with, sc

Coloration light-yellow to dark-oli
and belly whitish to orange, the latter
chain-like, double bars of darker pig
outlined posteriad with lighter pigme
dorsal fin with a dark, sometimes-osce
Interradial membranes variably darkene
streaks.

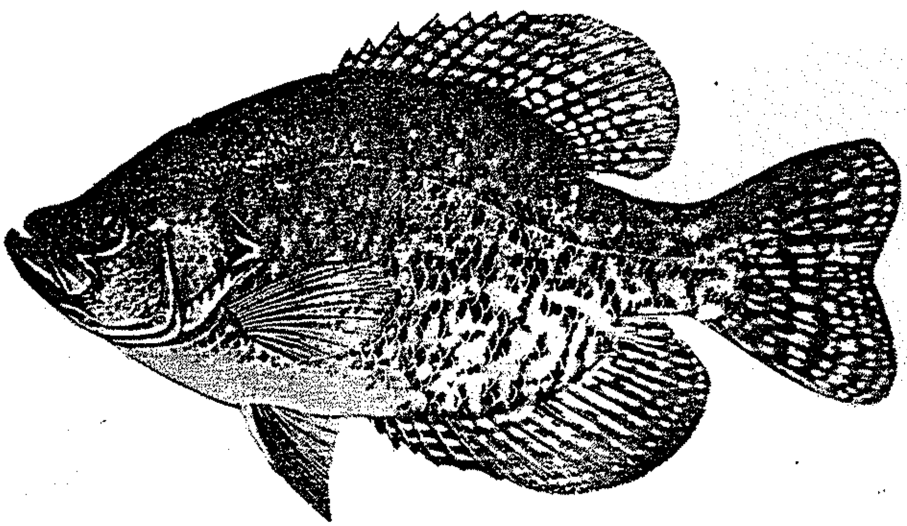
As with the largemouth bass,
be added to supplement publishe
biology (Emig, 1966b). In Arizona,
in any waters below 2,500 meters,
commonly in reservoirs and ponds
impoundments, and many smaller,
populations of tiny, yet reproducin
mouth bass, originally stocked wi
Lowe, 1967).

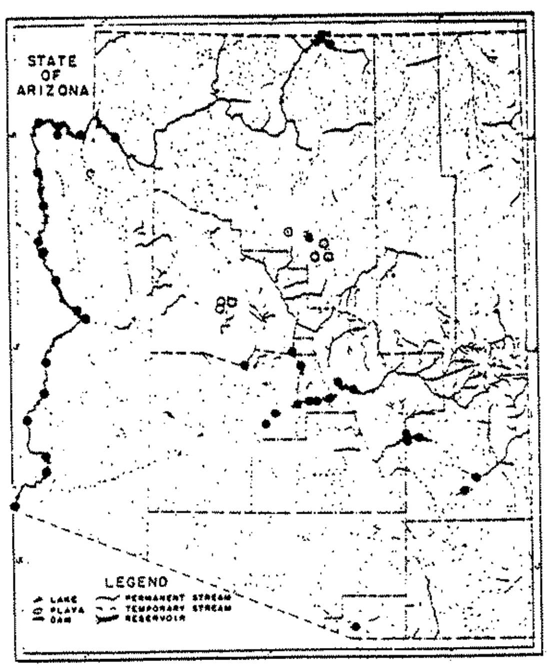
The bluegill has reproductive
They generally mature in their sec
at least at lower elevations, but m
more northern habitats. They usua
and often there are two peaks of ac
a month later (Bennett, 1962). Typ
20° C, or higher. Males select site
gravels, mud, or organic debris.
often than not in groups, or associa
As many as 500 nests per "colony"
areas in Alabama (Swingle & Sm
the eggs hatch in 1.5 to 3 days,
for several days after hatching (Tr
most prolific, small sunfish species,
and 49,000 eggs per year (Emig,

As indicated by their genera
heavily on smaller invertebrates.

Black crappie, *Pomoxis nigromaculatus* (LeSueur)

(Fig. 113, Map 40)





Pomoxis nigro-maculatus, Dill, 19… Mulch and Gamble, 1954: 16.

Pomoxis nigromaculatus, LaRiv… Follett, 1961: 228. Miller and Low…, 1966: 71. Goodson, 1966b: 312. … Deacon, 1968: 1426. Minckley and … Minckley, 1971: 187.

Body deep and compressed, … per unit length. Head shorter, lowe… length typically about same as distan… considerably greater than distanc… extended, often with abrupt an… rounded. Dorsal spines usually 7…

Ground color silvery, greenish-… cially on head and predorsal regio… oriented bars, more-or-less rando… often present, but not conspicuous… adults considerably darkened, approa… fins with blotches generally scattere… fins typically transparent, but pelv…

Black crappie are one of … zona impoundments, typically oc… warm-water fisheries. As noted … in their apparent habitat prefe… cooler, less vegetated, and mo…

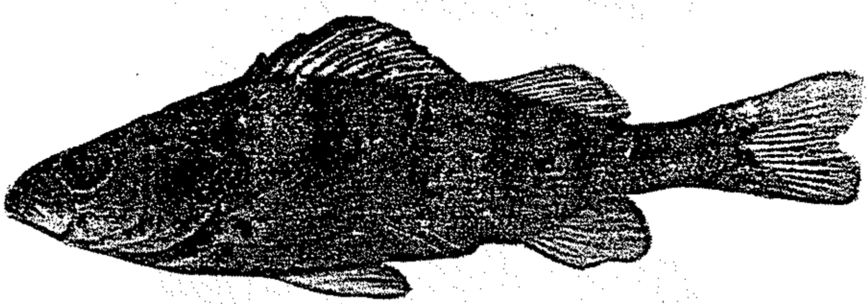
Spawning by black crappie … than that of the white, typica… depression is excavated, a few … in diameter, and the eggs are … nest and young for a time (Bre… crappie, this species generally …

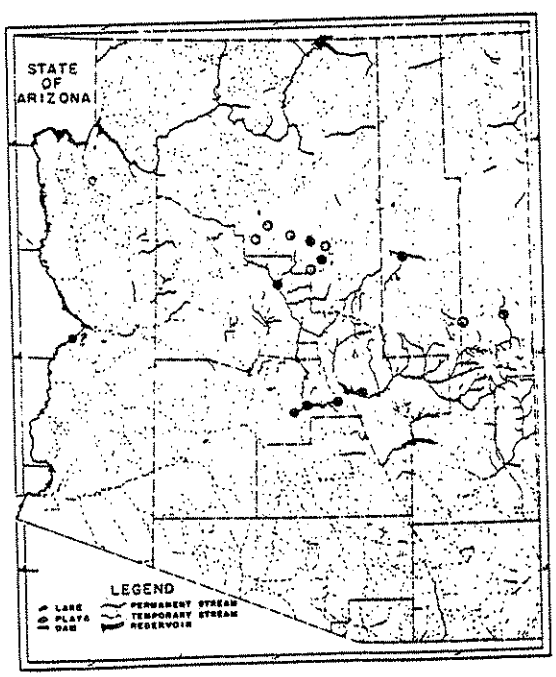
Much literature indicates … piscivorous, and that they feed m… ous larval and adult insects. In … a length of about 100 mm, the… fin shad. Kimsey, *et al.* (1957… surge in growth rates of this fish, indicating that at least in the ea… reservoirs were suffering fro… breeding male black crappie — … are almost invariably engorged … shad (Jon Ercole, Arizona Game … Presumably they remain near th… ately available to them, since bl… grounds at the same time remaine…

Black crappie (and white … and tend to travel in schools. … highly vulnerable when one loca…

Yellow perch, *Perca flavescens* (Mitchill)

(Fig. 116, Map 41)





Perca flavescens, (?) Dill, 1944.
150/ 1967: 150. Minckley, 1971:

Body laterally compressed, rela
Jaws lacking cardiform teeth, but
nating at, or near, base of hypura
without supplementary canals above
separated, but not markedly so. Pe
of base of one pelvic fin.

No conspicuous black spot on
yellowish ground-color, lighter be
bars. Dorsal, caudal, anal, and pecto
but without conspicuous speckling o

Yellow perch have been kn
(Miller & Lowe, 1967), when larg
elevation lakes of the central p
sporadic in occurrence, usually
stream Colorado River and its
population and stunting under
in Arizona to make it worthy
place to place certainly is to be

Within its native range, in
of the Rocky Mountains, yellow
sporting value. It sometimes rea
is especially sought by fishermen
Spawning takes place near shore
The eggs of the species are unic
like gelatinous matrix which is ac
& Hankinson, 1928), or non-adhe
(Webster, 1942; Everhart, 195
over aquatic vegetation or woo
and 3.0 cm wide. The eggs are
hatch to school immediately.

The species is planktivorous
over to larger invertebrates and

Family POM

Pomadasyids are carnivoro
America lives permanently in
of one Florida species (Tagatz,
making them desirable as food,
serving as forage for larger fish
compressed, and quite colorful in
fornia, where it was introduced
planted from there into a borrow
in the mid-1960s, from which it

by 8 or 9 prominent, dark, vertical bars.
r below, with lighter lips. Ground color
ale-gray on belly. Fins darkened, with a
dark, with an over-all, bluish sheen and

ict cichlids was present in a flooded
on the eastern edge of Phoenix from
doubtless destroyed the population).
urred in Mesa in summer 1970, but
le specimens are not uncommon in
rea, and there seems little doubt that
established in warmer waters of the
e populations of this species live in
l in southern Nevada (Deacon, *et al.*,
elsewhere in that state (Deacon, Uni-
comm., 1972). To my knowledge, it
er Colorado River.

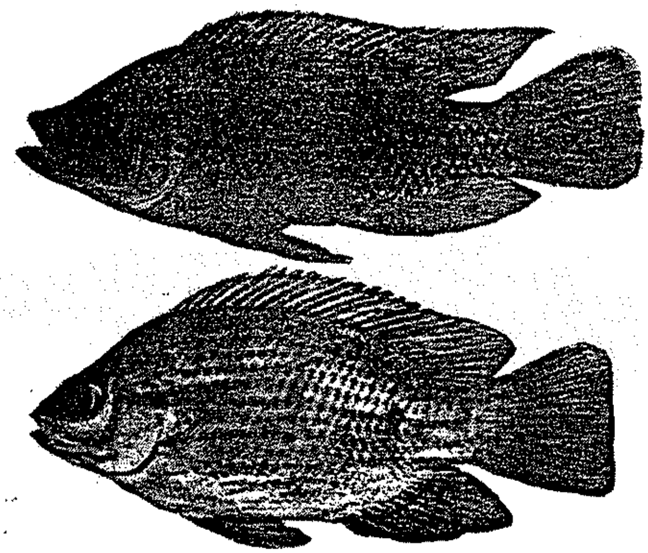
cm in length and is a highly pug-
itary fish. It reproduces prolifically
are laid on a solid object, and are
parents. The young also are aggres-
l able to fend for themselves. There
would create management problems
those now created by stunted popu-
should be vigorously opposed. The
f with an excess of convict cichlids
n them over to the Game and Fish
release them into any open waters,

l threat to sport fishing, but it also
siderable damage on native fish
roying them (Deacon, *et al.*, 1964;
vations). As is apparent, the native
dy have been decimated by many
ot add insult to injury.

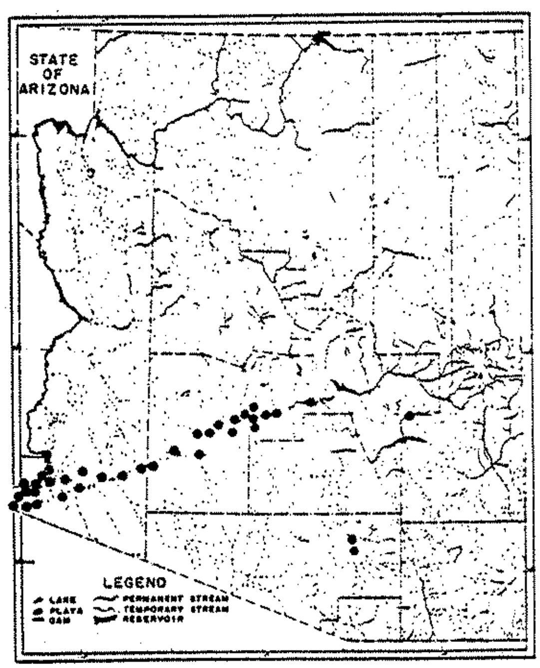
C. meeki (Brind), represented by
Arizona, and a yet-to-be-identified
viduals taken together in a canal
The last two fish resemble the Río
rd and Girard). I have seen both
sale in local aquarium shops (as
ectively). Another species of this
d cichlid, has been introduced in
is tributary to Lake Mead (Hubbs

Mozambique mouthbrooder, *Tilapia mossambica* (Peters)

(Fig. 121, Map 42)



Male above, Female below.



PAST AND PRESENT BIOTIC COMMUNITIES OF THE LOWER COLORADO RIVER MAINSTEM AND SELECTED TRIBUTARIES

VOLUME IV

Submitted by

Robert D. Ohmart

Center for Environmental Studies
Arizona State University
Tempe, Arizona 85287

In fulfillment of

Bureau of Reclamation
Contract No. 7-07-30-V0009
Modification No. 2

1979

GENERAL INTRODUCTION

To fulfill the obligations set forth by the Bureau of Reclamation under modification No. 2 of Contract No. 7-07-30-V0009, my staff and I in the Department of Zoology at Arizona State University undertook the effort of procuring information relating to the riparian vegetation and wildlife of the following rivers in Arizona: the Agua Fria, Bill Williams, lower Colorado (from Lees Ferry to the Mexican boundary), Gila, Kanab Creek, Little Colorado, Paria, Salt, San Pedro, Santa Cruz, Verde, and Virgin. Literature, both published and unpublished, was researched. These data are presented for each river under the following headings: historic (prior to 1931), change (1931 to 1970), and baseline (1970 to 1978). In addition, information on endangered species, impacts of future projects, species lists, and bibliographies are also presented.

The information included in this report is intended to help individuals concerned with river development and natural resource management to understand more fully how future developments may affect the existing wildlife and vegetation of the riparian communities along these rivers. General information is given which might be helpful in outlining future projects that would avoid adverse effects on riparian communities. Although this report is intended to provide assistance in primary planning for future river development, it is not, however, intended as a substitute for environmental analyses based on field studies of specific sites. Research required for such analyses should be more detailed than was possible under the time and monetary constraints of this data amalgamation effort.

METHODS

Historic (prior to 1931)

An extensive literature search was made to find historical descriptions of the vegetation and wildlife of the riparian communities of the following rivers in Arizona: Agua Fria, Bill Williams, lower Colorado (from Lees Ferry south to the Mexican boundary), Gila, Kanab Creek, Little Colorado, Paria, Salt, San Pedro, Santa Cruz, Verde and Virgin. These early descriptions of the flora and fauna are presented in narrative form for each of the river systems discussed in this voluminous report.

Change (1931 to 1970)

Major changes that have taken place in the riparian vegetation and wildlife of the river systems of Arizona as a result of construction of dams, lowered water tables, introduction of exotic species of plants (such as the salt

SPECIES LISTS

Separate species lists of plants, mammals, birds, reptiles and amphibians have been compiled for each river system presented in this report. Information was obtained through a literature search of various southwestern archives and government agencies.

These lists are intended as supplements to the historic and change narrative of each river system. Unfortunately, there was little information for various river systems in some categories (mostly on reptiles and amphibians).

Although the literature was thoroughly reviewed in compiling these lists, they should not however be considered complete lists of flora and fauna, as species were not always recorded in presently available literature.

THREATENED AND ENDANGERED SPECIES

Plants

A survey was made of the literature available on threatened and endangered plants of the following river systems in Arizona: Bill Williams, lower Colorado (from Lees Ferry to Lake Mead), lower Colorado (from Davis Dam to the Mexican boundary), Gila Kanab Creek, Little Colorado, Paria, Salt, San Pedro, Santa Cruz, Verde, and Virgin rivers. Localities where endangered plants were found were obtained from the Bureau of Land Management. Dr. Donald J. Pinkava, professor of botany, and Elinor Lehto, curator of the herbarium at Arizona State University, were consulted on distribution and taxonomy of threatened and endangered plants of Arizona.

Because of the lack of data on threatened and endangered plants in Arizona these lists are not complete. There were 18 species of threatened and endangered plants found on certain river systems. On some of the river systems no threatened or endangered plants were found. This does not mean there are none, just that field work on that particular river has been minimal.

Under each river system in this report there is a table which indicates plant species; group, whether threatened (T) or endangered (E); habitat preference and riparian contact taken from literature or field data; and the source of information.

Included in this report is the federal threatened and endangered list of plants of Arizona.

and Alton E. Higgins, who did a large part of the aerial surveys of the rivers. They were assisted at times by John R. Sanders and Kenneth V. Rosenberg.

The section on relative abundance, seasonal occurrence, and habitat of the birds found in the riparian areas along the rivers is the work of Scott B. Terrill. Much of his data comes from his personal field notes and from a search of the literature.

The section on endangered species was written by Robert L. McKernan. His information is based on literature research and publications of federal agencies and the Arizona Game and Fish Department.

In addition to the persons named above, the following individuals have researched literature on the various rivers and have contributed preliminary writeups on the rivers to which they were assigned: Sue Ann Davis, Jane R. Durham, Lauren M. Porzer, Diedrich Prigge IV, Kenneth V. Rosenberg, George P. Sheppard, and Duna L. Strachen.

Luanne Cali did the early part of the typing and word processor work. Cynthia Turner typed the bibliographic cards and preliminary species lists.

The task of seeing the project through the final stages fell tc Jane R. Durham and Cindy D. Zisner. Cindy finished the word processor work begun by Luanne Cali and also did much of the proof reading. In fact, Cindy has contributed to the completion of this work in so many ways that it is impossible in this limited space to list all of the things she has done. Without her and Jane R. Durham's able assistance this project could never have been completed in the time frame that it was.

I want to thank all of the above for their unselfish help in putting this report together and especially to Jane R. Durham and Cindy D. Zisner.

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THE VERDE RIVER

THE AGUA FRIA RIVER

THE BILL WILLIAMS RIVER

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THE SALT RIVER

INTRODUCTION

The Salt River, or Rio Salado as it was called in the early 1800's, begins in eastern Arizona where the Black and White rivers converge (elevation 4,200 feet). The river ends south of Phoenix where it joins the Gila River (elevation 1,100 feet). The Salt River drains a watershed of about 13,000 square miles, including the Verde River drainage (6,600 square miles). The Verde River is the Salt's main tributary. Ponderosa pine (*Pinus ponderosa*) is common on the higher tributaries. The Salt River itself flows through steep-wall canyons until it reaches Roosevelt Lake; the river is then impounded by a continuous chain of four, man-made lakes 60 miles in length. The lower Salt River reaches the broad floodplain of the Salt River Valley below Granite Reef Dam. The predominant vegetation of this floodplain is Lower Sonoran Desert species. Today the river seldom flows in the Salt River Valley.

Discharge at Roosevelt Dam averages 649,670 acre-feet per year and discharge at the Bartlett Dam on the Verde River averages 351,366 acre-feet per year or a combined discharge at Granite Reef Dam of 960,050 acre-feet per year. However, little of this water ever reaches the Gila River. Most of the water flows into a canal system administered by the Salt River Project. This water is used to support extensive agricultural areas in the Salt River Valley and supply water to the growing metropolitan Phoenix area.

HISTORIC

The first Anglo-American irrigation in the Salt River Valley began in 1868 (Shadegg 1969). The Salt and Tonto basins were also reported to be cultivated prior to the building of Roosevelt Dam in 1903 (Davis 1897). Early irrigation utilized earthen and brush diversion dams. The irrigation was dependent on the river flow, and subsequently agricultural areas were reduced in the Salt River Valley during the droughts of 1897, 1898, and 1899 (Shadegg 1969).

The river was also subject to extensive flooding. River waters measured 8 miles wide near present day 24th Street in Phoenix during the 1891 flood. These waters destroyed the diversion dams in the river bottom and huge, uprooted cottonwood trees (*Populus fremontii*) were reported "tumbling end over end" near Hayden's Ferry (present-day Tempe; White 1971).

In 1893, cottonwood, willow (*Salix* spp.), and honey mesquite (*Prosopis glandulosa*) trees were common in the Salt River Valley and furnished many nest sites for birds (Dodge 1894). Breninger (1898) also reported cottonwoods along the Salt

Literature Cited
Salt River
Historic

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The fifth impoundment of the Salt River is Granite Reef Dam. Completed in 1908, this dam serves to divert water from the river into Salt River Proect irrigation canals (Anonymous 1964). The dam is small and there has been minimal inundation of riparian lands.

Change Due to Attempts at Increasing Water Salvage

To effect an increase in water yield, man has attempted to remove native plants and this increase run-off. Some riparian vegetation (phreatophytes) was cleared near the confluence of the Salt and Gila rivers by the use of herbicides (Bowser 1967) during the 1950's and 1960's. The primary target was salt cedar (*Tamarix chinensis*).

In addition to phreatophyte control, attempts at water salvage have included some major clearing efforts on the watersheds of the Salt River. Herbicides were applied to 4,000 acres of chaparral prior to 1967 (Warskow 1967). The type of herbicide used on the chaparral was not specified. Herbicides used on the lower Salt River near the confluence with the Gila included the compounds 2,4,D and 2,4,5-T (Bowser 1967). These herbicides were carried into the river by the run-off. Herbicides are known to decrease community stability and diversity (Odum 1971); however, their exact effect on riparian communities has not been investigated. Further, the compound 2,4,5-T contains the compound dioxin, which has a harmful effect on man and wildlife even at low concentrations. Unfortunately, studies were not undertaken to assess the effects of herbicides in the communities below the application area, nor was there monitoring of the levels of herbicides and their by-products downstream on the Gila River.

Change on the Salt River Due to Irrigation

The first Anglo-American irrigation began in 1868 with the construction of the Swilling Ditch (Shadegg 1969). Many additional canals were constructed in the following three decades (Table 1). In 1889 there were 35,212 acres under irrigation and cultivation in Maricopa County (Davis 1897), see Table 1. It was estimated that 120,000 acres were under permanent irrigation by 1900 (Means 1900). In 1958 the land irrigated by the Salt River and associated groundwater pumping totaled 229,822 acres; the water was supplied in 176 miles of irrigation canals and 1,132 miles of laterals operated by the Salt River Project (U.S. Bureau of Reclamation 1961). As more lands were brought under cultivation, more water was withdrawn from the river.

Davis (1897) reported that by 1890 twice the flow of the Salt River was bound by water rights. However, most of the canal systems were fed by rock and brush diversion dams, which washed out with the floods. Subsequently, much of the water was used for agricultural development. The only permanent dam on the river at that time was 1 mile below the Verde/Salt confluence (Davis 1897). Although plenty of water was usually available for irrigation in the spring of the 1880's, the drought of 1897-1899 caused a reducted in the land that could be cultivated (Shadegg 1969). Today all canal systems are fed by Granite Reef Dam.

The high demand for water has left little water available to the riparian vegetation. This has probably been a contributing factor to the demise of riparian vegetation along the river through the Salt River Valley.

Another effect of the irrigation systems was the spread of phreatophytes, principally cottonwood trees, along the banks of the canals. Breninger (1898) reported the spread of the Ferruginous Owl up to 10 miles away from the river in this new habitat. It is probable that many other wildlife species spread with the habitat. Today many of these trees have been removed.

Change in River Flow

The Salt River Valley was subject to frequent flooding prior to the building of the four reservoirs on the Salt River and the two reservoirs on the Verde River. In 18yl water stood 8 miles wide in the floodplain near present day 24th Street in Phoenix (White 1971). Water routinely ran down the Salt through the Salt River Valley (Shadegg 1969). Today this river actually flows in the Salt River Valley infrequently and only after very substantial rainfall.

The change in river flow has decreased the water available to natural vegetation on the floodplain. This decrease in water has probably contributed to the loss of riparian vegetation in the Salt River Valley. Further, regeneration of some species such as cottonwoods is dependent on periodic flooding (Ohmart et al. 1977).

Changes on the Salt River Due to Other Factors

Considerable phreatophyte removal along the Salt River has been caused indirectly by extensive ground water pumping. Ground water in the Salt River Valley was once readily pumped from shallow wells (Arizona Improvement Co., 1897), but overpumping has now lowered the water table to over 400 feet deep in some parts of the Valley (Anonymous 1971). Due to the pumping, the Valley has sunk and subsequently cracks have developed along the desert floor. These cracks have led to extensive erosion in some areas. Dropping the water table has reduced or terminated the water available to such phreatophytes as mesquite, willow, and cottonwood trees. The large expanses of this vegetation that were found in the floodplains of the Salt River below Granite Reef Dam, only a

One of the important factors concerning wildlife species on the river is phreatophyte control. The Arizona Game and Fish Department views with concern any long-term modifications of the habitat (Spillman 1967). Any change in vegetative cover will inevitably have an effect on wildlife species living there. Such changes may be beneficial to some species and detrimental to others (Spillman 1967).

BASELINE VEGETATION RESULTS

Seven vegetation associations were identified on the Salt River, totaling 6,027.9 acres. Fifty-three percent of the vegetation was composed of honey mesquite community, of which 79 percent was structure Type IV. Twenty-two percent (1,353.6 acres) of the vegetation was salt cedar (types II through V); an additional 16.1 percent was cottonwood-willow including 476.8 acres of Type II. The remaining 8.5 percent included 307.4 acres of salt cedar/honey mesqiute Type IV (5.1 percent of the total) and 65.5 acres of arrowweed (Tessaria sericea). A few stands of sycamores (Platanus wrightii) and a single stand of sycamores and cottonwoods, ranging from 13 to less tha 30 acres each, were observed on the upper part of the Salt River, see Table 2.

Amphibian, Reptiles, Mammals

The only sustained extensive efforts to determine the occurrence and status of nongame invertebrates (excluding fish) on the Salt River were the contract studies conducted by members of the Department of Zoology at Arizona State University (and the Arizona Game and Fish Department) to assess the impact of the proposed Orme Dam and reservoir on the riparian environment and adjacent desert habitat. Since these data were collected from both the Salt and Verde rivers, above and below the confluence, the information is equally valid when addressing the ecological attributes of a single river (in this case the Salt River) when the discussion is limited to that part of the river affected by Orme Dam.

For reference to the relative abundances of amphibians, reptiles, and rodents see the Verde River section, Tables 3-5.

Table 3. Relative densities of lizards in various habitats occurring within the Buttes Dam site. Information is based on lizard counts, exact density data from the Orme Dam site, and field observations on lizards. See Table 4 for scientific names.

	Habitat type					
Lizard species	Desert scrub	Mesquite	Riverbed	Cottonwood-willow	Diverse wash	Rocky hillside
Banded gecko	6/acre*	1/acre	0	1/acre	medium	high
Desert iguana	medium**	absent	absent	absent	absent	absent
Chuckwalla	absent	absent	absent	absent	absent	medium
Greater earless lizard	medium	absent	absent	absent	medium	abundant
Zebra-tailed lizard	2/acre	13/acre	low	8/acre	8-13/acre	absent
Leopard lizard	1/acre	low	absent	absent	low	low
Desert spiny lizard	4/acre	10/acre	absent	10/acre	4/acre	low
Clark spiny lizard	absent	medium	absent	medium	low	medium
Side-blotched lizard	9/acre	3/acre	low	low	medium	high
Tree lizard	absent	50-150/a	low	75/acre	restricted	medium
Regal horned lizard	2/acre	absent	absent	2/acre	low	absent or low
Western whiptail	5/acre	12/acre	low	13/acre	medium	medium
Gila monster	low	absent or low	absent	absent	low	low

*Based on densities from Orme Dam Impact Study and field observations at the Buttes site.

**Relative abundance estimates based on field studies at the Buttes Dam site.

Table 4. (Continued)

Lizard species	Habitat Type: Desert scrub	Mesquite	Riverbed	Cottonwood-willow	Salt cedar-arrowweed
Greater Earless Lizard (*Cophosaurus texanus*)	2***	0	0	0	0
Zebra-tailed Lizard (*Callisaurus draconoides*)	2	13	0	8	2

* All numbers represent number of lizards per acre, and refer to only resident adults. Following breeding seasons, density is higher due to flooding of the habitat with juveniles.

** This density data is based on home range size of this species, the data of which was obtained from Tanner and Krogh (1965).

*** These species are very localized in their distributions in the Orme Dam site and hence these data are not representative for the entire dam site. For further information, see Table 1.

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Change and Baseline

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AVIAN ABUNDANCE TABLES

The southwestern United States offers a wide variety of habitats. In this area, elevational and precipitation patterns can vary widely on a relatively local scale. In general, there are associated with these different habitats a wide variety of vertebrate species.

Arizona is famous for its rich diversity of birds and other animal life. Within the state are such broad habitat types as montane forests, Sonoran and Chihuahuan deserts, grasslands, subtropical canyon forests, and riparian woodlands. Of these habitats, the riparian woodlands support the highest diversities and densities of birds yet measured in the United States.

In addition to high diversities and densities of species in general, several riparian areas offer the enthusiast the opportunity to observe species found nowhere else in the United States. These riparian areas, obviously very important to avifauna, are rapidly disappearing from the southwestern United States. As these areas continue to dwindle, so will the obligate riparian bird species associated with them.

Currently many habitats can be found along the major rivers and their drainages in Arizona. This report summarizes information on bird species which occur along the major rivers in Arizona. This includes species found in all of the habitats along the river. In examining this report, one should keep in mind that emphasis is placed on bird species associated with the riparian areas. This is essentially due to the fact that the riparian systems are river obligates themselves whereas the majority of the other habitats are not so closely linked with rivers.

The general purpose of the annotated bird species lists is to present, in concise tabular form, current information on relative abundance, seasonal occurrence and habitat-type utilization by birds recorded along the major rivers, primarily in Arizona, that comprise the drainages of the Colorado River. These rivers include the San Pedro, the Gila, the Santa Cruz, the Salt, the Verde, and the Little Colorado.

The following tables are summaries of observations of bird species on and adjacent to these rivers. River systems support a wide variety of habitats and are relatively important to birds in the arid Southwest. The lists, therefore, are lengthy, often including several hundred species for any given river.

Each bird species is categorized with respect to its known relative abundance, seasonal occurrence, and habitat

RELATIVE ABUNDANCE

Little actual quantitative biological work exists for the rivers in this study. For this reason only general categories of relative abundance are given.

Field notes of experienced observers often include the numbers of individual birds counted or estimated for each species observed in an area. Although little consistent or repetitive field work exists for these areas, common and abundant species are easily identified, even with sparse information.

Observations of less common species are listed in American Birds, a forum of informational exchange on rare, or uncommonly occurring species. Birds of Arizona (Phillips et al. 1964) provides relative abundance designations for all the species accounted for up to the date of publication.

By integrating these sources of information it is possible to arrive at a reliable estimate of relative abundance for most species recorded along the six river systems being considered here.

KEY TO SYMBOLS: RELATIVE ABUNDANCE

The following subjective categories are defined as follows:

ab Abundant. Refers to a species which is observed to make up a large percentage of the individuals in the area defined. Often present in relatively large numbers.

c Common. The species is well represented and consistently observed but not necessarily in large numbers. The numbers of observed individuals are generally not considered to comprise a large percentage of the total number of individual birds in an area.

e Erratic visitor into area. May be present in numbers one year and absent for the next several years. Examples include boreal species such as the Evening Grosbeak which sporadically invade lower elevational regions. This category also includes species that wander occasionally into a given area but in no known regular pattern of occurrence. An example is the Pine Siskin in the Salt River valley.

fc Fairly common. Small numbers observed in a given area, but species consistently present.

uc Uncommon. Seldom seen, or numbers quite small, but not considered to be out of known normal range.

SEASONAL OCCURRENCE

To further facilitate the understanding of bird species occurrences along the main tributaries of the Colorado River, the species can be categorized with respect to seasonal occurrences of those species along each river.

In determining impacts it is important to know not only how abundant a species is but also when it occurs at a given abundance as well. It is valuabme to assess whether a species breeds in an area, winters in an area, or merely passes through an area.

Again, personal field notes and the literature referred to were used in assigning a seasonal occurrence to the species on each list. Although birds are highly mobile organisms, there are consistent, predictable patterns to the movements of the majority of species.

Seasonal occurrence may be viewed as the mean of a series of observations. For example, records of a spring migrant may spill over into the early summer season (June) in small numbers or on an infrequent basis. Thus for the purpose of this report, such a species would be treated as a spring transient and not a summer visitor.

KEY TO SYMBOLS: SEASONAL OCCURRENCE

R Resident. Species present year-round. Does not necessarily refer to the same individuals.

Sp Spring occurrence (March through May).

TSp Found only as a transient during period of late January through late June. Refers to species moving through the area (generally in a southerly to northerly direction), but which do not breed or winter in the area.

S Summer occurrence (June and July).

F Fall occurrence (August through November).

TF Transient only. Found between early July and late December.

W Present from December through February.

T Transient during both spring and fall; found as a migrant only.

B Breeds in area.

HABITAT

Habitat designations may be interpreted in much the same manner as seasonal occurrence designations. In a sense, these categories of habitat type represent the mean of observations for a given species. For example, if a species is most often observed in a riparian situation, but occasional foraging forays take it into adjacent desert habitat, this species would receive the habitat designation for riparian and not for desert.

Some species are specialized in the sense that they limit themselves to one or two habitat types. Other species are more generally dispersed through a range of habitat types.

There are 15 broadly defined categories used for habitat classifications. These categories are briefly outlined in the key to the symbols section.

KEY TO SYMBOLS: HABITAT

R Riparian belt. Primarily phreatophytes directly associated with river bottoms and adjacent floodplains. Typical examples include cottonwood-willow associations, salt cedar, mesquite, salt cedar-mesquite mixes, etc.

D Desert. Palo verde-saguaro associations, creosote flats, Great Basin scrub (Little Colorado), salt bush flats, etc.

F Grasslands. Extensive grass cover.

S Rivers, streams, and immediate shorelines.

W Open water. Ponds, sewage ponds, lakes, etc., and their shorelines.

A Agriculture.

M Marsh.

H Residential. Buildings, yards, etc.

C Cliffs, steep rocky hillsides, etc.

B Brushy areas. Washes, scrubby mesquite, hedgerows, etc.

CF Coniferous forest.

P Pinyon-juniper type woodlands.

L Oak (live) woodlands.

SPECIES INCLUDED IN TABLES

For each river, the species list includes all those species listed in the field notes and literature for that river. The species of primary concern are those which breed in riparian habitat as well as those species which are relatively rare or are local breeders in the floodplains.

The habitats along the rivers are also important to many species which are winter visitors. Many passerines, both insectivores and granivores utilize these river areas, both as winter visitors and as transients.

In the arid Southwest, the importance of river systems and wetland habitats to water-associated species is obvious. Of primary concern here are species which use these areas extensively or regularly, as do several species of rails, herons, etc.

Species that are restricted to floodplain habitats are most likely to suffer negative impacts. Occasional migrants are less important to the assessment process. Nevertheless, in general, the greater the species richness of an area (taking into account the size of the area involved), the more valuable the habitat is for birds.

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Louisiana Heron	r	T	S,M,W	Quite rare in Arizona
Black-crowned Night Heron (B)	fc	FWSp	R,S,M,W	Breeding quite locally
Least Bittern (B)	r (l)uc	W SpS	M	Restricted to a few areas having extensive stands of <u>Typha</u> sp.
American Bittern	r	W	M	
Wood Stork	(e)r	(PB)S	S,M,W	Erratic postbreeding wanderer from the Gulf of California in summer and early fall
White-faced Ibis	c	T W	S,A,M,W	
Roseate Spoonbill	(e)r	(PB) SpS	S,M	
Whistling Swan	r	T	W	
Canada Goose	fc	FWSp	S,A,M,W	Maximum recorded was 1,500 wintering on Roosevelt Lake winter of 1955-1956
White-fronted Goose	r	FWSp	S,W	Rare, most records from 35th Avenue sewage ponds area, where this species has wintered
Snow Goose	uc	FWSp	S,A,W	
Black-bellied Whistling-Duck	(e)r	SpS	S,M	
Fulvous Whistling-Duck	r	SF	W	Most recent record--35th Avenue sewage ponds in 1976
Mallard	fc-c	FWSp	S,M,W	
Mexican Duck	x			<u>Birds of Arizona</u>
Gadwall	r c	S FWSp	S,M,W	
Pintail	uc c	S FWSp	S,M,W	
Green-winged Teal	c	FWSp	S,M,W	
Blue-winged Teal	fc uc	T W	S,M,W W	
Cinnamon Teal (B)	uc c	WS T	S,M,W	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Cooper Hawk (B)	fc c	S FWSp	R O,G	Breeds in riparian
Red-tailed Hawk (B)	c	R	O,G	
Swainson Hawk	c	T	O,A	
Zone-tailed Hawk	uc	T	O,R,D,C	
White-tailed Hawk	r	W	O,A	No recent records
Rough-legged Hawk	uc fc	WSp F		Appears to be most numerous in late fall
Ferruginous Hawk	fc	FWSp	O,A	
Harris Hawk (B)	c	R	R,D,B	
Black Hawk (B)	(l)r r	S T		Dependent on permanent water and riparian habitat
Golden Eagle (B)	fc	R	O,G	Utilizes cliff sites for breeding
Bald Eagle (B)	(l)r fc	S W	 R,W,S	Breeding highly localized
Marsh Hawk	c	FWSp	O,A,M	
Osprey (B)	(l)r fc	S T	 O,S,W	Has bred, but does not do so regularly
Caracara	r	R (formerly)	O	One recent record (1977)
Praire Falcon (B)	fc	R	O,G	Utilizes cliff sites for breeding
Peregrine Falcon	r	TW	O,G	
Merlin	uc	FWSp	O,G	
American Kestrel (B)	c	R	G	
Gambel Quail (B)	ab	R	D,B,R	
Ring-necked Pheasant (B)	?	R		Introductions do not appear to be successful in the Phoenix area
Clapper Rail (B)	(l)	SpS	M	Very local in small numbers
Virginia Rail	 fc-c(l)	S FWSp	 M	Possibly breeding near southwest Phoenix
Sora	fc c	S FWSp	 M	Breeding needs confirmation

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Short-billed Dowitcher	r	FWSp	S,M	
Long-billed Dowitcher	uc fc c	S W T	 S,M	
Stilt, Sandpiper	uc	FT	S,M	Most records are from sewage treatment plants in southwest Phoenix, where there are more records for this species than any other location in Arizona
Semipalmated Sandpiper	r	TF	S	(Specimen and photographs; Terrill 1980)
Western Sandpiper	uc c	W T	 S,M,A	
Marbled Godwit	uc	T	S	
Ruff	x	WSp	S	The single record for Arizona involved a wintering bird at the 35th Avenue ponds in 1975-1976
Sanderling	r	T	S	
American Avocet (B)	uc c	SW T	S,M	
Black-necked Stilt (B)	c-ab	R	S,M	Numbers decrease in winter
Red Phalarope	r	TF	W	
Wilson Phalarope	c ab	SP SF	 S,M,W	
Northern Phalarope	fc-ab	T	W	Abundant in fall only when sewage pond at 35th Avenue is full
Jaeger	x	FT	W	A photographed (University of Arizona) individual was initially identified as a Parasitic Jaeger, it is now believed to be a Long-tailed Jaeger
Western Gull	x		F	Dead individual picked up 8 November 1963 (appeared on 6 November 1963)
Herring Gull	r	FT	W	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Elf Owl (B)	fc	SpSF	D	
Burrowing Owl (B)	c uc-fc	SpSF W	F,A	Greatest concentrations appear in the vicinity of 35th to 27th Avenue and the Salt River (35th Avenue sewage ponds)
Long-eared Owl	uc	FWSp	O,R,A,B	
Short-eared Owl	fc	FWSp	F,A,M	
Poor-will (B)	uc fc	W SpSF	O D,A,C	Winter status and distribution poorly understood
Common Nighthawk	x	Oct. 1978	A	Near 51st and the Salt River
Lesser Nighthawk (B)	ab r	SpSF W	O,G	
Vaux Swift	uc	T	O,G	
White-throated Swift (B)	fc	R	O,G	
Black-chinned Hummingbird (B)	c	SpSF	R,D,H,B	
Costa Hummingbird (B)	fc	Sp	D	
Anna Hummingbird (B)	c	R	R,H	
Calliope Hummingbird	r	T	B	
Broad-tailed hummingbird	uc	T	R,D,B	
Rufous Hummingbird	r fc	TSp TF	R,H	
Broad-billed Hummingbird	uc	(PB) FW	R,D	
Belted Kingfisher	fc	FWSp	S,M,W	
Common Flicker (B)	c	R	G	Numbers increased by influx of "Red-shafted" Flickers in fall, winter, and spring; "Yellow-shafted" Flickers are rare in fall and winter
Gila Woodpecker (B)	c	R	R,D,H	
Acorn Woodpecker	(e)r	W	R,H	
Lewis Woodpecker	(e)	W	A,R,H	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Western Flycatcher	r c	W T	R R,D,A,M H,B	Transient birds are occasionally recorded in early June and late July, but they are certainly transients of spring and fall periods, respectively
Coues' Flycatcher	r	FW	R,B	
Western Wood Pewee (B)	c-ab	T	R,D,A,H,B	Breeding occurs only on the upper Salt
Olive-sided Flycatcher	uc	T	T,D	
Vermilion Flycatcher (B)	fc	R	R,S,A,M,B	Most common in Salt River Valley near confluence with Verde River
Horned Lark (B)	fc ab	S FWSp	D,F,A	
Violet-green Swallow	r c-ab	W T	O,G	
Tree Swallow	fc c-ab	W T	O,G	
Bank Swallow	fc c	TSp TF	O,M,W O,M,W	
Rough-winged Swallow (B)	fc c ab	W S TSp	O,G O,G O,G	
Barn Swallow	c ab	TSp TF	O,G O,G	
Cliff Swallow (B)	c	SpSF	O,G	Utilizes manmade structures for nesting such as buildings, bridges, etc.
Purple Martin (B)	(l)fc	SpSF	O	Very local colonies on upper Salt River
Steller Jay	(e)	W	R	
Scrub Jay	(e)	FWSp	R,A,H,P	Occurs more regularly than Steller Jays
Common Raven (P)	c	R	O,G	
Common Crow	(e)uc	FWSp	R,A	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
American Robin	(e)fc-ab	FWSp	R,H,B	
Rufous-backed Robin	r	WSp	R,B	
Varied Thrush	r	W	R	
Hermit Thrush	fc-c	T		
	fc	W	R,G,B	
Swainson Thrush	uc	T	R	
Western Bluebird	(e)fc-c	FWSp	R,A,B	
Mountain Bluebird	(e)uc-c	FWSp	A,F	Erratic from year to year
Townsend Solitaire	(e)uc	FW	R	
Blue-gray Gnatcatcher	fc	FWSp	R,B	
Black-tailed Gnatcatcher (B)	fc	R	R,D,B	
Golden-crowned Kinglet	(e)uc-fc	FW	R	
Ruby-crowned Kinglet	c	FWSp	R,H,B	
Water Pipit	ab	FWSp	F,A,M,S	
Cedar Waxwing	uc	W		
	fc	T	R,H,B	
Phainopepla (B)	c	W		
	ab	Sp		
	fc	SF	R,D	
Northern Shrike	x	W (1 Jan. 1974)	A	Near the river bottom near 35th Avenue and the Salt (Terrill)
Loggerhead Shrike (B)	c	R	D,F,A,M,H,B	
Hutton Vireo	uc	FWSp	R	
Bell Vireo (B)	x	W		
	c	SpSF (early)	R,B	
Gray Vireo	r	T	R	
Solitary Vireo	c	T	R,H,B	
	uc	W	R	
Red-eyed Vireo	r	SF (early)	R	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Ovenbird	r	TW	R	
Northern Waterthrush	r	TW	R,S,M	
Kentucky Warbler	x	TF (1977)	R	115th Avenue and the Salt River fall record for Arizona (<u>American Birds</u> 1978)
Common Yellowthroat (B)	(l)c c-ab	S FWSp	M R,M,A,B	
Yellow-breasted Chat (B)	c fc	S T (late spring, early fall)	R R,B	
Wilson Warbler	r ab	W T	R,B G	
American Redstart	r uc	S (July) FTW	 R,H,B	
Painted Redstart	uc	T	R	
House Sparrow (B)	ab	R	H,A,F	
Eastern Meadowlark	fc	FWSp	F,A	
Western Meadowlark (B)	c ab	S FWSp	 D,F,A	
Yellow-headed Blackbird	ab	FWSp	F,A,M,H,B	
Red-winged Blackbird (B)	ab	R	R,F,S,A,M,H,B	
Orchard Oriole	r	FW	R	
Hooded Oriole (B)	c	SpSF	R,D,H,B	Most closely associated with cottonwood-willow for breeding in this area
Scott Oriole	uc	T	D	
Northern Oriole (B)	c	SpSF	R,H,B	The nominate rare <u>I. g. galbula</u> is a rare transient, <u>I. g. bullockii</u> breeds in cottonwood-willow
Rusty Blackbird	r	W	S	
Brewer Blackbird	ab	FWSp	C	

Species	Relative abundance	Seasonal occurrence	Habitat	Comments
Rufous-sided Towhee	fc	FWSp	R,H,B	
Brown Towhee (B)	uc	R	C,B	Erratic to most of the Salt River, most regular along rocky hillsides of the upper Salt River
Abert Towhee (B)	c-ab	R	R,D,A,H,B	
Lark Bunting	(e)fc-ab	FWSp	F,A,B	
Savannah Sparrow	c-ab	FWSp	F,A,M	
Vesper Sparrow	c	FWSp	F,A,B	
Lark Sparrow	fc c-ab	S (July) FWSp	R F,A,H,B	
Rufous-crowned Sparrow (B)	u	R	C,B	
Black-throated Sparrow (B)	c	R	D	
Sage Sparrow	fc	FWSp	D,A,B	
Dark-eyed Junco	fc	FWSp	R,F,A,H,B	
Gray-headed Junco	uc-fc fc	W T	R,F,A,H,B	
Chipping Sparrow	c c-ab	W T	G	
Clay-colored Sparrow	r	T	B	
Brewer Sparrow	ab	FWSp	R,D,F,A, H,B	
Black-chinned Sparrow	r	T	B	
Harris Sparrow	uc	WSp	R,B	
White-crowned Sparrow	ab	FWSp	G	
Golden-crowned Sparrow	r	WSp	R,B	
White-throated Sparrow	uc	FWSp	R,H,B	
Fox Sparrow	uc	WT	R,B	
Lincoln Sparrow	ab	FWSp	R,M,B	
Swamp Sparrow	uc	FWSp	M	

PLANTS - SALT RIVER

Species	Prior to 1931	1931 on
EPHEDRAĆEAE		
Long-leaved joint-fir (_Ephedra_ _trifurca_)		USDI 1976
TYPHACEAE		
Cat-tail (_Typha_ _domingensis_)		USDI 1976
POTAMOGETONACEAE		
Leafy pondweed (_Potamogeton_ _foliosus_)		USDI 1976
GRAMINAE		
Rescue grass (_Bromus_ _catharticus_)		USDI 1976
Red brome (_Bromus_ _rubens_)		USDI 1976
Fescue (_Festuca_ _octoflora_)		USDI 1976
Bigelow grass (_Poa_ _bigelovii_)		USDI 1976
Annual bluegrass (_Poa_ _annua_)		USDI 1976
Stink grass (_Eragrostis_ _cilianensis_)		USDI 1976
Lovegrass (_Eragrostis_ _diffusa_)		USDI 1976
Saltgrass (_Distichlis_ _spicata_ var. _stricta_) (_D._ _stricta_)		USDI 1976
Giant reed (_Arundo_ _donax_)		USDI 1976

Species	Prior to 1931	1931 on
Red sprangletop (*Leptochloa filiformis*)		USDI 1976
Mexican sprangletop (*Leptochloa uninervia*)		USDI 1976
Bermuda grass (*Cynodon dactylon*)		USDI 1976
Hairy grama (*Bouteloua hirsuta*)		USDI 1976
Blue grama (*Bouteloua gracilis*)		USDI 1976
Needle grama (*Bouteloua aristidoides*)		USDI 1976
Slender grama (*Bouteloua filiformis*)		USDI 1976
Side-oats grama (*Bouteloua curtipendula*)		USDI 1976
Littleseed canary grass (*Phalaris minor*)		USDI 1976
Canary grass (*Phalaris caroliniana*)		USDI 1976
Arizona cottontop (*Trichachne californica*)		USDI 1976
Crab grass (*Digitaria sanguinalis*)		USDI 1976
Knotgrass (*Paspalum distichum*)		USDI 1976
Dallis grass (*Paspalum dilatatum*)		USDI 1976
SALICACEAE		
Fremont cottonwood (*Populus fremontii*)		Stamp and Ohmart 1975 USDI 1976 Vitt et al. 1976
Populus sp.	Dodge 1894	
Goodding willow (*Salix gooddingii*)		Stamp and Ohmart 1975 USDI 1976

Species	Prior to 1931	1931 on
TAMARICACEAE		
Salt cedar (*Tamarix chinensis*)		Stamp and Ohmart 1975
CACTACEAE		
Saguaro (*Cereus giganteus*)		Vitt et al. 1976
Opuntia sp.		Stamp and Ohmart 1975 Vitt et al. 1976
SOLANACEAE		
Desert thorn (*Lycium* sp.)		Stamp and Ohmart 1975
COMPOSITAE		
Annual bristleweed (*Machaeranthera gracilis*) (*Haplopappus gracilis*)		Stamp and Ohmart 1975
Broom baccharis (*Baccharis sarathroides*)		Stamp and Ohmart 1975 Vitt et al. 1976
Arrowweed (*Tessaria sericea*) (*Pluchea sericea*)		Stamp and Ohmart 1975 Vitt et al. 1976
Burro bush (*Hymenoclea monogyra*)		Stamp and Ohmart 1975
White bur sage (*Ambrosia dumosa*) (*Franseria dumosa*)		Vitt et al. 1976
Burro bush (*Ambrosia deltoidea*) (*Franseria deltoidea*)		Stamp and Ohmart 1975
Brittle bush (*Encelia farinosa*)		Vitt et al. 1976

BIRDS - SALT RIVER

Species	Prior to 1931	1931 on
PODICIPEDIDAE		
Eared Grebe (<u>Podiceps nigricollis</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Pied-billed Grebe (<u>Podilymbus podiceps</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
PELECANIDAE		
White Pelican (<u>Pelecanus erythrorhynchos</u>)	Phillips et al. 1964 (1930)	
SULIDAE		
Blue-footed Booby (<u>Sula nebouxii</u>)		Phillips et al. 1964 (1953)
PHALACROCORACIDAE		
Double-crested Cormorant (<u>Phalacrocorax auritus</u>)		Phillips et al. 1964
ARDEIDAE		
Great Blue Heron (<u>Ardea herodias</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Green Heron (<u>Butorides striatus</u>)		Stamp and Ohmart 1975 Rea 1977
Little Blue Heron (<u>Florida caerulea</u>)		Phillips et al. 1964 (1958)
Common Egret (<u>Casmerodius albus</u>)		Stamp and Ohmart 1975
Snowy Egret (<u>Egretta thula</u>)		Stamp and Ohmart 1975
Louisiana Heron (<u>Hydranassa tricolor</u>)		Phillips et al. 1964 (1932)
Black-crowned Night Heron (<u>Nycticorax nycticorax</u>)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977

Species	Prior to 1931	1931 on
Least Bittern (_Ixobrychus exilis_)		Stamp and Ohmart 1975 Rea 1977
THRESKIORNITHIDAE		
White-faced Ibis (_Plegadis chihi_)		Stamp and Ohmart 1975
ANATIDAE		
Canada Goose (_Branta canadensis_)		Phillips et al. 1964 Stamp and Ohmart 1975
Snow Goose (_Chen hyperborea_)		Phillips et al. 1964
Black-bellied Whistling-Duck (_Dendrocygna autumnalis_)		Phillips et al. 1964
Mallard (_Anas platyrhynchos_)		Phillips et al. 1964 Stamp and Ohmart 1975
Gadwall (_Anas strepera_)		Phillips et al. 1964 Stamp and Ohmart 1975
Pintail (_Anas acuta_)		Stamp and Ohmart 1975
Green-winged Teal (_Anas crecca carolinensis_)		Stamp and Ohmart 1975
Blue-winged Teal (_Anas discors_)		Stamp and Ohmart 1975 Rea 1977
Cinnamon Teal (_Anas cyanoptera_)		Stamp and Ohmart 1975 Rea 1977
American Wigeon (_Anas americana_)		Stamp and Ohmart 1975
Northern Shoveler (_Anas clypeata_)		Phillips et al. 1964 Stamp and Ohmart 1975
Redhead (_Aythya americana_)		Stamp and Ohmart 1975
Ring-necked Duck (_Aythya collaris_)		Phillips et al. 1964 Stamp and Ohmart 1975
Canvasback (_Aythya valisineria_)		Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Greater Scaup (*Aythya marila*)		Stamp and Ohmart 1975
Lesser Scaup (*Aythya affinis*)		Stamp and Ohmart 1975
Bufflehead (*Bucephala albeola*)		Phillips et al. 1964 (1943)
Ruddy Duck (*Oxyura jamaicensis*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Common Merganser (*Mergus merganser*)		Phillips et al. 1964 Stamp and Ohmart 1975
Red-breasted Merganser (*Mergus serrator*)	Phillips et al. 1964 (1917)	Stamp and Ohmart 1975
CATHARTIDAE		
Turkey Vulture (*Cathartes aura*)		Phillips et al. 1964 Stamp and Ohmart 1975
ACCIPITRIDAE		
Mississippi Kite (*Ictinia mississippiensis*)		Stamp and Ohmart 1975
Goshawk (*Accipiter gentilis*)		Stamp and Ohmart 1975
Sharp-shinned Hawk (*Accipiter striatus*)		Stamp and Ohmart 1975
Cooper Hawk (*Accipiter cooperii*)		Stamp and Ohmart 1975
Red-tailed Hawk (*Buteo jamaicensis*)		Phillips et al. 1964 Stamp and Ohmart 1975
Broad-winged Hawk (*Buteo platypterus*)		Stamp and Ohmart 1975
Swainson Hawk (*Buteo swainsoni*)		Stamp and Ohmart 1975
Zone-tailed Hawk (*Buteo albonotatus*)		Stamp and Ohmart 1975
Rough-legged Hawk (*Buteo lagopus*)		Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Ferruginous Hawk (*Buteo regalis*)		Phillips et al. 1964 Stamp and Ohmart 1975
Gray Hawk (*Buteo nitidus*)		Stamp and Ohmart 1975
Harris Hawk (*Parabuteo unicinctus*)		Stamp and Ohmart 1975
Black Hawk (*Buteogallus anthracinus*)		Stamp and Ohmart 1975
Bald Eagle (*Haliaeetus leucocephalus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Marsh Hawk (*Circus cyaneus*)		Stamp and Ohmart 1975
PANDIONIDAE		
Osprey (*Pandion haliaetus*)	Phillips et al. 1964 (1917)	Phillips et al. 1964 Stamp and Ohmart 1975
FALCONIDAE		
Caracara (*Caracara cheriway*)		Phillips et al. 1964
Prairie Falcon (*Falco mexicanus*)		Stamp and Ohmart 1975
Peregrine Falcon (*Falco peregrinus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Merlin (*Falco columbarius*)		Phillips et al. 1964 Stamp and Ohmart 1975
American Kestrel (*Falco sparverius*)		Stamp and Ohmart 1975
PHASIANIDAE		
Gambel Quail (*Lophortyx gambelii*)	Breninger 1889	USAE 1959 Stamp and Ohmart 1975 Rea 1977
RALLIDAE		
Clapper Rail (*Rallus longirostris*)		Stamp and Ohmart 1975 Rea 1977

Species	Prior to 1931	1931 on
Virginia Rail (*Rallus limicola*)		Phillips et al. 1964 Stamp and Ohmart 1975
Sora (*Porzana carolina*)		Phillips et al. 1964 Stamp and Ohmart 1975
Common Gallinule (*Gallinula chloropus*)		Phillips et al. 1964 (1933) Stamp and Ohmart 1975 Rea 1977
American Coot (*Fulica americana*)		Stamp and Ohmart 1975 Rea 1977
CHARADRIIDAE		
Killdeer (*Charadrius vociferus*)		Stamp and Ohmart 1975 Rea 1977
SCOLOPACIDAE		
Common Snipe (*Capella gallinago*)		Stamp and Ohmart 1975 Rea 1977
Long-billed Curlew (*Numenius americanus*)		Phillips et al. 1964
Spotted Sandpiper (*Actitis macularia*)		Stamp and Ohmart 1975 Rea 1977
Greater Yellowlegs (*Tringa melanoleuca*)		Stamp and Ohmart 1975
Least Sandpiper (*Calidris minutilla*)		Stamp and Ohmart 1975 Rea 1977
Western Sandpiper (*Calidris mauri*)		Stamp and Ohmart 1975 Rea 1977
Stilt Sandpiper (*Micropalama himantopus*)		Phillips et al. 1964
RECURVIROSTRIDAE		
American Avocet (*Recurvirostra americana*)		Rea 1977
Black-necked Stilt (*Himantopus mexicanus mexicanus*)		Stamp and Ohmart 1975 Rea 1977
LARIDAE		
Ring-billed Gull (*Larus delawarensis*)		Phillips et al. 1964 Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Bonaparte Gull (*Larus philadelphia*)		Phillips et al. 1964
Forster Tern (*Sterna forsteri*)		Phillips et al. 1964
COLUMBIDAE		
Band-tailed Pigeon (*Columba fasciata*)		Stamp and Ohmart 1975
White-winged Dove (*Zenaida asiatica*)	Dodge 1894	USAE 1959 Phillips et al. 1964 Spillman 1967 Stamp and Ohmart 1975 Rea 1977
Mourning Dove (*Zenaida macroura*)	Dodge 1894	USAE 1959 Phillips et al. 1964 Spillman 1967 Rea 1977
Ground Dove (*Columbina passerina*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Inca Dove (*Scardafella inca*)	Phillips et al. 1964 (1885) Dodge 1894	Stamp and Ohmart 1975
CUCULIDAE		
Yellow-billed Cuckoo (*Coccyzus americanus*)		Stamp and Ohmart 1975 Rea 1977
Roadrunner (*Geococcyx californianus*)		Stamp and Ohmart 1975 Rea 1977
TYTONIDAE		
Barn Owl (*Tyto alba*)		Stamp and Ohmart 1975
STRIGIDAE		
Screech Owl (*Otus asio*)		Stamp and Ohmart 1975
Great Horned Owl (*Bubo virginianus*)		Stamp and Ohmart 1975 Rea 1977
Elf Owl (*Micrathene whitneyi*)		Phillips et al. 1964 Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Burrowing Owl (*Athene cunicularia*)		Phillips et al. 1964
Short-eared Owl (*Asio flammeus*)		Stamp and Ohmart 1975
Saw-whet Owl (*Aegolius acadicus*)		Phillips et al. 1964
CAPRIMULGIDAE		
Whip-poor-will (*Caprimulgus vociferus*)		Phillips et al. 1964 (1952)
Lesser Nighthawk (*Chordeiles acutipennis*)	Phillips et al. 1964 (1897)	Stamp and Ohmart 1975 Rea 1977
APODIDAE		
White-throated Swift (*Aeronautes saxatalis*)		Phillips et al. 1964 Stamp and Ohmart 1975
TROCHILIDAE		
Black-chinned Hummingbird (*Archilochus alexandri*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Costa Hummingbird (*Calypte costae*)		Phillips et al. 1964 Stamp and Ohmart 1975
Anna Hummingbird (*Calypte anna*)		Phillips et al. 1964 Stamp and Ohmart 1975
Broad-tailed Hummingbird (*Selasphorus platycercus*)		Stamp and Ohmart 1975
Calliope Hummingbird (*Stellula calliope*)		Phillips et al. 1964
ALCEDINIDAE		
Belted Kingfisher (*Megaceryle alcyon*)		Phillips et al. 1964 Stamp and Ohmart 1975
PIGIDAE		
Common Flicker (*Colaptes auratus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Gila Woodpecker (*Melanerpes uropygialis*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977

Species	Prior to 1931	1931 on
Acorn Woodpecker (*Melanerpes formicivorus*)		Phillips et al. 1964
Lewis Woodpecker (*Melanerpes lewis*)		Phillips et al. 1964
Yellow-bellied Sapsucker (*Sphyrapicus varius*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Williamson Sapsucker (*Sphyrapicus thyroideus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Hairy Woodpecker (*Picoides villosus*)		Phillips et al. 1964
Ladder-backed Woodpecker (*Picoides scalaris*)		Phillips et al. 1964 Stamp and Ohmart 1975
TYRANNIDAE		
Cassin Kingbird (*Tyrannus vociferans*)		Phillips et al. 1964 Stamp and Ohmart 1975
Western Kingbird (*Tyrannus verticalis*)		Phillips et al. 1964 Stamp and Ohmart 1975
Tropical Kingbird (*Tyrannus melancholicus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Scissor-tailed Flycatcher (*Muscivora forficata*)		Phillips et al. 1964 (1935, 1958)
Wied Crested Flycatcher (*Myiarchus tyrannulus*)		Phillips et al. 1964 Stamp and Ohmart 1975
Ash-throated Flycatcher (*Myiarchus cineracens*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Eastern Phoebe (*Sayornis phoebe*)		Phillips et al. 1964
Black Phoebe (*Sayornis nigricans*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Say Phoebe (*Sayornis saya*)		Phillips et al. 1964 Stamp and Ohmart 1975
Gray Flycatcher (*Empidonax wrightii*)		Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Dusky Flycatcher (*Empidonax oberholseri*)		Phillips et al. 1964 Stamp and Ohmart 1975
Hammond Flycatcher (*Empidonax hammondii*)		Phillips et al. 1964 Stamp and Ohmart 1975
Western Flycatcher (*Empidonax difficilis*)		Phillips et al. 1964 Stamp and Ohmart 1975
Willow Flycatcher (*Empidonax traillii*)		Stamp and Ohmart 1975
Coues Flycatcher (*Contopus pertinax*)		Phillips et al. 1964
Western Wood Pewee (*Contopus sordidulus*)		Stamp and Ohmart 1975
Olive-sided Flycatcher (*Nuttallornis borealis*)		Stamp and Ohmart 1975
Vermilion Flycatcher (*Pyrocephalus rubinus*)	Dodge 1894	Phillips et al. 1964 Stamp and Ohmart 1975
Beardless Flycatcher (*Camptostoma imberbe*)		Stamp and Ohmart 1975
ALAUDIDAE		
Horned Lark (*Eremophila alpestris*)		Phillips et al. 1964 Stamp and Ohmart 1975
HIRUNDINIDAE		
Violet-green Swallow (*Tachycineta thalassina*)		Phillips et al. 1964 Stamp and Ohmart 1975
Tree Swallow (*Iridoprocne bicolor*)		Phillips et al. 1964 Stamp and Ohmart 1975
Bank Swallow (*Riparia riparia*)		Stamp and Ohmart 1975
Rough-winged Swallow (*Stelgidopteryx ruficollis*)		Phillips et al. 1964 Stamp and Ohmart 1975
Barn Swallow (*Hirundo rustica*)		Stamp and Ohmart 1975
Cliff Swallow (*Petrochelidon pyrrhonota*)		Phillips et al. 1964 Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Purple Martin (<u>Progne</u> <u>subis</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
CORVIDAE		
Steller Jay (<u>Cyanocitta</u> <u>stelleri</u>)		Phillips et al. 1964
Scrub Jay (<u>Aphelocoma</u> <u>coerulescens</u>)		Phillips et al. 1964
Common Raven (<u>Corvus</u> <u>corax</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Common Crow (<u>Corvus</u> <u>brachyrhynchos</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Clark Nutcracker (<u>Nucifraga</u> <u>columbiana</u>)		Phillips et al. 1964 (1935, 1936)
PARIDAE		
Mountain Chickadee (<u>Parus</u> <u>gambeli</u>)		Phillips et al. 1964
Bridled Titmouse (<u>Parus</u> <u>wollweberi</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Verdin (<u>Auriparus</u> <u>flaviceps</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Bushtit (<u>Psaltriparus</u> <u>minimus</u>)		Phillips et al. 1964
SITTIDAE		
White-breasted Nuthatch (<u>Sitta</u> <u>carolinensis</u>)		Phillips et al. 1964
Red-breasted Nuthatch (<u>Sitta</u> <u>canadensis</u>)		Phillips et al. 1964
CERTHIIDAE		
Brown Creeper (<u>Certhia</u> <u>familiaris</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
CINCLIDAE		
Dipper (<u>Cinclus</u> <u>mexicanus</u>)		Phillips et al. 1964

Species	Prior to 1931	1931 on
TROGLODYTIDAE		
House Wren (Troglodytes aedon)		Phillips et al. 1964 Stamp and Ohmart 1975
Bewick Wren (Thryomanes bewickii)		Phillips et al. 1964 Stamp and Ohmart 1975
Cactus Wren (Campylorhynchus brunneicapillus)		Phillips et al. 1964 Stamp and Ohmart 1975
Long-billed Marsh Wren (Cistothorus palustris)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Canyon Wren (Catherpes mexicanus)		Stamp and Ohmart 1975
Rock Wren (Salpinctes obsoletus)		Stamp and Ohmart 1975
MIMIDAE		
Mockingbird (Mimus polyglottos)		Phillips et al. 1964 Stamp and Ohmart 1975
Brown Thrasher (Toxostoma rufum)		Phillips et al. 1964
Bendire Thrasher (Toxostoma bendirei)		Phillips et al. 1964 Stamp and Ohmart 1975
Curve-billed Thrasher (Toxostoma curvirostre)		Phillips et al. 1964 Stamp and Ohmart 1975
Le Conte Thrasher (Toxostoma lecontei)		Phillips et al. 1964
Crissal Thrasher (Toxostoma dorsale)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
TURDIDAE		
American Robin (Turdus migratorius)		Stamp and Ohmart 1975
Hermit Thrush (Catharus guttatus)		Phillips et al. 1964 Stamp and Ohmart 1975
Swainson Thrush (Catharus ustulatus)		Phillips et al. 1964 Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Western Bluebird (*Sialia mexicana*)		Stamp and Ohmart 1975
Mountain Bluebird (*Sialia currucoides*)		Stamp and Ohmart 1975
SYLVIIDAE		
Blue-gray Gnatcatcher (*Polioptila caerulea*)		Phillips et al. 1964 Stamp and Ohmart 1975
Black-tailed Gnatcatcher (*Polioptila melanura*)		Phillips et al. 1964 Stamp and Ohmart 1975
Golden-crowned Kinglet (*Regulus satrapa*)		Phillips et al. 1964 Stamp and Ohmart 1975
Ruby-crowned Kinglet (*Regulus calendula*)		Phillips et al. 1964 Stamp and Ohmart 1975
MOTACILLIDAE		
Water Pipit (*Anthus spinoletta*)		Phillips et al. 1964 Stamp and Ohmart 1975
BOMBYCILLIDAE		
Cedar Waxwing (*Bombycilla cedrorum*)		Phillips et al. 1964 Stamp and Ohmart 1975
PTILOGONATIDAE		
Phainopepla (*Phainopepla nitens*)		Phillips et al. 1964 Stamp and Ohmart 1975
LANIIDAE		
Loggerhead Shrike (*Lanius ludovicianus*)	Dodge 1894	Stamp and Ohmart 1975
STURNIDAE		
Starling (*Sturnus vulgaris*)		Phillips et al. 1964 Stamp and Ohmart 1975
VIREONIDAE		
Hutton Vireo (*Vireo huttoni*)		Phillips et al. 1964 Stamp and Ohmart 1975
Bell Vireo (*Vireo bellii*)	Phillips et al. 1964 (1889)	Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977

Species	Prior to 1931	1931 on
Gray Vireo (*Vireo vicinior*)		Stamp and Ohmart 1975
Solitary Vireo (*Vireo solitarius*)		Phillips et al. 1964 Stamp and Ohmart 1975
Red-eyed Vireo (*Vireo olivaceus*)		Stamp and Ohmart 1975
Warbling Vireo (*Vireo gilvus*)		Phillips et al. 1964 Stamp and Ohmart 1975
PARULIDAE		
Black-and-white Warbler (*Mniotilta varia*)		Phillips et al. 1964 Stamp and Ohmart 1975
Orange-crowned Warbler (*Vermivora celata*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Nashville Warbler (*Vermivora ruficapilla*)		Phillips et al. 1964 Stamp and Ohmart 1975
Virginia Warbler (*Vermivora virginiae*)		Stamp and Ohmart 1975
Lucy Warbler (*Vermivora luciae*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Northern Parula (*Parula americana*)		Phillips et al. 1964 (1952) Stamp and Ohmart 1975
Yellow Warbler (*Dendroica petechia*)		Phillips et al. 1964 Stamp and Ohmart 1975
Yellow-rumped Warbler (*Dendroica coronata*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Black-throated Gray Warbler (*Dendroica nigrescens*)		Phillips et al. 1964 Stamp and Ohmart 1975
Townsend Warbler (*Dendroica townsendi*)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Hermit Warbler (*Dendroica occidentalis*)		Phillips et al. 1964 (1956) Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Northern Waterthrush (<u>Seiurus noveboracensis</u>)	Phillips et al. 1964 (1897)	Phillips et al. 1964
MacGillivray Warbler (<u>Oporornis tolmiei</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Common Yellowthroat (<u>Geothlypis trichas</u>)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Yellow-breasted Chat (<u>Icteria virens</u>)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Wilson Warbler (<u>Wilsonia pusilla</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
American Redstart (<u>Setophaga ruticilla</u>)		Stamp and Ohmart 1975
Painted Redstart (<u>Myioborus picta</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
PLOCEIDAE		
House Sparrow (<u>Passer domesticus</u>)	Phillips et al. 1964 (1913)	Phillips et al. 1964 Stamp and Ohmart 1975
ICTERIDAE		
Eastern Meadowlark (<u>Sturnella magna</u>)		Stamp and Ohmart 1975
Western Meadowlark (<u>Sturnella neglecta</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Yellow-headed Blackbird (<u>Xanthocephalus xanthocephalus</u>)		Stamp and Ohmart 1975 Rea 1977
Red-winged Blackbird (<u>Agelaius phoeniceus</u>)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977
Hooded Oriole (<u>Icterus cucullatus</u>)		Phillips et al. 1964 Stamp and Ohmart 1975
Scott Oriole (<u>Icterus parisorum</u>)		Phillips et al. 1964
Northern Oriole (<u>Icterus galbula</u>)		Phillips et al. 1964 Stamp and Ohmart 1975 Rea 1977

Species	Prior to 1931	1931 on
Brewer Blackbird (<u>Euphagus cyanocephalus</u>)		Phillips et al. 1964
Great-tailed Grackle (<u>Quiscalus mexicanus</u>)		Phillips et al. 1964
Brown-headed Cowbird (<u>Molothrus ater</u>)		Phillips et al. 1964 Rea 1977
Bronzed Cowbird (<u>Molothrus aeneus</u>)		Phillips et al. 1964
THRAUPIDAE		
Hepatic Tanager (<u>Piranga flava</u>)		Phillips et al. 1964
Summer Tanager (<u>Piranga rubra</u>)		Phillips et al. 1964 Rea 1977
FRINGILLIDAE		
Cardinal (<u>Cardinalis cardinalis</u>)		Phillips et al. 1964
Black-headed Grosbeak (<u>Pheucticus melanocephalus</u>)		Phillips et al. 1964
Blue Grosbeak (<u>Guiraca caerulea</u>)	Phillips et al. 1964 (1889)	
Lazuli Bunting (<u>Passerina amoena</u>)		Phillips et al. 1964
Evening Grosbeak (<u>Hesperiphona vespertina</u>)		Phillips et al. 1964
House Finch (<u>Carpodacus mexicanus</u>)		Phillips et al. 1964
Pine Siskin (<u>Carduelis pinus</u>)		Phillips et al. 1964
American Goldfinch (<u>Carduelis tristis</u>)		Phillips et al. 1964
Lesser Goldfinch (<u>Carduelis psaltria</u>)		Phillips et al. 1964
Lawrence Goldfinch (<u>Carduelis lawrencei</u>)		Phillips et al. 1964

Species	Prior to 1931	1931 on
Rufous-sided Towhee (Pipilo erythrophthalmus)		Phillips et al. 1964
Brown Towhee (Pipilo fuscus)		Phillips et al. 1964
Abert Towhee (Pipilo aberti)		Phillips et al. 1964 Rea 1977
Lark Bunting (Calamospiza melanocorys)		Phillips et al. 1964
Savannah Sparrow (Passerculus sandwichensis)		Phillips et al. 1964
Vesper Sparrow (Pooecetes gramineus)		Phillips et al. 1964
Lark Sparrow (Chondestes grammacus)		Phillips et al. 1964
Rufous-crowned Sparrow (Aimophila ruficeps)		Phillips et al. 1964
Black-throated Sparrow (Amphispiza bilineata)		Phillips et al. 1964
Sage Sparrow (Amphispiza belli)		Phillips et al. 1964
Dark-eyed Junco (Junco hyemalis)		Phillips et al. 1964
Chipping Sparrow (Spizella passerina)		Phillips et al. 1964
Brewer Sparrow (Spizella breweri)		Phillips et al. 1964
Black-chinned Sparrow (Spizella atrogularis)		Phillips et al. 1964 (1942)
White-crowned Sparrow (Zonotrichia leucophrys)		Phillips et al. 1964
White-throated Sparrow (Zonotrichia albicollis)		Phillips et al. 1964
Lincoln Sparrow (Melospiza lincolnii)		Phillips et al. 1964 Rea 1977

Species	Prior to 1931	1931 on
Song Sparrow (*Melospiza melodia*)		Phillips et al. 1964 Rea 1977

AMPHIBIANS AND REPTILES - SALT RIVER

Species	Prior to 1931	1931 on
AMPHIBIANS		
AMBYSTOMIDAE		
Tiger salamander (*Ambystoma tigrinum*)		Vitt et al. 1976
PELOBATIDAE		
Couch spadefoot toad (*Scaphiopus couchii*)		Vitt et al. 1976
Hammond spadefoot toad (*Scaphiopus hammondii*)		Vitt et al. 1976
BUFONIDAE		
Colorado River toad (*Bufo alvarius*)		Vitt et al. 1976
Woodhouse toad (*Bufo woodhousei*)		Vitt et al. 1976
Great Plains toad (*Bufo cognatus*)		Vitt et al. 1976
Red-spotted taod (*Bufo punctatus*)		Vitt et al. 1976
RANIDAE		
Bullfrog (*Rana catesbeiana*)		Vitt et al. 1976
Leopard frog (*Rana pipiens*)		Vitt et al. 1976
REPTILES		
KINOSTERNIDAE		
Sonoran mud turtle (*Kinosternon sonoriense*)		Vitt et al. 1976

Species	Prior to 1931	1931 on
TESTUDINIDAE		
Desert tortoise (*Gopherus agassizii*)		Vitt et al. 1976
TRIONYCHIDAE		
Spiny softshell turtle (*Trionyx spinifer*)		Vitt et al. 1976
IGUANIDAE		
Desert iguana (*Dipsosaurus dorsalis*)		Vitt et al. 1976
Long-nosed leopard lizard (*Gambelia wislizenii*)		Vitt et al. 1976
Chuckwalla (*Sauromalus obesus*)		Vitt et al. 1976
Greater earless lizard (*Holbrookia texana*)		Vitt et al. 1976
Zebra-tailed lizard (*Callisaurus draconoides*)		Vitt et al. 1976
Desert spiny lizard (*Sceloporus magister*)		Vitt et al. 1976
Long-tailed brush lizard (*Urosaurus graciosus*)		Vitt et al. 1976
Tree lizard (*Urosaurus ornatus*)		Vitt et al. 1976
Side-blotched lizard (*Uta stansburiana*)		Vitt et al. 1976
Regal horned lizard (*Phrynosoma solare*)		Vitt et al. 1976
GEKKONIDAE		
Banded gecko (*Coleonyx variegatus*)		Vitt et al. 1976
TEIDAE		
Western whiptail (*Cnemidophorus tigris*)		Vitt et al. 1976

Species	Prior to 1931	1931 on
HELODERMATIDAE		
Gila monster (Heloderma suspectum)		Vitt et al. 1976
LEPTOTYPHLOPIDAE		
Western blind snake (Leptotyphlops humilis)		Vitt et al. 1976
COLUBRIDAE		
Black-necked gartersnake (Thamnophis cyrtopsis)		Vitt et al. 1976
Checkered gartersnake (Thamnophis marcianus)		Vitt et al. 1976
Sonora whipsnake (Masticophis bilineatus)		Vitt et al. 1976
Coachwhip (Masticophis flagellum)		Vitt et al. 1976
Desert patchnosed snake (Salvadora hexalepis)		Vitt et al. 1976
Gopher snake (Pituophis melanoleucus)		Vitt et al. 1976
Glossy snake (Arizona elegans)		Vitt et al. 1976
Longnosed snake (Rhinocheilus lecontei)		Vitt et al. 1976
Common kingsnake (Lampropeltis getulus)		Vitt et al. 1976
Saddled leafnosed snake (Phyllorhynchus browni)		Vitt et al. 1976
Spotted leafnosed snake (Phyllorhynchus decurtatus)		Vitt et al. 1976
Western groundsnake (Sonora semiannulata)		Vitt et al. 1976
Western shovelnosed snake (Chionactis occipitalis)		Vitt et al. 1976

Species	Prior to 1931	1931 on
Banded sandsnake (Chilomeniscus cinctus)		Vitt et al. 1976
Sonoran lyre snake (Trimorphodon lambda)		Vitt et al. 1976
Night snake (Hypsiglena torquata)		Vitt et al. 1976
Western blackheaded snake (Tantilla planiceps)		Vitt et al. 1976
ELAPHIDAE		
Arizona coralsnake (Micruroides euryxanthus)		Vitt et al. 1976
CROTALIDAE		
Western diamondback rattlesnake (Crotalus atrox)		Vitt et al. 1976
Black-tailed rattlesnake (Crotalus molossus)		Vitt et al. 1976
Mohave rattlesnake (Crotalus scutulatus)		Vitt et al. 1976
Tiger rattlesnake (Crotalus tigris)		Vitt et al. 1976
Sidewinder (Crotalus cerastes)		Vitt et al. 1976

MAMMALS - SALT RIVER

Species	Prior to 1931	1931 on
SORICIDAE		
Desert shrew (*Notiosorex crawfordi*)		Stamp and Ohmart 1975
VESPERTILIONIDAE		
Big brown bat (*Eptesicus fuscus*)		Cockrum 1960
LEPORIDAE		
Desert cottontail (*Sylvilagus audubonii*)		USAE 1959
SCIURIDAE		
Harris antelope squirrel (*Ammospermophilus harrisii*)		Cockrum 1960 Stamp and Ohmart 1975
Rock squirrel (*Spermophilus variegatus*)		Stamp and Ohmart 1975
Round-tailed ground squirrel (*Spermophilus tereticaudus*)		Stamp and Ohmart 1975
Cliff chipmunk (*Eutamias dorsalis*)		Stamp and Ohmart 1975
GEOMYIDAE		
Valley pocket gopher (*Thomomys bottae*)		Stamp and Ohmart 1975
HETEROMYIDAE		
Arizona pocket mouse (*Perognathus amplus*)		Stamp and Ohmart 1975
Bailey pocket mouse (*Perognathus baileyi*)		Stamp and Ohmart 1975
Desert pocket mouse (*Perognathus penicillatus*)		Stamp and Ohmart 1975

Species	Prior to 1931	1931 on
Merriam kangaroo rat (*Dipodomys merriami*)		Stamp and Ohmart 1975
CASTORIDAE		
Beaver (*Castor canadensis*)		Cockrum 1960
CRICETIDAE		
Southern grasshopper mouse (*Onychomys torridus*)		Stamp and Ohmart 1975
Cactus mouse (*Peromyscus eremicus*)		Cockrum 1960 Stamp and Ohmart 1975
Hispid cotton rat (*Sigmodon hispidus*)		Stamp and Ohmart 1975
White-throated woodrat (*Neotoma albigula*)		Stamp and Ohmart 1975
MURIDAE		
House mouse (*Mus musculus*)		Stamp and Ohmart 1975
MUSTELIDAE		
River otter (*Lutra canadensis*)		Turkowski and Lewis 1971

Literature Cited
Salt River
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Salt River - Threatened and Endangered Birds.

Species	Group	Habitat preference	Riparian contact	Source
Black-bellied Whistling-Duck (*Dendrocygna autumnalis*)	III	Ponds, marshes with abundant emergent vegetation.	Irregularly strays into lower Salt River Valley.	American Birds 1949-1979
Mississippi Kite (*Ictinia mississippiensis*)	II	Riparian obligate, streamside situations, mature riparian community, good insect habitat.	Individuals observed near confluence of Verde and Salt rivers. No breeding record for the Salt River. Breeds near confluence on Verde.	Glinski and Ohmart 1978
Southern Bald Eagle* (*Haliaeetus leucocephalus leucocephalus*)	II	Accessibility to water, suitable trees, cliff faces.	Three current nest sites and and three past nest sites occur on the Salt River.	Todd 1977a Hildebrandt and Ohmart 1978
Peregrine Falcon* (*Falco peregrinus*)	II	Open, grassy country, cliff faces and near river systems.	Use during migration and winters where suitable habitat exists.	Phillips et al. 1964 Glinski and Ohmart 1976
Yuma Clapper Rail* (*Rallus longirostris yumanensis*)	II	Wet marshes or swamp habitat with dense herbaceous vegetation.	Recruitment range and historic range in lower Salt River.	Phillips et al. 1964 Todd 1977b
Great Egret (*Casmerodius albus*)	III	Marshes, irrigated lands, ponds, mudflats, shores.	Winter and transient utilization of lower Salt River.	Phillips et al. 1964
Snowy Egret (*Egretta thula*)	III	Marshes, ponds, river bottom, mudflats, etc.	Common transient, uncommon in summer and winter.	Terrill 1979
Black-crowned Night Heron (*Nycticorax nycticorax*)	III	Willow thickets near water, woody vegetation for roosting.	Formerly bred on Salt River. Currently a transient and winter visitor.	Phillips et al. 1964
Zone-tailed Hawk (*Buteo albonotatus*)	III	Riparian systems, arid country, desert mountains, nest site selection, mature cottonwoods, sycamores, has been seen in evergreen trees, primarily Upper Sonoran.	Found primarily at the confluence of Salt and Verde rivers (requires riparian).	Phillips et al. 1964 Glinski and Ohmart 1978
Black Hawk (*Buteogallus anthracinus*)	III	Wooded streambottoms with permanent water, creeks and rivers.	Found at confluence of Salt and Verde rivers and in some upper Salt River locations (requires riparian).	Glinski and Ohmart 1978
Osprey (*Pandion haliaetus*)	III	River systems, lakes and dams.	Found in winter along Salt River and its lakes; transient.	Phillips et al. 1964

Species	Group	Habitat preference	Riparian contact	Source
Tropical Kingbird (Tyrannus melancholicus)	IV	Riparian systems, cottonwood groves and scattered trees.	Has been observed twice at Granite Reef Dam, along Salt River east of Phoenix.	American Birds 1967 Phillips et al. 1964 Terrill 1975

*On Federal Endangered Species List

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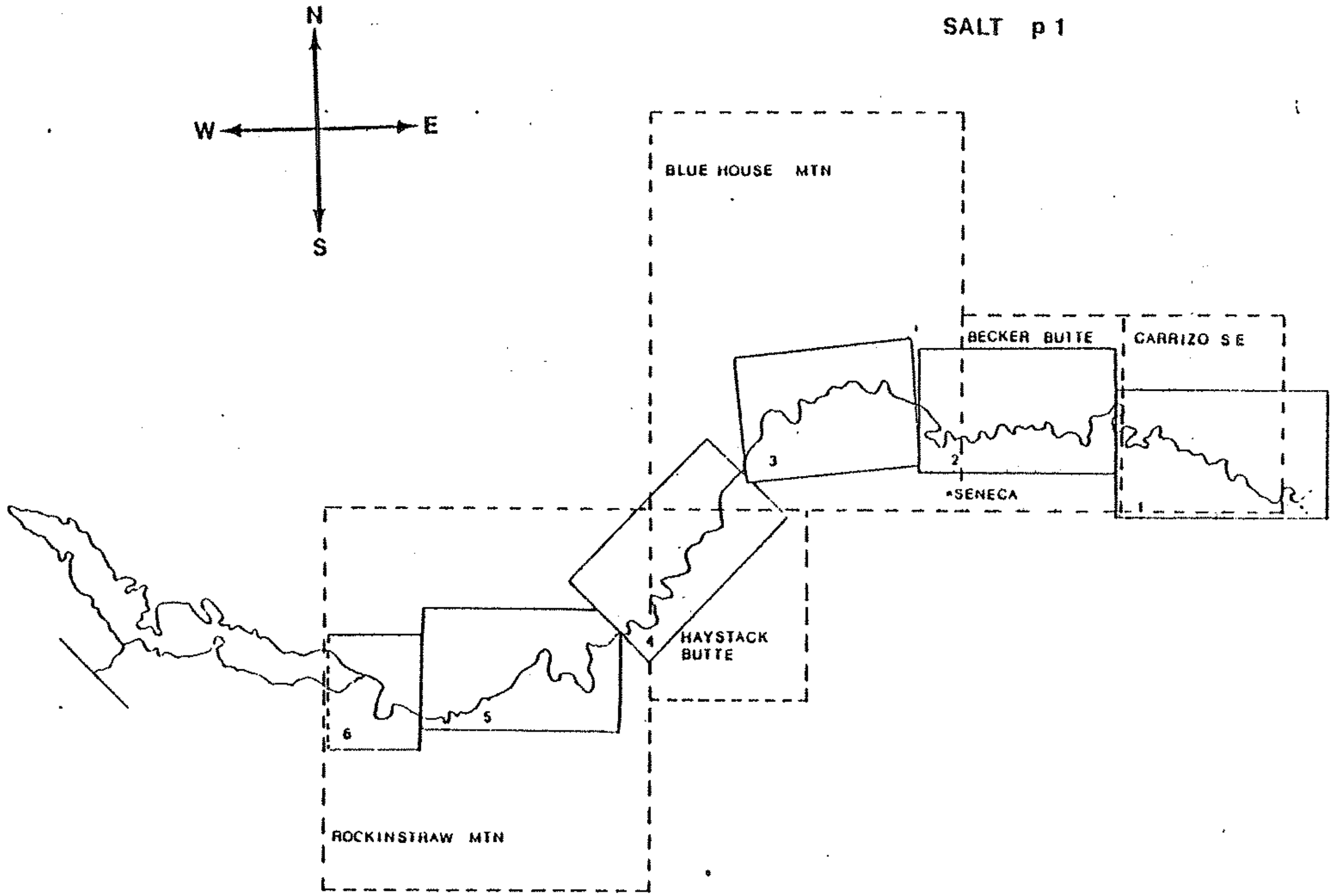
SALT p 1



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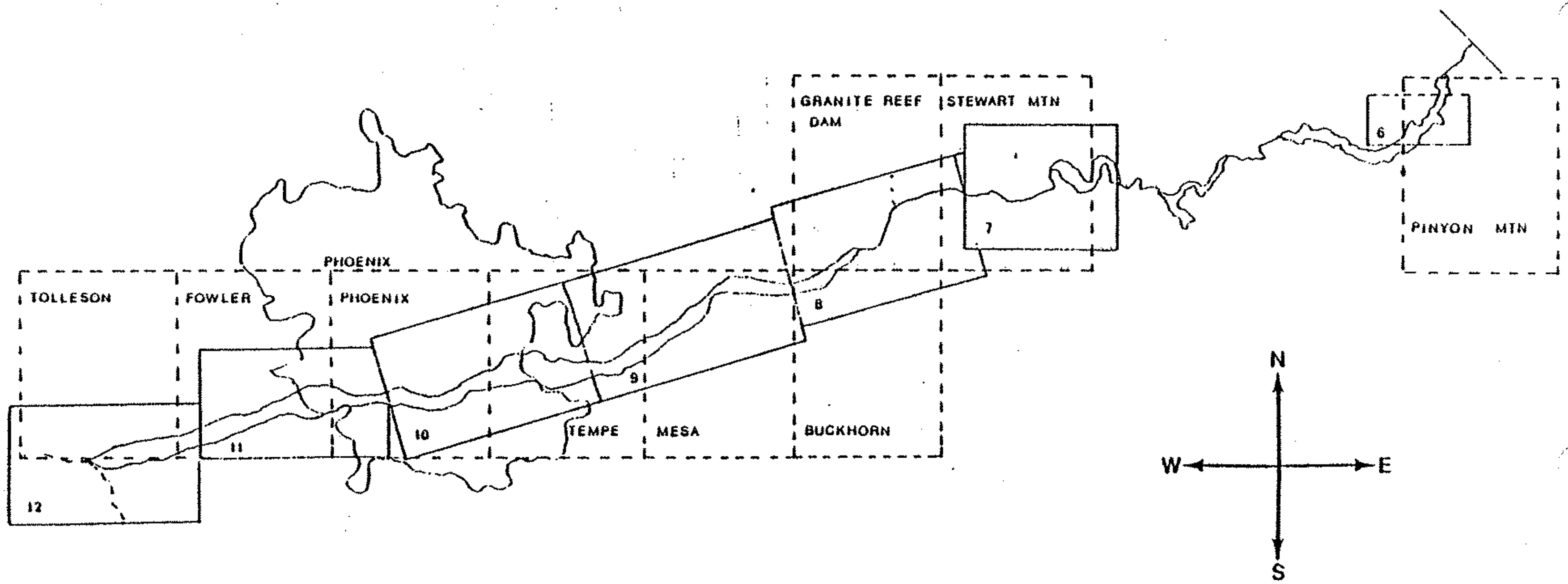

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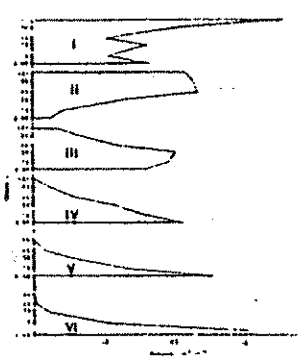
KEY

COMMUNITY

- COTTONWOOD
- HONEY MESQUITE
- SALT CEDAR
- SYCAMORE
- COTTONWOOD/SYCAMORE
- ARROWWEED
- SALT CEDAR/HONEY MESQUITE

STRUCTURAL TYPE



SALT RIVER

1978

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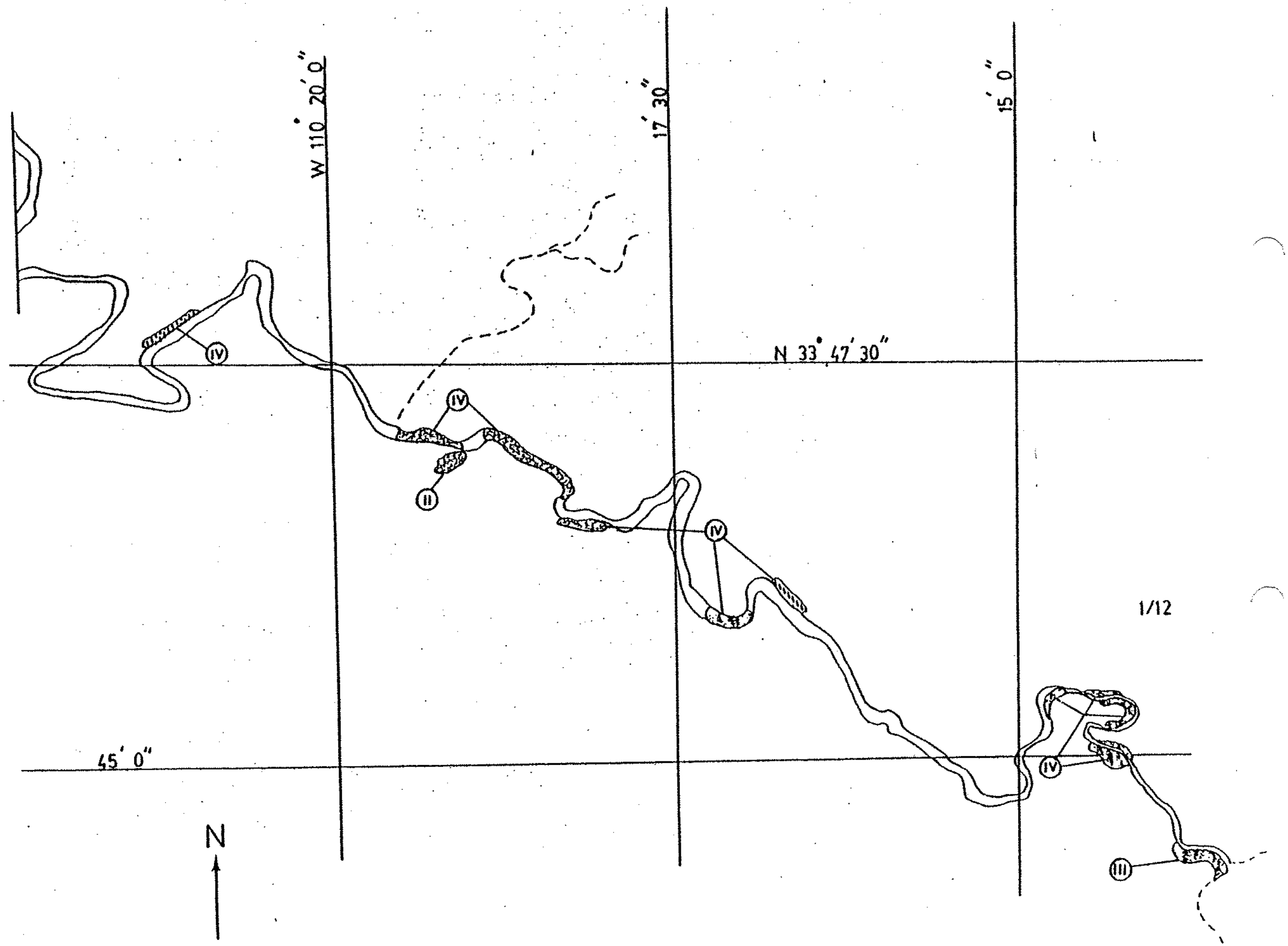
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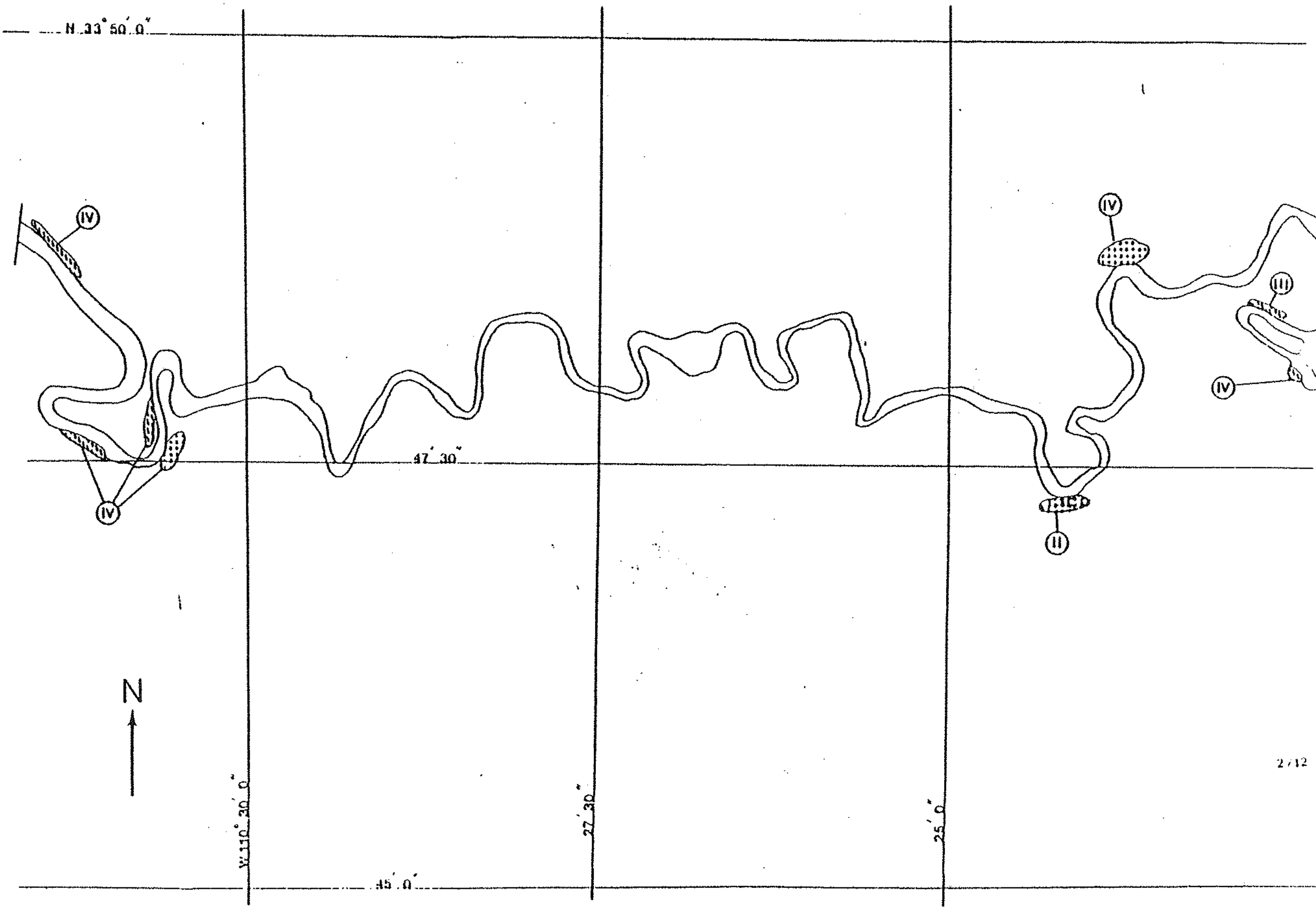

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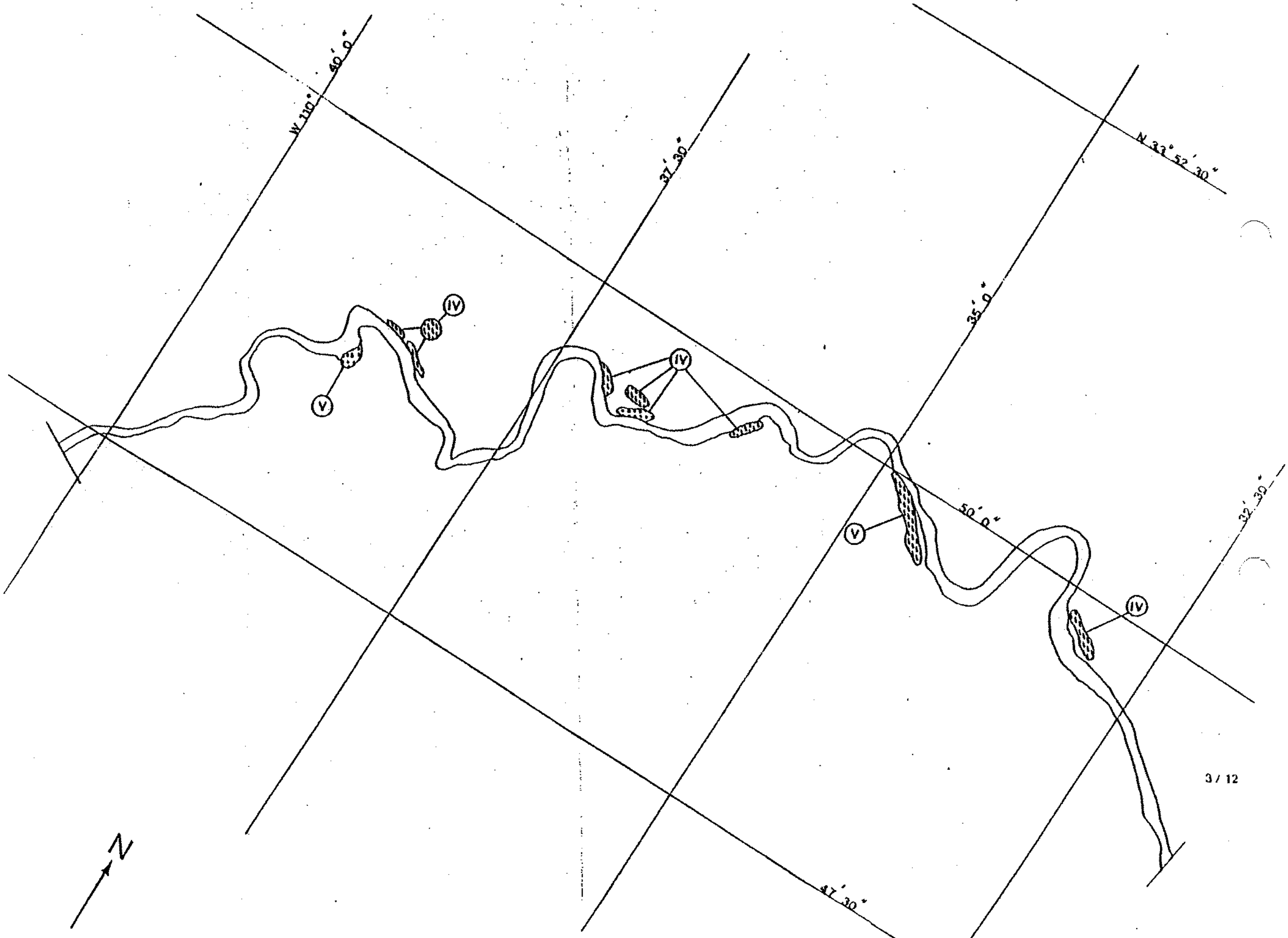
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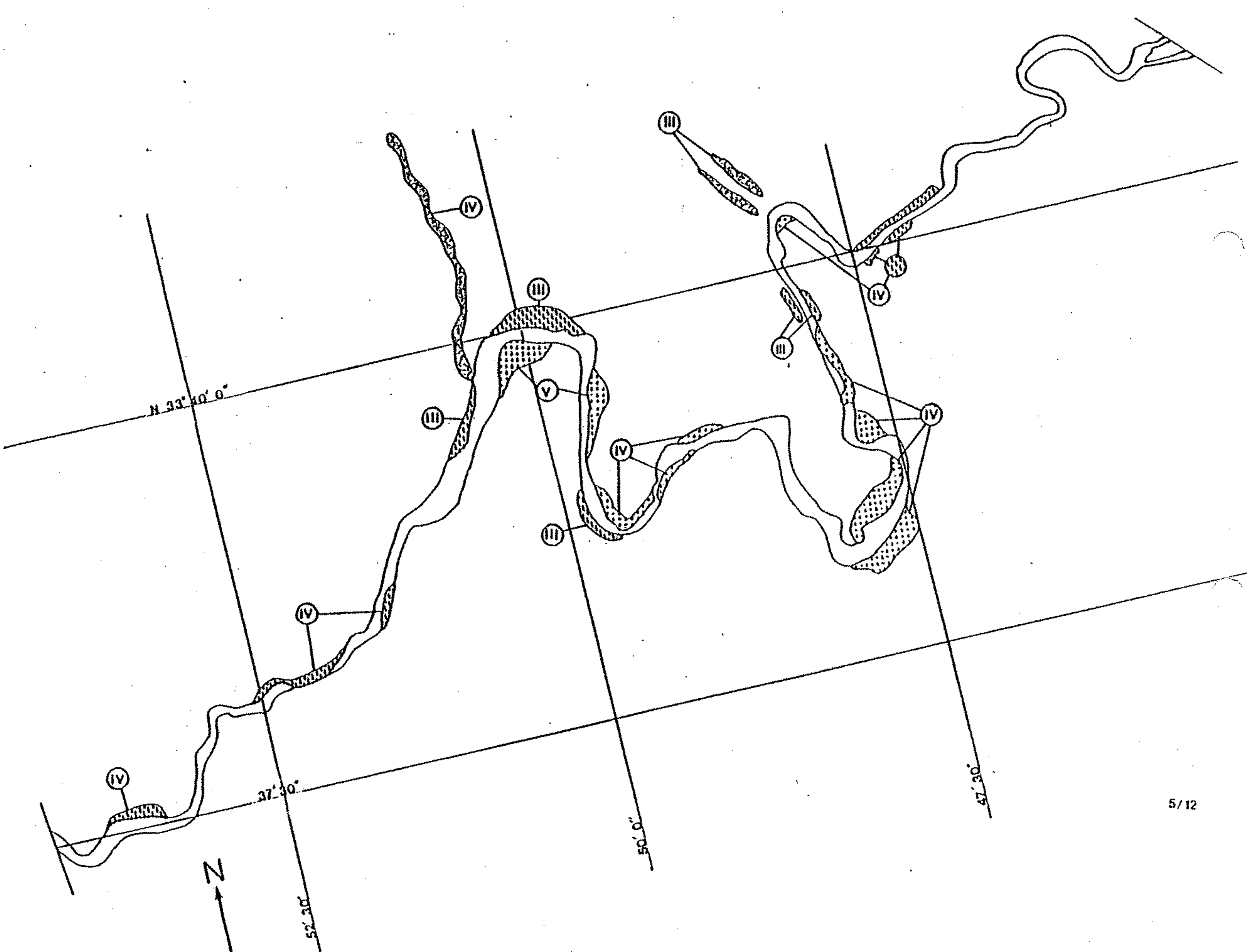

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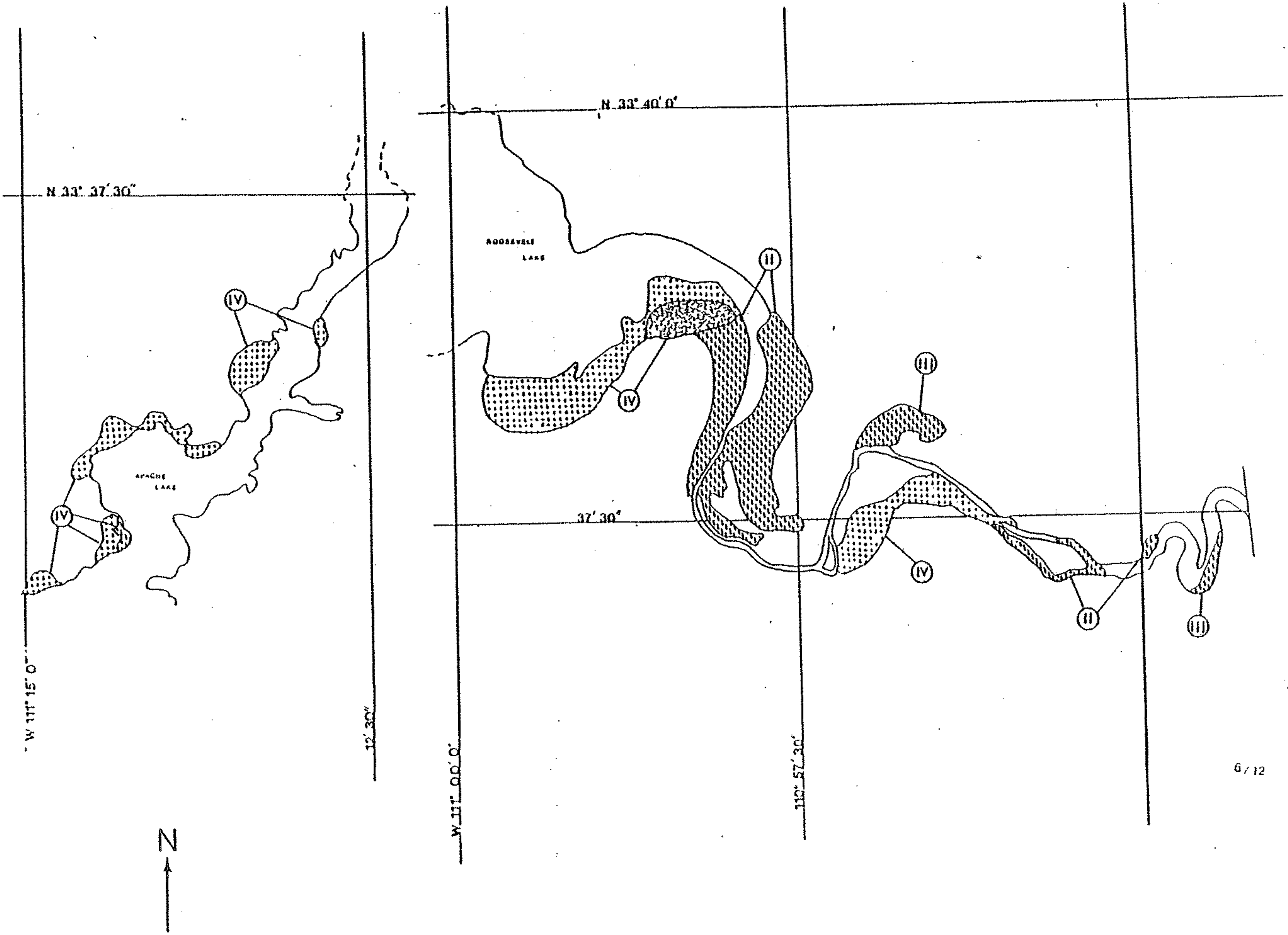
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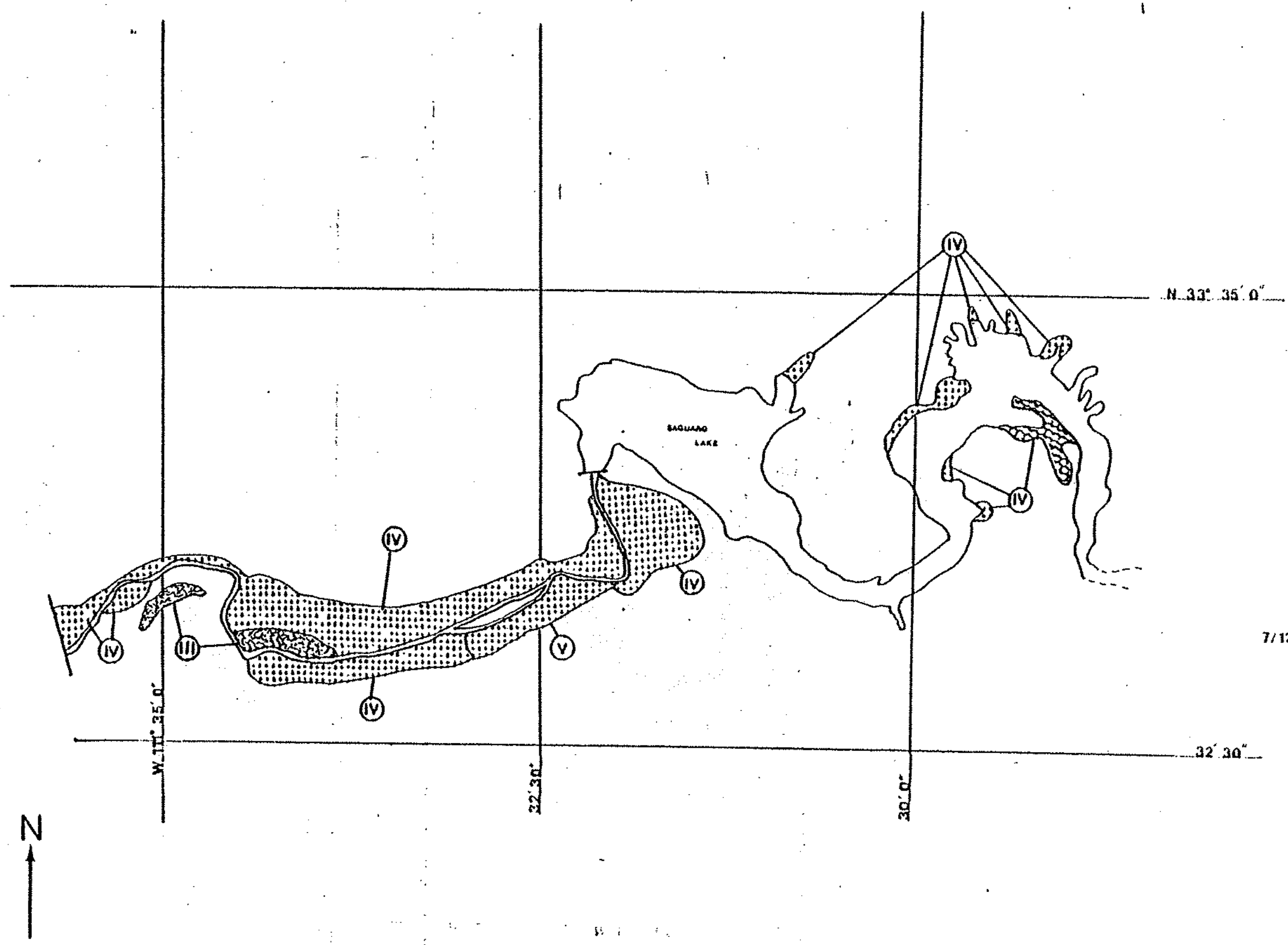
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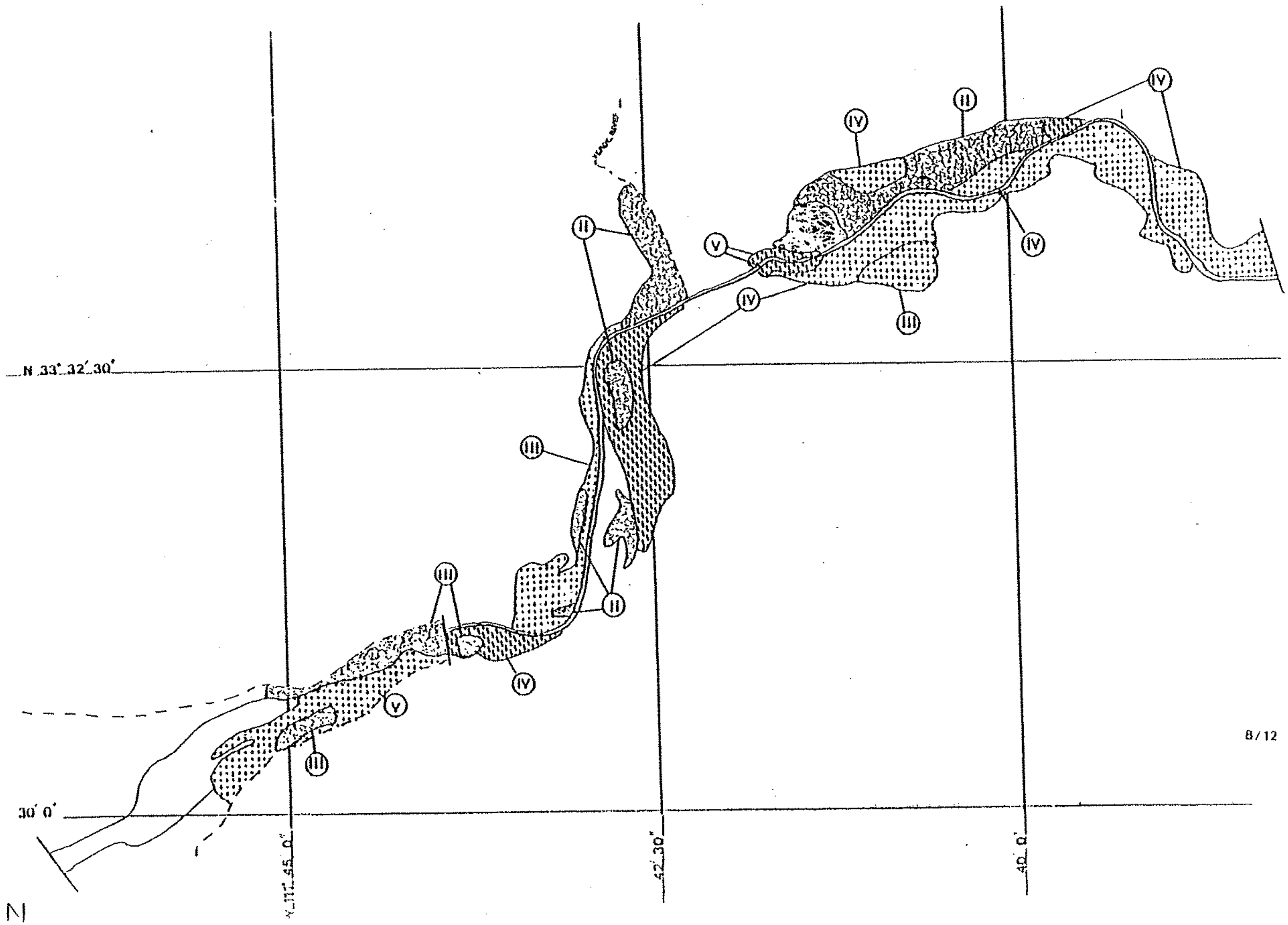

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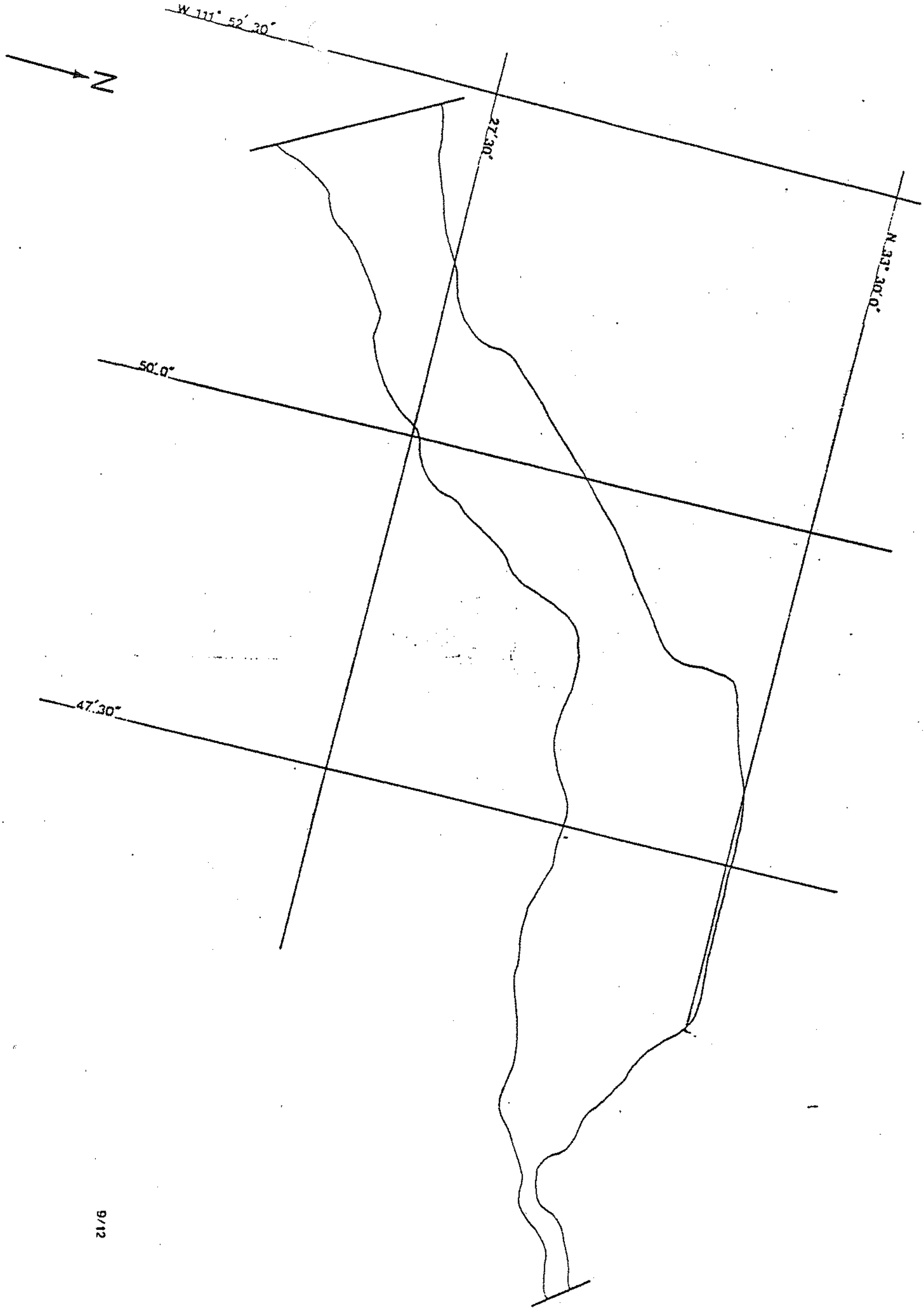

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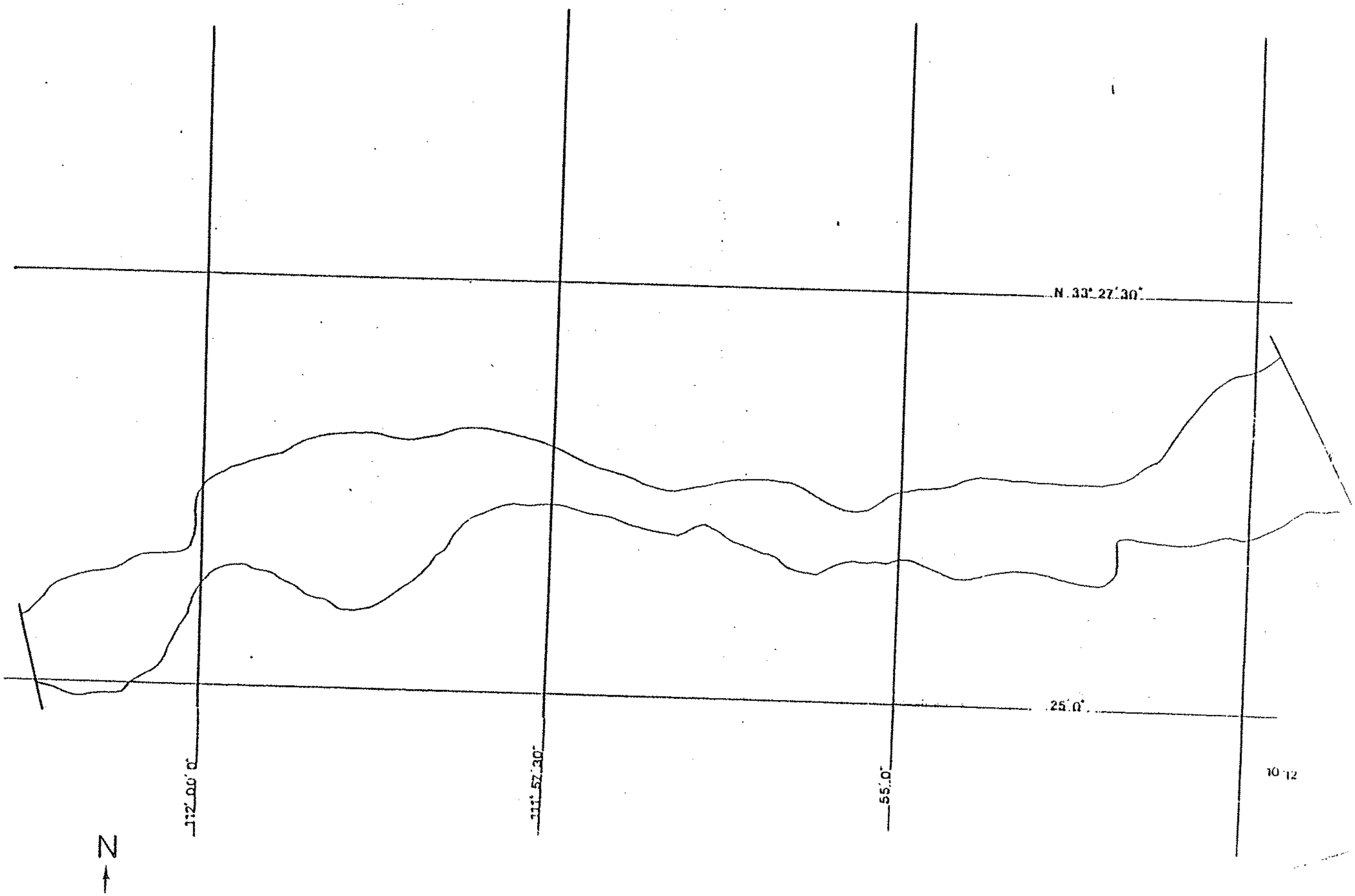
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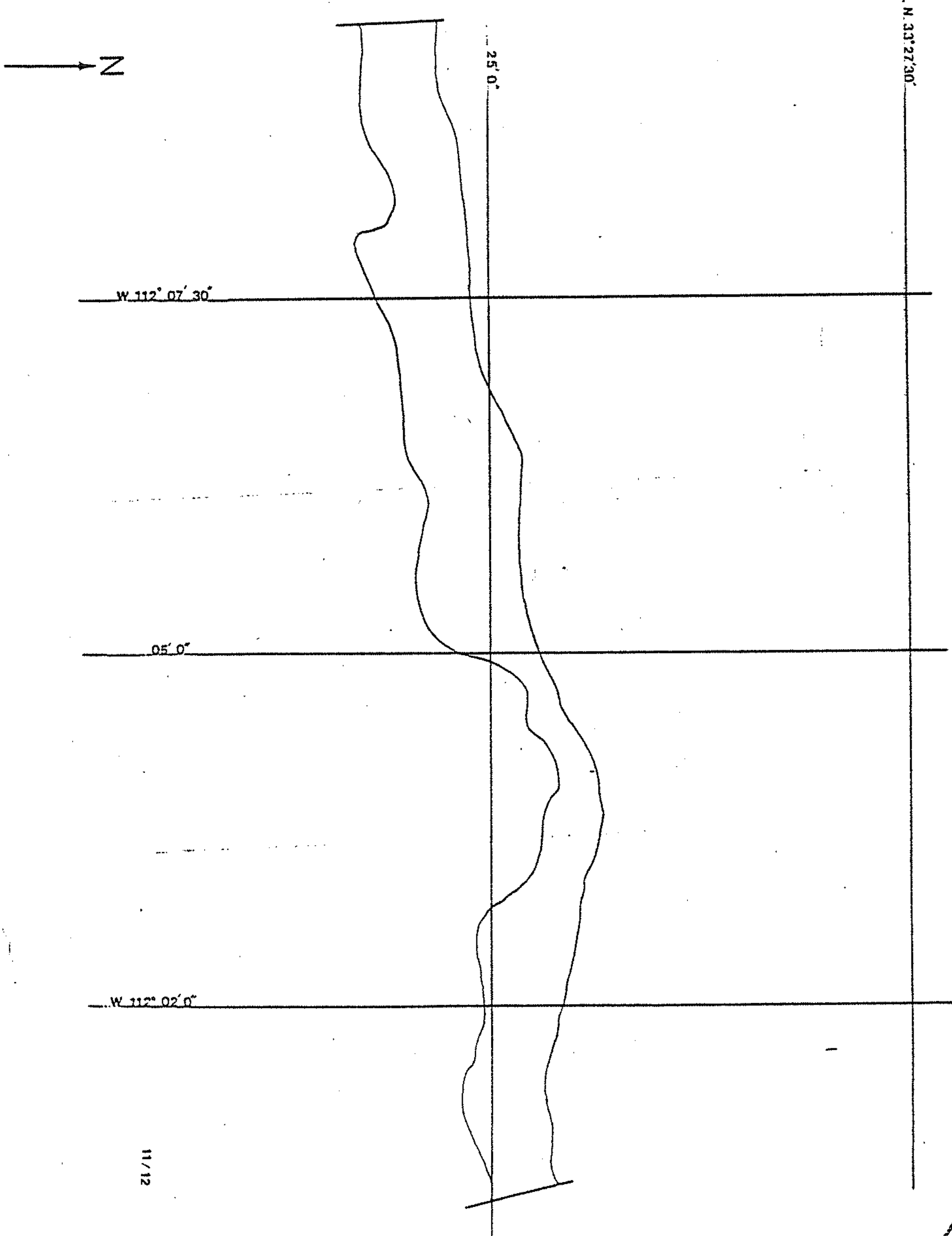

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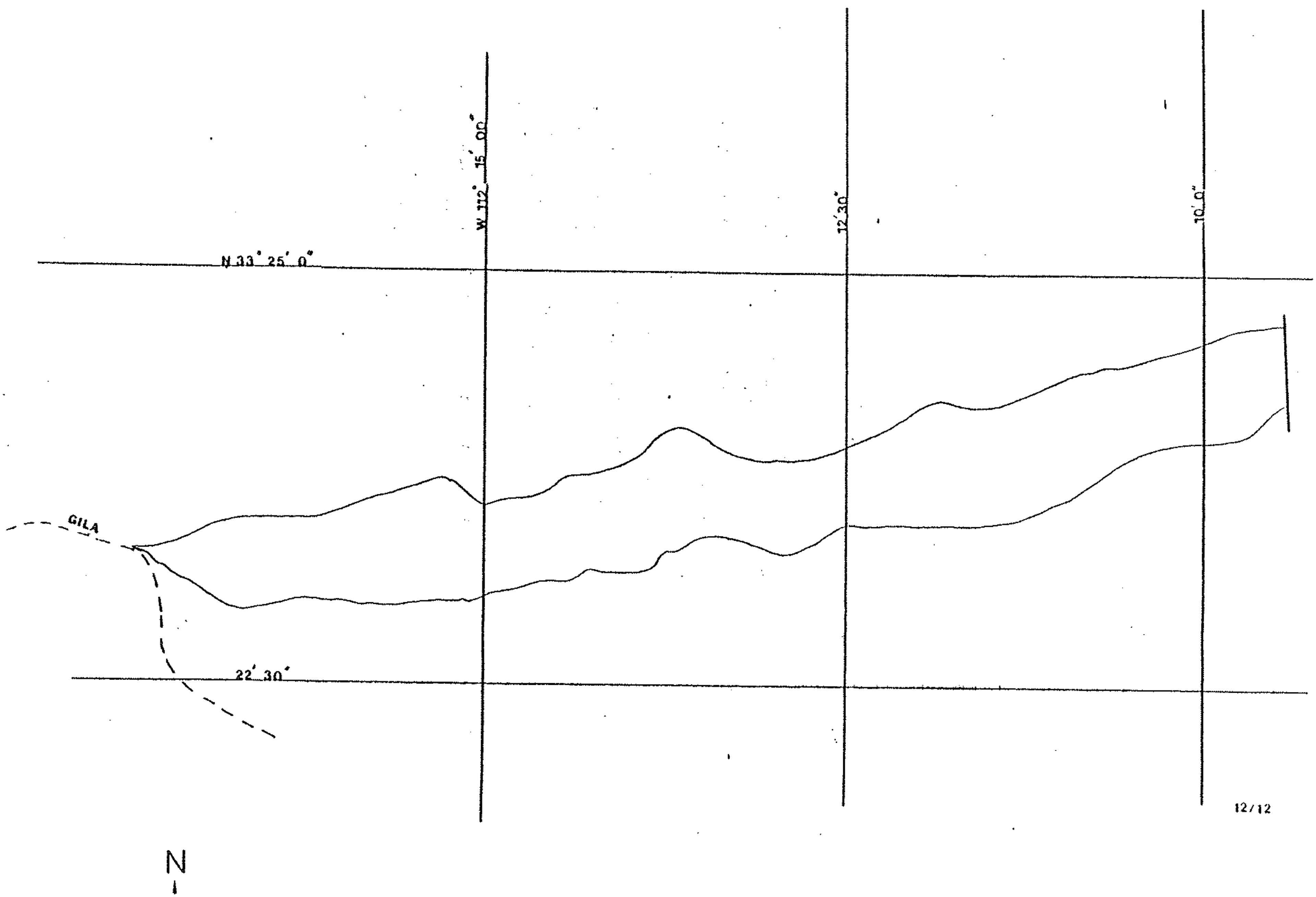

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USDA Forest Service
General Technical Report RM-206

September 1991

Native Fishes of Arid Lands: A Dwindling Resource of the Desert Southwest

Photographs by

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Tempe, Arizona

Text by

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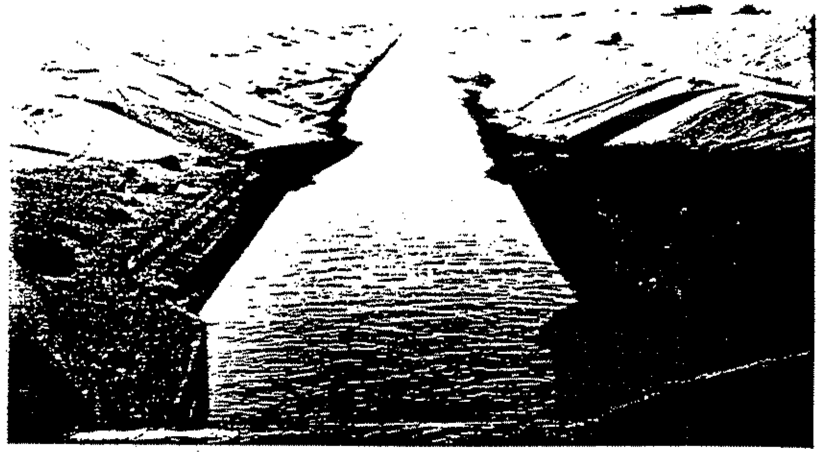
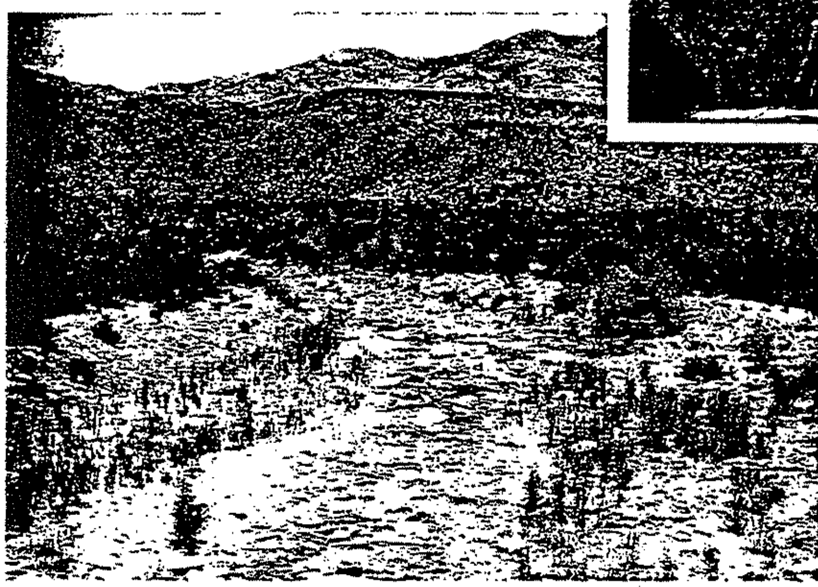
Arizona State University
Tempe, Arizona

[1]Headquarters in Fort Collins, Colorado, in cooperation with Colorado State University. The Bureau of Reclamation, USDI, helped finance the printing of this publication.





Rinne, John N.; Minckley, W. L. 1991. Native fishes of arid lands: a dwindling resource of the desert Southwest. Gen. Tech. Rep. RM-206. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 45 p.

Includes color photos of 44 species of fishes, many published for the first time. Text describes aquatic systems in the mountains and deserts of the Southwest, the unique fishes they support, and habitats the fishes need.

Front cover: Roundtail chub.

Back cover: Aravaipa Creek, one of the best examples of native fish habitat remaining in Arizona.

[illegible] diverting flow into inland basins such as the Salton Sea. The Colorado River Delta was further influenced by a remarkable tidal bore. Tides in the Sea of Cortez exceed 9.0 m at the river's mouth, among the highest in the world. Swift, destructive tidal currents moved with remarkable speed for more than 100 km upstream.

Low Desert, Riverine Fish Communities

Canyons of large desert rivers present two basic types of habitat. Most impressive are the reaches that are termed whitewater in the jargon of river runners, where bottom irregularities cause waves, whirlpools, and other turbulence. The second type is called flatwater, where deep, strong, unobstructed flow occurs, but with little surface roughness (Fig. 58).

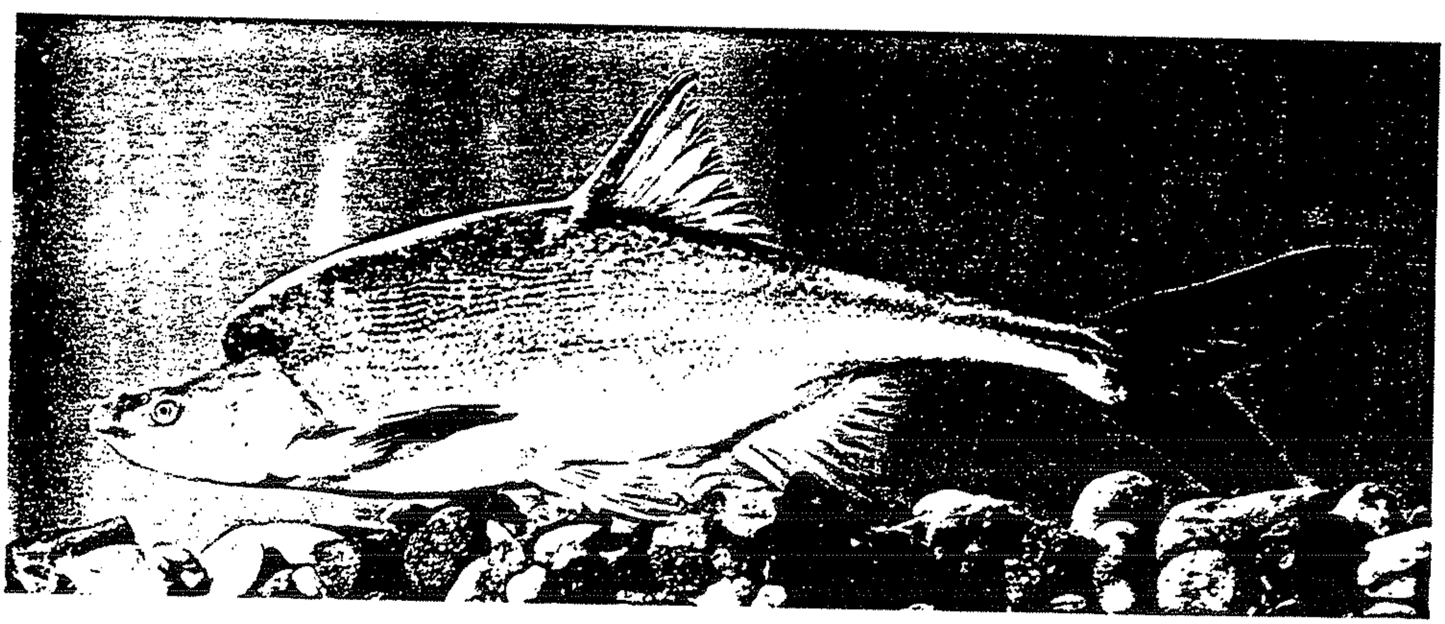
Figure 58. Looking downstream from a flatwater reach to a major rapid on the Colorado River in Grand Canyon, Arizona, 1970.

The Colorado River is notorious for whitewater, especially in the Grand Canyon, and the Rio Yaqui flows through similarly constrained reaches through parts of its course. Wider places separating canyons tend to have different faunal compositions, covered below.

Canyons of the Colorado River support a special fish community consisting mostly of humpback chub, speckled dace, bluehead mountain-sucker, and flannelmouth sucker. Of these, only the humpback chub (Fig. 59) is found in whitewater, where it lives in deep eddies associated with large boulders, indentations in canyon walls, or other protecting obstructions. This is one of the most bizarre minnow species in the world, with large, strong fins, leathery skin with deeply embedded scales, and a remarkable hump between the head and dorsal fin. The last reflects a powerful and compact musculature required for movement within its habitat and through rapids separating one eddying habitat from another. Despite years of study, little is actually known of the humpback chub's feeding and reproduction. We know that it lives a relatively long time, perhaps more than 30 years, and that it reproduces in spring/early summer. The fish is rare, and classed as endangered, so few have been sacrificed for biological examination.

Speckled dace (Fig. 31) live along sand and gravel bars of flatwater reaches of the Colorado River. Flannelmouth suckers (Fig. 60) remain in deeper water except when feeding, when they move onto

Figure 59. The largest known population of endangered humpback chub lives in the lowermost Little Colorado River, Arizona. This adult, 36.0 cm in total length, was photographed at Willow Beach National Fish Hatchery.



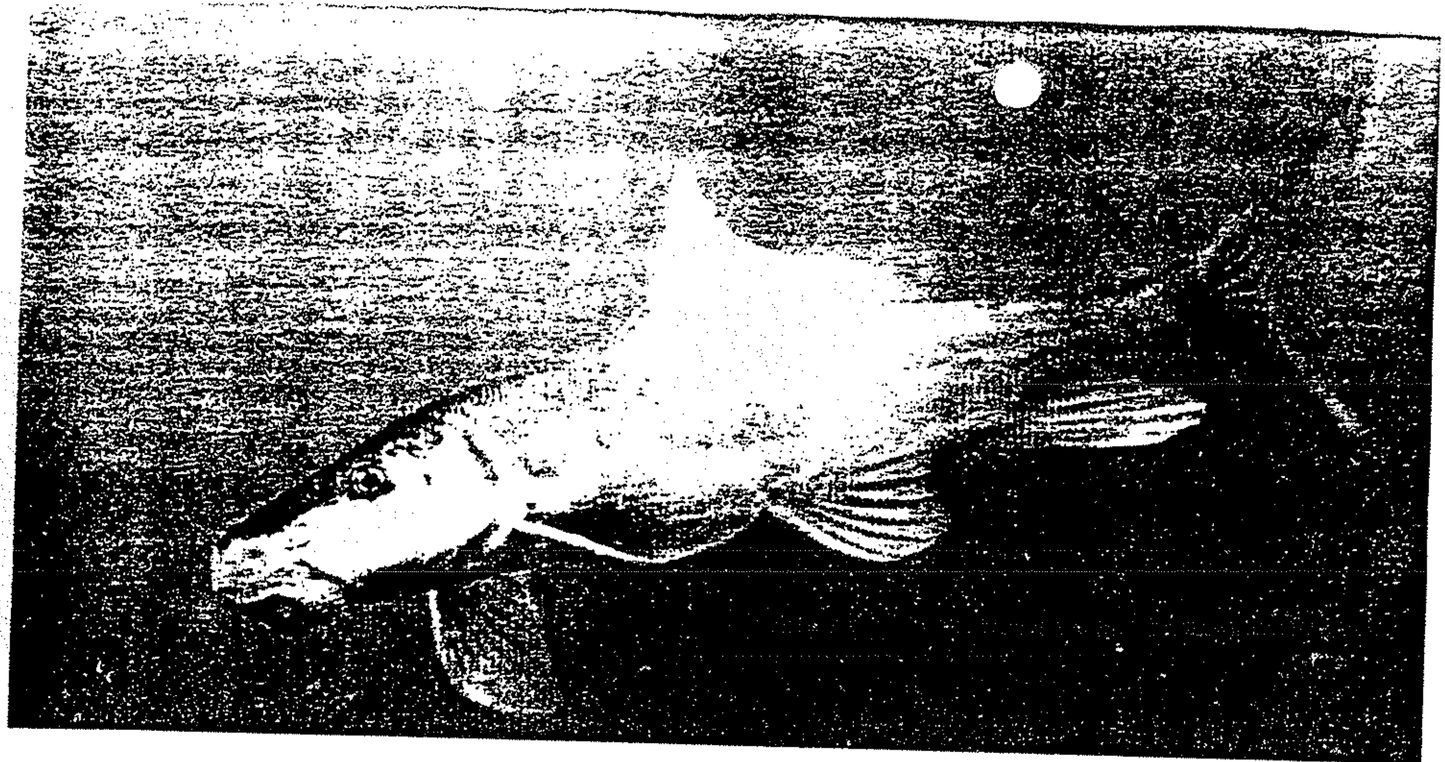
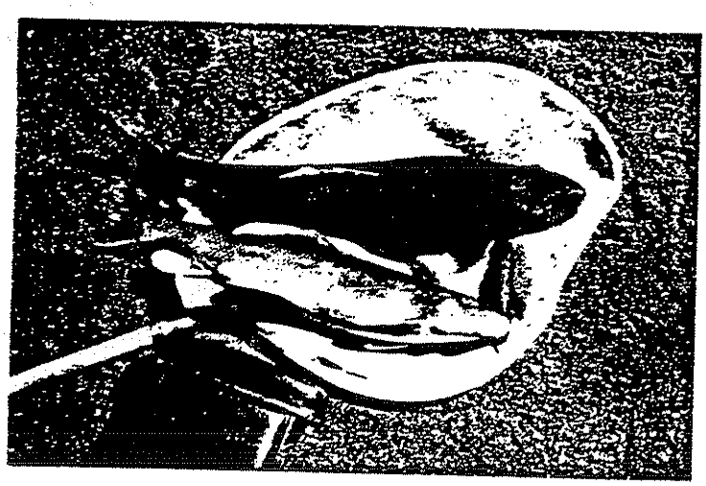


Figure 60. Flannelmouth sucker, 28.5 cm in total length, from the Virgin River, Arizona. This species remains common in the upper Colorado River basin, but has disappeared entirely from the lower basin (including the Gila River drainage) downstream from Lake Mead.

moderate rapids and riffles in pursuit of bottom-dwelling invertebrates, algae, and organic debris. Bluehead mountain-suckers (Fig. 61) tend to feed on harder bottoms, scraping algal films and other organic materials (including clinging invertebrates) from rocks with their modified, cartilaginous jaws. All three of the last species breed in spring on riffles.

Figure 61. Breeding adults of bluehead mountain-sucker, ca. 45.0 and 35.0 cm in total length, from the mouth of the Paria River, Arizona. This species remains abundant within its native range in the upper Colorado River basin. Photograph by W. G. Kepner.



Canyon-bound reaches of the Rio Yaqui are occupied by roundtail chubs, Yaqui suckers, and Yaqui catfish/*bagre del Yaqui* (Fig. 62). Beautiful shiners and Mexican stonerollers live along the banks and in quieter places. It is notable here that little sampling has been done in these reaches, which are mostly isolated and accessible only by river. It will not be surprising if future collectors in the Rio Yaqui and its major tributaries discover new species of swift-water fishes.

The fish community of wider, less dramatic lower parts of the Colorado River, most of which is now dry or otherwise highly modified, consisted of a small number of special kinds, plus in its lowermost reaches a few marine species that entered from the Gulf of California. Freshwater fishes of the lowermost reach included Colorado squawfish/*charalote*, bonytail/*charalito elegante*, and razorback sucker/*matalote jorobado*, all of which passed readily through canyon reaches, but rarely lived there. All available evidence indicates that squawfish and razorback were abundant and that bonytail was common as well. Flannelmouth sucker, woundfin, and roundtail chub also were present, but are represented by only a few specimens in early collections and must have been relatively rare. Shallow sloughs and backwaters supported desert pupfish. Roundtail chub, Yaqui

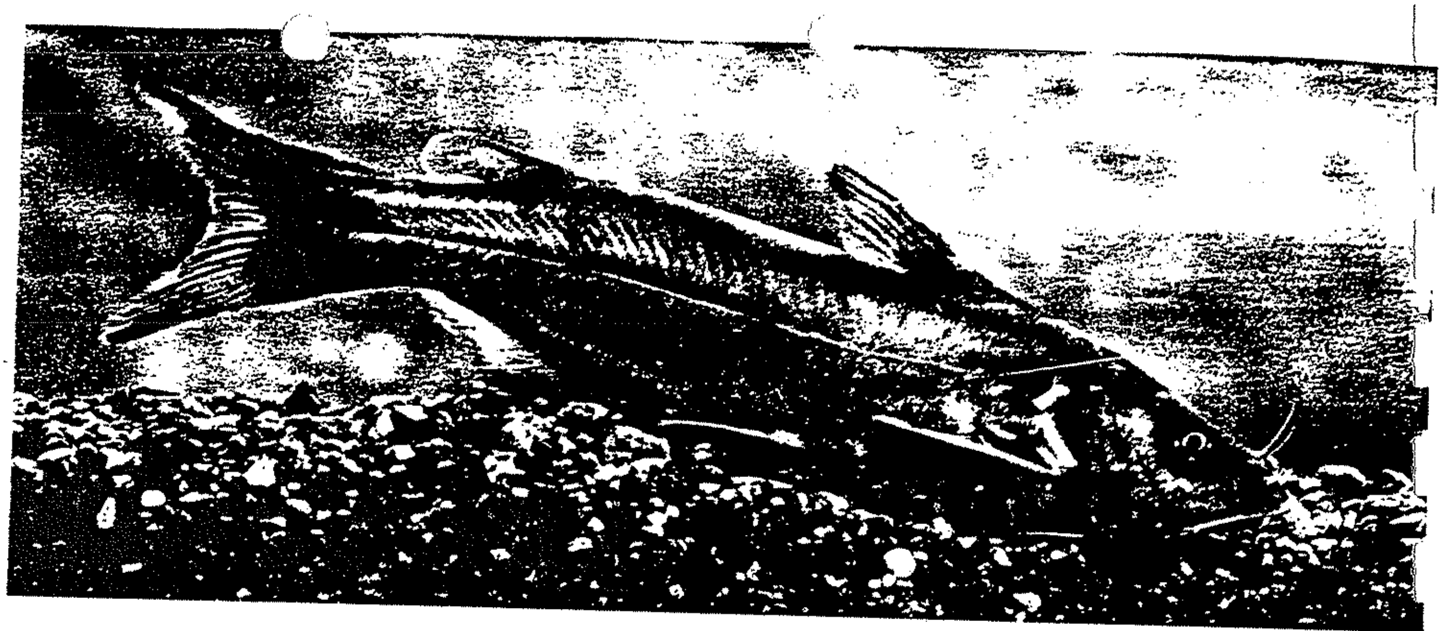


Figure 62. Yaqui catfish/*bagre del Yaqui*, ca. 35 cm in total length, from the Rio Sirupa (Rio Aros) mainstream, Chihuahua. This species, considered of special concern, almost certainly lived in the past in San Bernardino Creek, Arizona. It remains relatively common in the Rio Yaqui system.

sucker, and Yaqui catfish are joined by Pacific shad/*sardinita del Pacifico* and Sinaloan cichlid/*mojarra sinaloense* in the lowermost Rio Yaqui. No studies have appeared on the ecology of any of these five species in Mexican waters, but as already covered, the roundtail, sucker, and catfish have conspecific or close relatives in streams of the United States, where some data are available.

Habitats of Colorado squawfish (Figs. 63–64) include deeper pools, eddies, riffles, sloughs, quiet backwaters, creek mouths, swift runs, and shallows along shore. This is the largest North American minnow, achieving lengths of almost 1.8 m and perhaps 45 kg in weight. Young move into embayments and backwaters along the channel, and feed mostly on crustaceans and insects, shifting to

Figure 63. Colorado squawfish/*charalote* caught near the mouth of Cherry Creek, Arizona, near the turn of the century. This endangered species is now extirpated from the lower Colorado River basin. Photograph provided by W. L. Minckley.

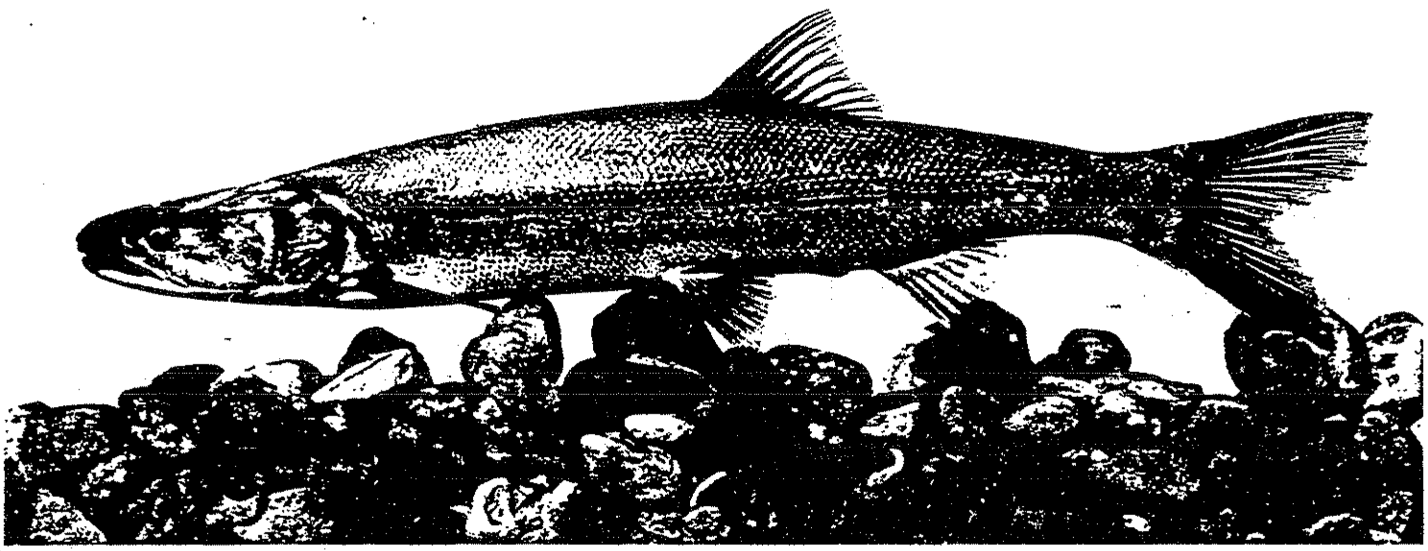


Figure 64. Colorado squawfish/*charalote*, 36.0 cm in total length. The specimen is a hatchery-reared offspring (1974 year-class) of broodfish captured in the Green River basin of Utah.

fishes after becoming longer than 75 to 100 mm. Adults eat other fishes and thus probe and wander extensively in search of food. A squawfish of 90 cm long or more must have devoured almost any other fish in the river.

Squawfish spawn over gravel bars in channels of rivers in spring or summer, after water temperatures exceed 20° to 21° C. They often move long distances to reproduce, and return year after year to the same or a similar spawning area. Major runs in spring into the Gila River, well documented in old newspaper accounts, must have been related to spawning. Breeding squawfish become silvery above and creamy yellow on the belly with an intense array of bright golden flecks on the upper sides.

Razorback suckers (Fig. 65) tended to occupy strong, uniform currents over sandy bottoms. They also lived in eddies and backwaters lateral to the river channels, sometimes concentrating in deep places near cut banks or fallen trees. Large adults approached or exceeded 75 cm in length and more than 5.0 kg in weight. A remnant population of large adults in Lake Mohave, Arizona-Nevada, spawns from late January through April over gravelly bottoms in relatively shallow water (Fig. 66). Males become dark brown to black on the back and develop a russet- to orange-colored lateral band and yellow belly. Coarse, sharp tubercles, which are horn-like outgrowths of skin, are developed on the anal, caudal, and pelvic fins, and on the caudal peduncle. These function to hold the female during the spawning act. Females that have spawned repeatedly may be scarred and abraded from contacts with males and with rocky bottoms. The eggs are adhesive and are deposited in spaces between gravels. They hatch in a few days and young move to the shoreline for a time.

Despite successful reproduction, there is no evidence for successful recruitment of young fish into the Lake Mohave population for more than two decades. Larvae mysteriously disappear before achieving 15 mm total length. The same situation appears to exist in other, riverine parts of the Colorado River basin, and the species is proposed for listing as endangered. Under natural conditions in streams, young fish must have occupied shorelines, then moved with growth into habitats similar to those just described for young squawfish. Razorbacks feed mostly from the bottom, but have elongated, "fuzzy" gillrakers and a subterminal mouth both characteristic of planktonic or detrital feeding habits.

Remarkably little is known of the ecology of bonytail (Fig. 67), and they are almost gone in nature. A small population persists in Lake Mohave, but only a few have been recorded from the upper Colorado River in recent years. As with razorbacks, there are no records of successful recruitment of this species for many decades; specimens caught in nature all appear to be old (35–40 yr) adults. Bonytail are large, streamlined fishes that have long

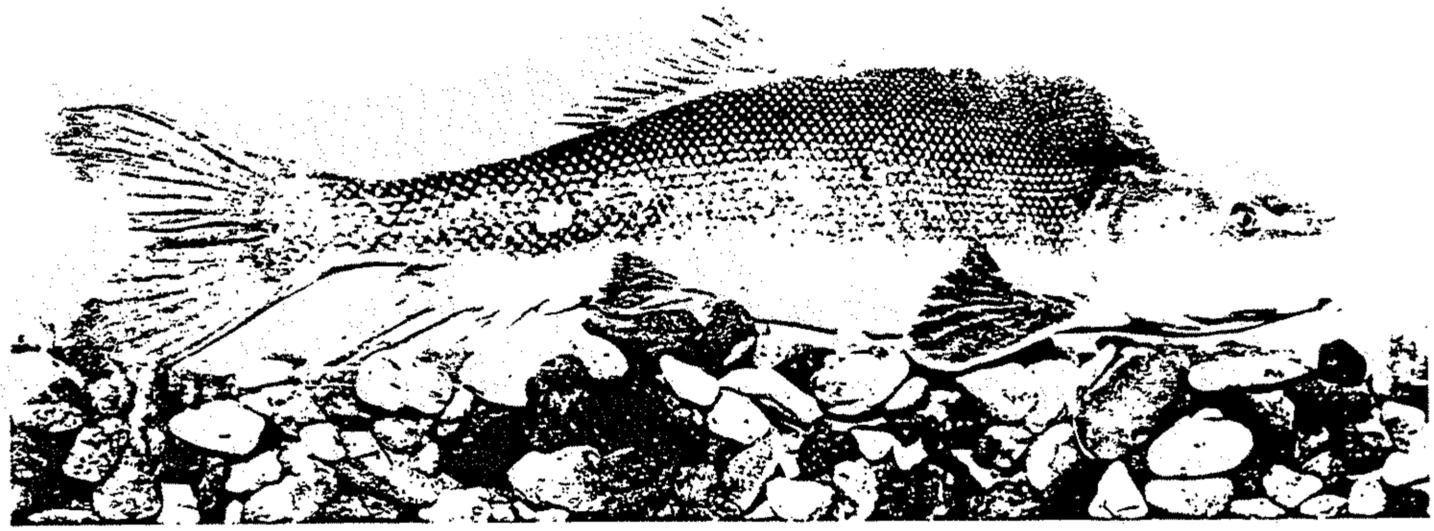


Figure 65. Male razorback sucker/*matalote jorobado*, 57.5 cm in total length, from Lake Mohave, Arizona-Nevada. This formerly widespread, mainstream species of the Colorado River basin is now reduced to three local populations and scattered individuals. There are no records documented by specimens from Mexico since near the turn of the century. It has been proposed for listing as endangered throughout its range.

Figure 66. Three male razorback suckers/*matalote jorobado* approaching a female in a spawning aggregation in Lake Mohave, Arizona-Nevada. Photograph by Gordon Mueller

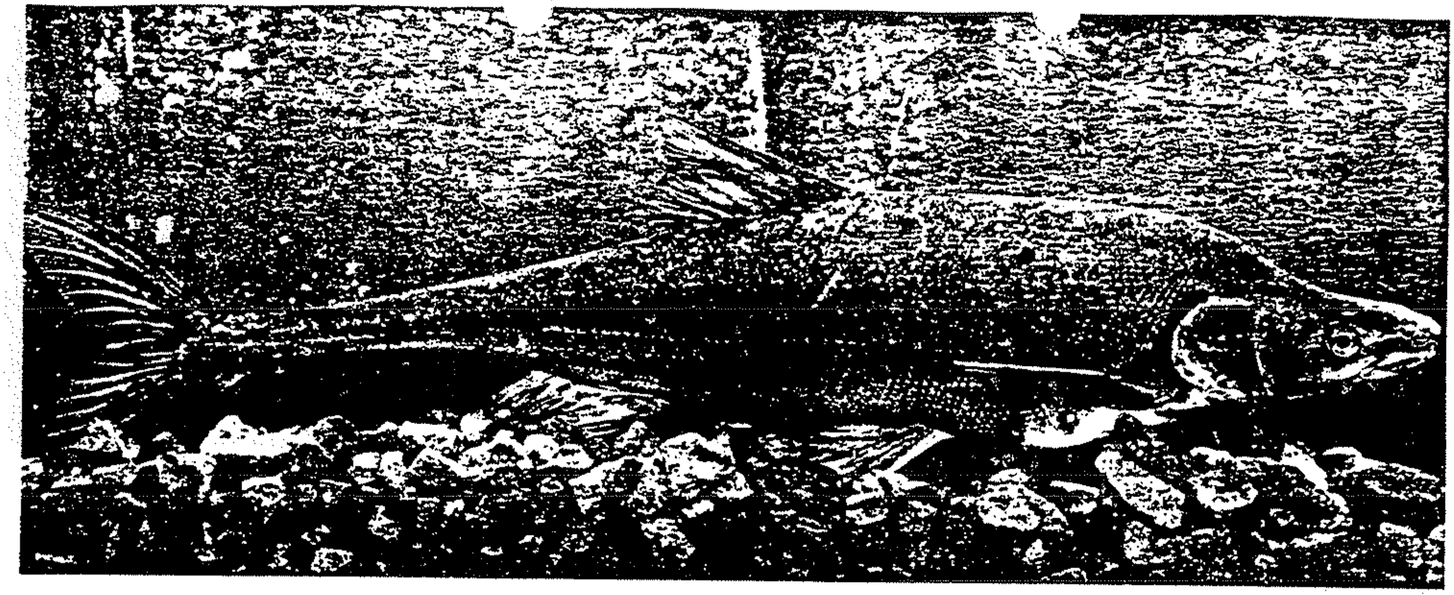


Figure 67. Bonytail/*charalito eleganti*, 52 cm in total length, from Lake Mohave, Arizona-Nevada. This is considered by many workers to be the most endangered freshwater fish in western North America. An attempt is underway to move all individuals encountered in nature into captivity to serve as a broodstock for future reintroductions.

been thought to be adapted to turbulent habitats, similar to those inhabited by humpback chubs. It seems more likely, however, that their body shape makes them most at home in relatively swift but laminar flow, as is still found over smooth sand bottoms in the Colorado River channel. A few adults examined for food habits had eaten a high percentage of terrestrial invertebrates, drifting insects that had been blown by wind or otherwise fallen into the river. Occurrence of adult aquatic insects in stomachs also implies feeding at or near the water surface. The only reproductive activities recorded for bonytail are of aggregations of adults over gravelly "reefs" in artificial impoundments; habitats and activities of young are unknown in nature. The largest recorded bonytail was about 65 cm in length.

Two other species of the mainstream Colorado River attain relatively large sizes. Flannelmouth suckers can grow to nearly a meter in length and roundtail chub to more than 40 cm; both are discussed elsewhere. The next two species are relatively small. Woundfin (Fig. 68) rarely exceed 10 cm long, and desert pupfish rarely exceed 40 mm, even as an extremely large adult. The first three of these were rare in early collections from the lower Colorado River basin, and the last was almost certainly common in more ephemeral habitat too severe for other species, such as on the delta itself. Desert pupfish persist on the delta at present, typically in highly saline pools associated with inflowing springs and seeps.

The woundfin was the only small, short-lived species known from the channel of the lower Colorado River. This species is one of a unique group of North American minnows in having the leading rays of its dorsal fin modified into a stout spine. Other members of this minnow group also have such rays, but not so spectacularly developed. The species is adapted for life in highly turbid water over shifting sand bottoms. Its fins are large and sickle-shaped, and dorsal streamlining is extreme while the lower body is flattened to fit closely to the

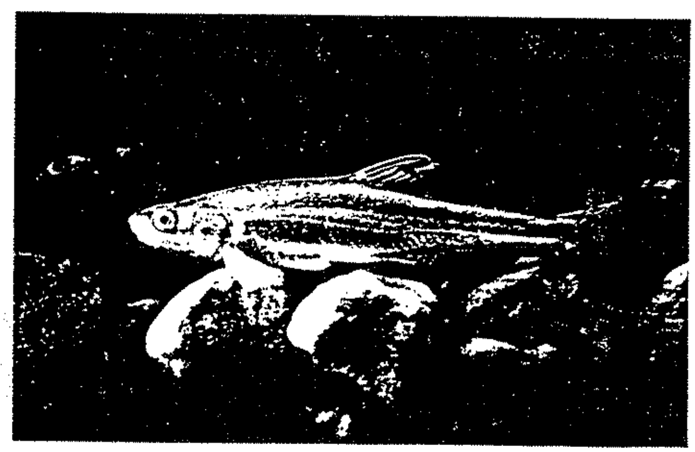


Figure 68. Woundfin, ca. 90 mm in total length, from the Virgin River, Arizona. This endangered species, once known from both the lower Colorado and Gila rivers, is now completely restricted to the Virgin River mainstream, Nevada-Arizona-Utah.

bottom. The scales are reduced to bony platelets, some of which form longitudinally arranged ridges that may function to direct water over the body surface and assist in maintenance of position in swift runs. Woundfin select areas with rocky substrate in current for spawning, at a temperature of about 25 ° C. Young grow rapidly, achieving lengths of 20 to 40 mm a month or two after hatching. The species was known from the Gila and lowermost Colorado rivers in the late 1800s but since then has been found only in the Virgin River mainstream.

In the Rio Yaqui, the Pacific shad/*sardinita del Pacifico* (Fig. 69) is a midwater inhabitant of lakes or open parts of rivers. They feed on finely divided detrital material from the bottom or on plankton in the water column, and in doing so act as an avenue for these foodstuffs through the food chain to larger fishes. Shad in freshwaters provide a food base for predatory fishes just as anchovies provide food for larger fishes in the sea. With construction and filling of reservoirs in the Rio Yaqui system, Pacific shad appeared far inland, thus acting as forage for larger fishes in those newly created habitats. The threadfin shad, a similar species from eastern drainages of the United States and Mexico, has recently been introduced into the Rio Yaqui basin, the results of which are not predictable.

The Yaqui catfish (Fig. 62) resembles the common channel catfish of eastern North America. They commonly achieve more than 40 cm in length and a kilogram in weight, and live in relatively deep water during the day, only to move onto riffles and runs at night to feed. The few stomachs that have been examined contained aquatic invertebrates, other fishes, and organic debris. Spawning is apparently similar to channel catfish, with the male defending eggs in a depression or hole in the bank and protecting his newly hatched young for a time. Young live in shallower water than adults, often on riffles among cobble and boulders. Channel, blue, and flathead catfishes from eastern North America have now been introduced into the Rio Yaqui system, and there is already evidence of hybridization between the first and the Yaqui catfish.

Last among the freshwater fishes characterizing the lowermost Rio Yaqui basin is the colorful Sinaloan cichlid (Fig. 70), which lives in quiet waters of the mainstream, creek mouths, and sloughs and

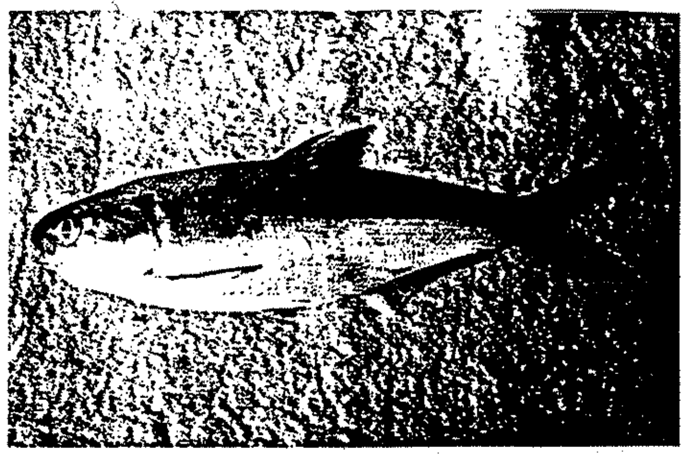


Figure 69. Pacific shad/*sardinita del Pacifico*, 17.8 cm in total length, from Marina del Rey, Presa Alvaro Obregon, Sonora. Status of this midwater, possibly estuarine species is speculative. It is known from scattered localities near the sea in western Sonora.

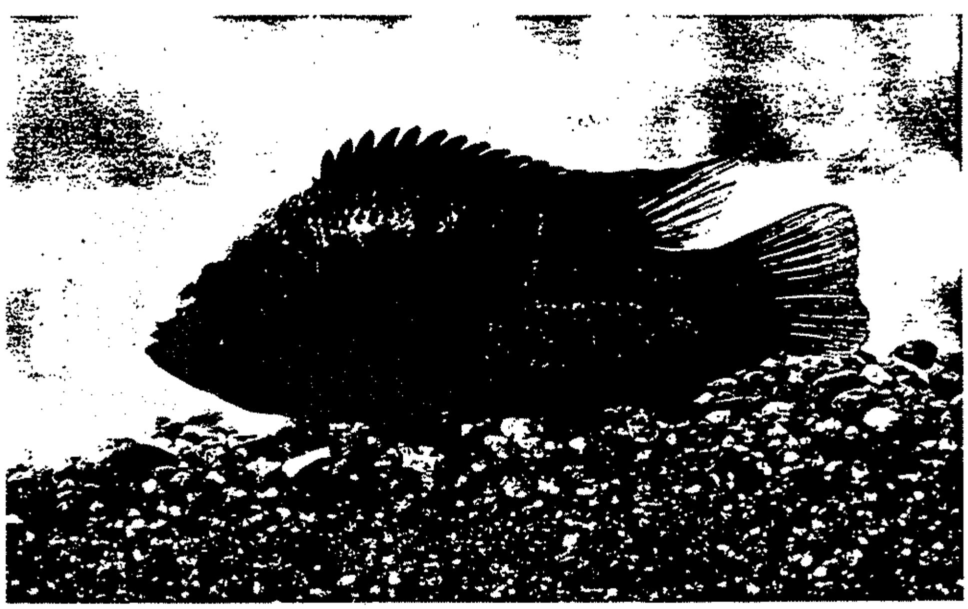


Figure 70. Sinaloan cichlid/*mojarra sinaloense*, 12.5 cm in total length, from Rio Chico, Sonora. Status of this species is unknown.

backwaters. Cichlids are tropical in d[illegible]bution, and the lower Rio Yaqui is the northernmost limit of natural occurrence of this group on the west coast of Mexico. Sinaloan cichlids attain lengths of at least 25 cm and weights of 0.5 kg. Nothing is known of its breeding habits, but most species of this group spawn in spring and summer. Young are aggressively guarded by a parent until large enough to fend for themselves. They then move to quiet vegetated areas to feed and grow. Cichlid species sometimes have highly specialized food habits, but Sinaloan cichlids appear to be generalists, feeding on detrital materials, invertebrates, and aquatic vegetation.

Marine Species

It would be remiss not to include a few marine components of the fish faunas of these two river basins, especially since aquatic communities of the deltas received essentially no study before they were highly modified or essentially destroyed by upstream developments. Most fish species from the Gulf of California scarcely penetrated the Colorado River upstream past the zone of tidal influence. Only striped mullet/*lisa* and Pacific tenpounder/*machete* moved far inland. The giant totoaba/*totoaba* (Fig. 71), endemic to the upper Gulf of California, spawns in the Colorado River estuary, and was an important commercial fish in the past. It has almost disappeared due to overfishing and likely as a result of changes following construction of mainstream dams in the United States.

A substantially lar[illegible] marine fauna existed on the Rio Yaqui delta. Striped mullet (Fig. 72) are common, and comprise a major resource for Mexican fishermen. Other kinds of mullets are present, reflecting the tropical influences in this more southern fauna. Sea trouts are present, and snooks come into distributaries and move as far upstream as the dam at Presa Alvaro Obregon, more than 100 km from the sea. Machete also is present, as are two marine catfishes.

The most upstream record for striped mullet in the Colorado River is near Blythe, California, about 300 km from the sea. Pacific tenpounder (Fig. 73) moved about half that distance, to near Yuma, Arizona. Both occupied the Salton Sea after it filled in 1905–07, but disappeared after a few years, presumably due to lack of reproductive success. Both species now move upstream in the Rio Yaqui to the insurmountable dam forming Presa Alvaro Obregon. There is no information on their distributions prior to construction of that dam. Machete rarely exceed 36 cm long in the lower Colorado River, but they achieve 91 cm or more in length in the sea. Its major prey are small plankton-feeding fishes such as anchovies that school in rich estuarine areas.

Striped mullet form a substantial part of the fish fauna in mouths of major tropical and subtropical rivers worldwide. They remain an important component of the deltaic fish community of the lower Colorado River, feeding mostly on detritus, finely divided organic materials that accumulate in quiet places. Mullet typically spawn in the sea, and

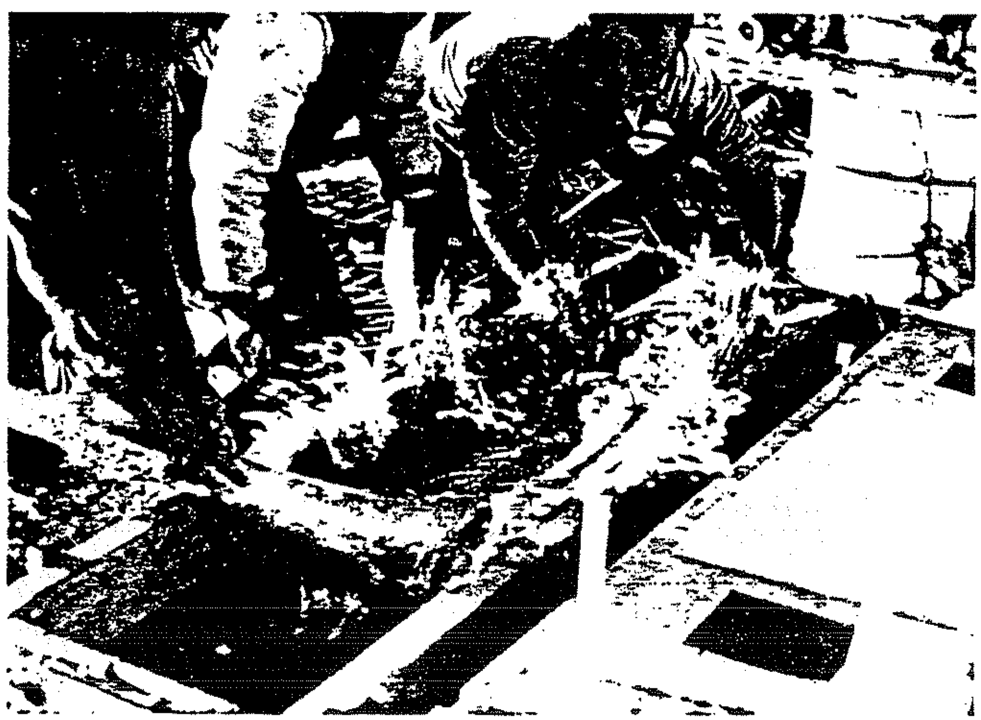


Figure 71. This photograph of a totoaba/*totoaba* being handled on a research vessel provides a perspective of the size of this giant endemic of the Gulf of California. Photograph provided by J. R. Hendrickson.

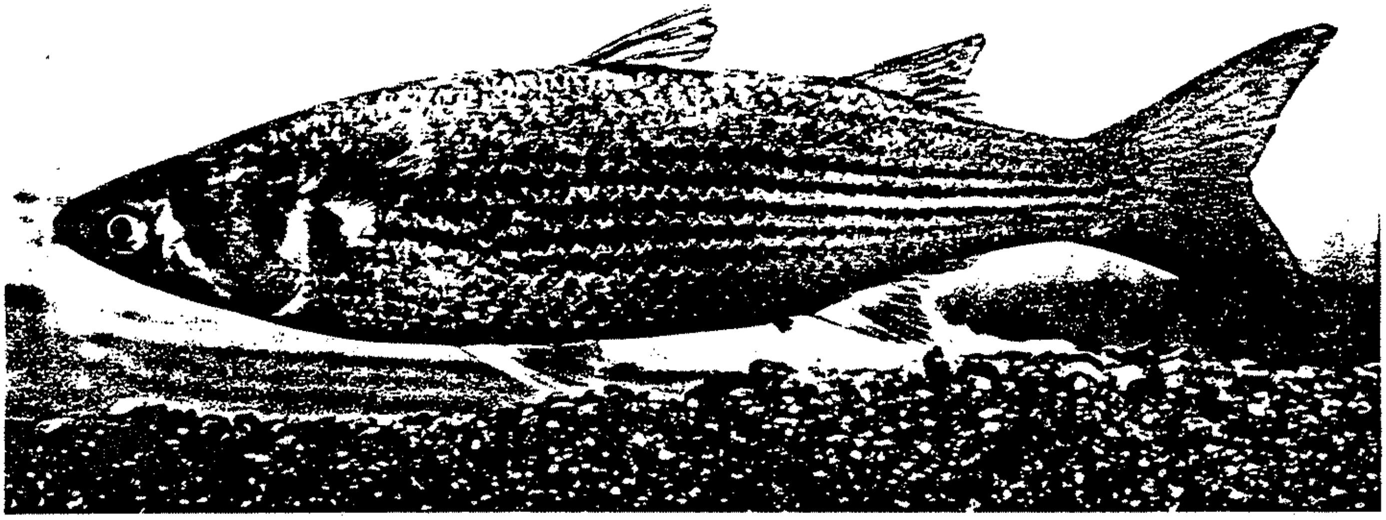


Figure 72. Striped mullet/*lisa*, 38 cm in total length, from Estuario de Santa Clara, Sonora. This predominately marine species enters the lower parts of major rivers throughout most of the tropics worldwide; it was not considered by the American Fisheries Society.

their young move into estuaries to feed and grow. Young individuals (to 15 cm total length) swarm in the Colorado River estuary; larger (presumably older) fish tend to move farther upstream when water is available. When adult (longer than 35 cm) they disappear from freshwater, moving back to the sea to reproduce.

Fishes of Desert Oases

Springs rising from subsurface sources sometimes form special aquatic habitats in deserts, which may be inhabited by equally special fishes. Springs occur where fractures in the earth allow deep waters to rise to the surface, or as points where water accumulating at higher altitude and percolating through porous strata emerges. Water from deep sources often is hot and charged with gasses and salts otherwise uncommon in a region. Others represent a simple intersection of a local water table with the land surface. Spring water is typically clear and constant in volume. Fishes living in such places have few environmental cues other than daylength—there are no spring floods or summer droughts, seasonal temperature changes, or changes in substrate or turbidity with which to deal. They may thus reproduce throughout the year and grow at a constant rate dependent on population size rather than physical factors.

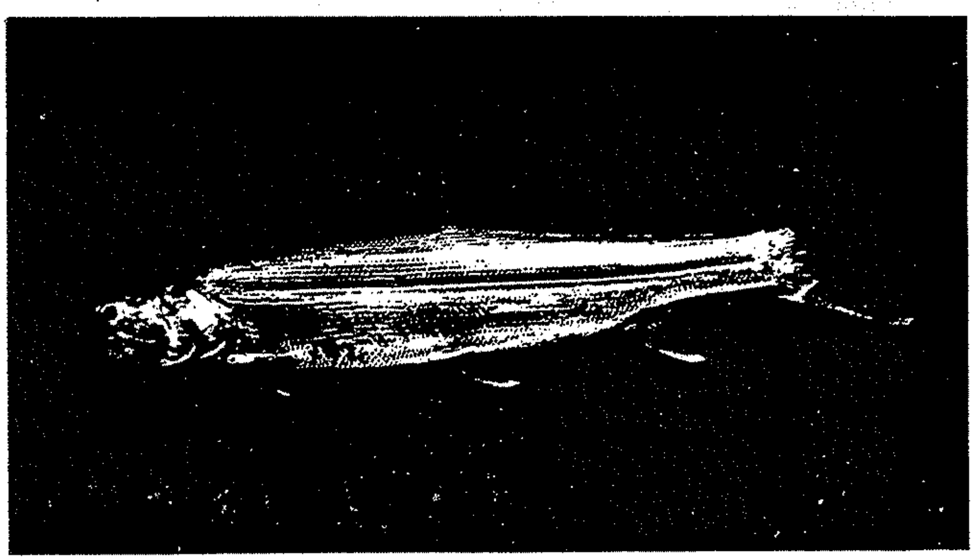


Figure 73. Pacific tenpounder/ *machete*, 15.0 cm in total length, from Estuario de Santa Clara, Sonora. This relative of the tarpon was not considered by the American Fisheries Society.

Relative inaccessibility and a time lag in construction of reservoirs in Mexico has isolated that region from introduced fishes. Populations of non-native fishes are only now becoming available to invade and populate Mexican watersheds, and interactions among introduced and native species in that country are only beginning. The bottom line is, when non-native fishes become dominant, native fishes disappear. This pattern has been repeated with minor exceptions throughout western United States, and may be predicted with confidence in Mexico.

This ends the presentation, with the hypothesis that biological interactions are the ultimate factor causing disappearance of native fishes in the United States, even where physical and chemical conditions resemble the natural state. The "how" of species replacement has been avoided, other than by pronouncement and inference, and is left to future research. Unique possibilities exist to test these ideas through experimentation under field conditions, and to apply the findings to perpetuation of native fishes and natural aquatic systems, if humans chose to do so.

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APPENDIX II. LIST OF COMMON AND SCIENTIFIC NAMES

NATIVE SPECIES

Tarpons and tenpounders, Family ELOPIDAE

Pacific tenpounder/*machete*	*Elops affinis*

Anchovies, Family ENGRAULIDAE

Shads, Family CLUPEIDAE

Pacific shad/*sardinita del Pacifico*	*Dorosoma smithi*

Salmons and trouts, Family SALMONIDAE

Apache trout	*Oncorhynchus apache*
Mexican golden trout/*trucha dorada mexicana*	*Oncorhynchus chrysogaster*
Gila trout	*Oncorhynchus gilae*
San Pedro Martir trout/*trucha de San Pedro Martir*	*Oncorhynchus mykiss nelsoni*
Yaqui trout/*trucha de Yaqui*	*Oncorhynchus* sp.[1]

Minnows, Family CYPRINIDAE

Longfin dace/*charalito aleta larga*	*Agosia chrysogaster*
Mexican stoneroller/*rodapiedras mexicano*	*Campostoma ornatum*
Ornate minnow/*sardinita ornata*	*Codoma ornata*
Beautiful shiner/*sardinita hermosa*	*Cyprinella formosa*
Humpback chub	*Gila cypha*
Sonoran chub/*charalito sonorense*	*Gila ditaenia*
Bonytail/*charalito eleganti*	*Gila elegans*
Desert chub/*charalito del desierto*	*Gila eremica*
Gila chub/*charalito del Gila*	*Gila intermedia*
Yaqui chub/*charalito Yaqui*	*Gila purpurea*
Roundtail chub/*charalito aleta redonda*	*Gila robusta*
Undescribed chub (Rio Yaqui)	*Gila* sp.
Pahranagat spinedace	*Lepidomeda altivelis*
White River spinedace	*Lepidomeda albivallis*
Virgin spinedace	*Lepidomeda mollispinis*
Little Colorado spinedace	*Lepidomeda vittata*
Spikedace	*Meda fulgida*
Moapa dace	*Moapa coriacea*
Woundfin/*charalito*	*Plagopterus argentissimus*
Colorado squawfish/*charalote*	*Ptychocheilus lucius*
Las Vegas speckled dace	*Rhinichthys deaconi*
Speckled dace/*pesecito moteado*	*Rhinichthys osculus* subspp.[2]
Loach minnow/*charalito adornado*	*Tiaroga cobitis*

Suckers, Family CATOSTOMIDAE

Yaqui sucker/*matalote Yaqui*	*Catostomus bernardini*
Cahita sucker/*matalote cahita*	*Catostomus cahita*
Sonoran sucker/*matalote sonorense*	*Catostomus insignis*
Flannelmouth sucker/*matalote*	*Catostomus latipinnis*

NATIVE SPECIES (Continued)

Leopold sucker/*matalote del Bavispe*	*Catostomus leopoldi*
Opata sucker/*matalote Opata*	*Catostomus wigginsi*
Little Colorado sucker	*Catostomus* sp.
Desert mountain-sucker/*matalote del desierto*	*Pantosteus clarki*
Bluehead mountain-sucker	*Pantosteus discobolus*
Rio Grande mountain-sucker/*matalote del Rio Bravo*	*Pantosteus plebeius*
Razorback sucker/*matalote jorobado*	*Xyrauchen texanus*

Ariid catfishes, Family ARIIDAE

Bullhead catfishes, Family ICTALURIDAE

Yaqui catfish/*bagre del Yaqui*	*Ictalurus pricei*

Livebearers, Family POECILIIDAE

Gila topminnow/*charalito*	*Poeciliopsis o. occidentalis*
Yaqui topminnow/*charalito*	*Poeciliopsis o. sonoriensis*
Common name unknown	*Poeciliopsis monacha*
All-female topminnow	*Poeciliopsis monacha-occidentalis*
Common name unknown	*Poeciliopsis prolifica*

Killifishes, Family CYPRINODONTIDAE

Desert pupfish/*cachorrito del desierto*	*Cyprinodon macularius*
Whitefin pupfish/*cachorrito aleta blanco*	*Cyprinodon* sp.
Monkey Spring pupfish	*Cyprinodon* sp.

Mexican livebearers, Family GOODEIDAE

White River springfish	*Crenichthys baileyi*

Mullets, Family MUGILIDAE

Striped mullet/*lisa*	*Mugil cephalus*

Cichlids or Mojarras, Family CICHLIDAE

Sinaloan cichlid/*mojarra sinaloense*	*Cichlasoma beani*

Drums and sea trouts, Family SCIAENIDAE

Totoaba/*totoaba*	*Cynoscion macdonaldi*

Snooks, Family CENTROPOMIDAE

NON-NATIVE SPECIES

Gars, Family LEPISOSTEIDAE

Bowfins, Family AMIIDAE

Pikes, Family ESOCIDAE

Northern pike	*Esox lucius*

Shads, Family CLUPEIDAE	
Threadfin shad	*Dorosoma petenense*
Salmons and trouts, Family SALMONIDAE	
Rainbow trout	*Oncorhynchus mykiss*
Cutthroat trout	*Oncorhynchus clarki*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Minnows, Family CYPRINIDAE	
Common carp	*Cyprinus carpio*
Grass carp	*Ctenopharyngodon idellus*
Red shiner	*Cyprinella lutrensis*
Golden shiner	*Notemigonus crysoleucus*
Fathead minnow	*Pimephales promelas*
Redside shiner	*Richardsonius balteatus*
Freshwater catfishes, Family ICTALURIDAE	
Black bullhead	*Ameiurus melas*
Yellow bullhead	*Ameiurus natalis*
Channel catfish	*Ictalurus punctatus*
Blue catfish	*Ictalurus furcatus*
Flathead catfish	*Pylodictis olivaris*
Sunfishes, Family CENTRARCHIDAE	
Green sunfish	*Lepomis cyanellus*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Smallmouth bass	*Micropterus dolomieui*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Temperate basses, Family PERCICHTHYIDAE	
White bass	*Morone chrysops*
Yellow bass	*Morone mississippiensis*
Striped bass	*Morone saxatilis*
Perches and darters, Family PERCIDAE	
Walleye	*Stizostedion vitreum*
Cichlids (tilapias), Family CICHLIDAE	
Blue tilapia	*Oreochromis aurea*
Mossambique mouthbrooder	*Oreochromis mossambica*
Zill's tilapia	*Tilapia zilli*

[1]This common name is applied, collectively, to trouts of Sonora and Chihuahua (rios Yaqui, Mayo, and Casas Grandes basins).

[2]Systematics of the speckled dace complex has defied interpretation for years. A number of subspecies are described, some of which are listed as imperiled, and others remain widespread and relatively abundant.

Arizona Riparian Inventory and Mapping Project

A report to the Governor, President of the
Senate and Speaker of the House

Arizona Game and Fish Department

Director
Duane L. Shroufe

Commissioners
Larry Taylor, Chairman
Beth T. Woodin, Vice Chairman
Arthur Porter
Nonie Johnson
Michael M. Golightly

December 1, 1993

Section IV

Riparian Areas and Wildlife Habitats

A. The Riparian Ecosystem

Although riparian areas cover only a small percentage of the landscape, they are among the most biologically productive of all lands. A basic knowledge of riparian ecosystems and the functions that occur within these systems is essential to understanding their biological importance.

An ecosystem can be defined as a discrete geographic unit of the landscape consisting of various biotic and abiotic components which are related through interchanges of chemical nutrients and energy (Collier et al. 1973, Bailey 1982). More simply, an ecosystem consists of a community of organisms together with its physical habitat. The boundaries of ecosystems are open and permeable to allow for the transfer of energy and materials to or from other ecosystems.

Riparian areas are found at the interface between terrestrial (upland) and aquatic ecosystems and, therefore, interact with both. Because of their transitional location within the landscape, riparian areas are especially complex. This transitional zone, or ecotone, is influenced by changes in upland activities as well as by changes occurring in the stream channel, lake or marsh bed. The biotic and abiotic components of the riparian system are inextricably linked to groundwater, surface water and hydrologic processes in the aquatic environment and to changes in vegetative cover, rates of erosion and surface water run-off in upland ecosystems.

Riparian systems can also be viewed as being connected linearly, forming corridors along the network of water courses within a watershed. These water courses provide a means of transferring energy, nutrients, genetic material and abiotic components along the system. The associated riparian area provides natural travel corridors for wildlife movement and a linear patchwork of wildlife habitats that, in desert areas, is dramatically different than the adjacent upland vegetation (Figure 29). These travel ways keep areas from becoming reproductively isolated.

The linear connectedness and the ecotonal nature of riparian areas illustrate the principle that changes in one part of the system may directly influence other parts of the system. In other words, a stand of riparian vegetation is influenced by surface and ground water, flood events, nutrient availability, the actions of invertebrates and wildlife, adjacent land uses and numerous other components. Because one aspect cannot and should not be viewed in isolation of other components, riparian areas should be examined within the context of the entire watershed.

Riparian areas are intimately tied to the watercourse along which they are located. As dynamic features of the landscape, they are constantly adjusting in response to geologic and hydrologic forces (Brown et al. 1978). Disturbances of both upland and fluvial origin, such as flood and

Figure 29. Cienega Creek in Pima County, Arizona supports a corridor of riparian vegetation that winds through semi-desert grasslands.

debris flows, affect riparian areas. Some of the hydrologic forces influencing riparian ecosystems are:

1) periodicity and duration of flow (surface and groundwater),
2) depth and fluctuation of the water table,
3) interaction of regional and local groundwater flow systems,
4) rate of surface flow,
5) chemical composition of inflows (both surface and groundwater) and
6) temperature of the water and surrounding environment (Cooper et al. 1990).

Geologic influences include:

1) depth of valley alluvium and degree of channel cutting,
2) width of valley floor,
3) valley and stream channel gradients,
4) channel sediments and floodplain soils and
5) interaction of regional water table with local aquifers and the topographic surface (Cooper et al. 1990).

Geomorphic events include debris flows, sediment transport, scouring, sediment deposition, channel migration and erosion.

Understanding disturbance is critical to understanding riparian ecosystems primarily because ecologically diverse areas are maintained by these natural disturbances (Naiman 1992). Because the biotic community found in riparian ecosystems has had to adapt to constantly changing conditions, a high degree of ecological diversity results (Kalliola et al. 1992). The high degree of diversity in riparian areas is particularly evident in the vegetative communities found there. Numerous studies of vascular plants in riparian areas show unusually high levels of biodiversity (Nilsson 1986, Salo et al. 1986, Kalliola and Puhakka 1988, Nilsson et al. 1989, Raedeke 1989, Tabacchi et al. 1990, Gregory et al. 1991, Kalliola et al. 1992, Nilsson 1992, Decamps and Tabacchi 1993, Naiman et al. 1993, Stromberg 1993a). One explanation for this apparent diversity is that riparian vegetation occupies one of the most dynamic areas of the landscape. Distribution and composition of riparian vegetative communities reflect:

1) the intensity and frequency of floods;
2) variations in climate as streams flow from high to low altitudes or across biomes;
3) disturbances imposed on the riparian corridor by upland environments (debris flows, erosion), and;
4) small-scale variations in topography and soils as a result of lateral migration of river channels (Naiman et al. 1993).

Collectively, these forces create a mosaic of plant communities and provide a variety of habitats in which a diversity of species are able to co-exist. Plant species richness and diversity tend to greatly influence terrestrial and aquatic wildlife.

Factors influencing the composition, size and function of riparian areas are also found to change with elevation. The Brown, Lowe and Pase (1979) classification system described in Section I, can be used to classify riparian plant communities according to where they are located on a valley longitudinal profile. For instance, in the upper reaches of a valley, channel gradients tend to be steep and stream energy is high. Very little sediment deposition occurs so floodplains and riparian ecosystem development is minimal, usually occurring in narrow bands along the stream corridor. The vegetation is dominated by scrub willows with conifers and aspen invading from the adjacent uplands (Neff et al. 1979). At high elevations where valley gradients level off, wet meadows are often formed. Some of these wet meadows are spring-fed and occur at the base of mountains. They tend to be too wet for major tree encroachment and are dominated by a mix of grasses, sedges and an assortment of forbs (Subirge no date).

The mid-portion of the stream is characterized by the development of a narrow but distinct floodplain. Within this zone, the floodplain tends to constantly adjust to changes in channel aggradation and degradation processes (Cooper et al. 1990). These areas may be vegetated by either mixed broadleaf deciduous communities or cottonwood-willow communities (Neff et al. 1979). Cave Creek and Turkey Creek in the Chiricahua Mountains are examples of this zone.

At lower elevations, the stream gradient levels out and sediment depositional processes dominate. It is within this area where the floodplain reaches its maximum development. Large streams or rivers that occur lower in the watershed are characterized by larger and more diverse vegetative communities that develop in response to wide, geomorphically complex floodplains. These broad floodplains are formed by hydrologic and geomorphic processes that result in seasonal flooding, lateral channel migration, sediment deposition or aggradation, and formation of backwaters and marshes (Naiman 1992). They tend to be dominated by cottonwood-willow communities and mesquite bosques. In disturbed systems, cottonwood-willow may be replaced by salt cedar. In Arizona, the San Pedro River and the lower Verde River provide excellent examples of this type of riparian corridor.

We begin to see, then, that ecological linkages between the terrestrial and aquatic ecosystems occurring in riparian areas take place within the context of the fluvial and geomorphic processes that occur there. Modification of landforms by the actions of these processes may occur slowly over long periods of time or may occur as large-scale, episodic events. Their spatial scale may range from a localized shift in a stream channel to a basin-wide flood event. The result of these events is the mosaic of landforms that characterize riparian areas such as stream channels, floodplains, channel bars, terraces and alluvial fans. In fact, the shape and area of each of these features is directly influenced by its location within the drainage network, the amount of streamflow and local geology and geomorphology (E. Swanson et al. 1988).

Component processes of riparian ecosystems take on a pattern of interdependency with geomorphic and hydrologic factors influencing development of riparian vegetation, and riparian vegetation influencing the animal community, hydrologic and geomorphic factors. The following statements illustrate these relationships. Disturbances and processes within the ecosystem determine the spatial pattern and successional development of riparian vegetation. In the presence of sufficient water, riparian area development increases as the width and depth of valley alluvium increases (Cooper et al. 1990). Valley floor landforms and associated riparian vegetation form an array of physical habitats within the active channels and floodplains. The streamside plant communities that occupy these habitats determine the abundance and quality of nutritional resources for aquatic ecosystems (Gregory et al. 1991). Riparian vegetation, in turn, influences the evolution of geomorphic surfaces. Networks of roots from grasses and woody vegetation that cover the banks of streams and lakes increase resistance to erosion. Aboveground stems of streamside vegetation increase channel roughness during overbank flow and may decrease the erosive action of floods and actually cause deposition of sediment. This interrelatedness between riparian vegetative communities, and fluvial and geomorphic processes characterizes the riparian ecosystem. The complexity of relationships that exists between riparian areas and adjacent streams and uplands makes it mandatory that any assessment of riparian areas be based on an ecosystem approach, evaluating the total functional condition of the system as opposed to a singular component.

The ADWR report mandated by this legislation (ADWR 1993) addresses the relationships between riparian vegetation and hydrology including the effects of changes in water availability and streamflow on riparian vegetation. It is our intent to present information in this section that supports the ADWR report, but that focuses more heavily on relationships between riparian areas and wildlife.

B. Functions and Values of Riparian Areas

Factors that affect landform, and vegetative and wildlife diversity consequently influence the diversity of functions occurring within a riparian area (Naiman et al. 1993). These factors are the key to functional assessment of riparian areas. The term "functions" refers to biological, chemical, or physical processes that occur in riparian areas and wetlands as a result of the geomorphic, topographic, physiographic and hydrologic position in the landscape (Jakle 1991). Functions are part of the self-sustaining properties of the ecosystem. They operate within a riparian area whether or not they are viewed as important to society (Adamus et al. 1991). Some functions may also have a corresponding societal value. However, "value" denotes the social significance of an attribute. This dichotomy is the origin of the commonly used phrase "functions and values."

Some examples of riparian values include importance to wildlife, recreation, scenic and aesthetic qualities, water quality, commercial/agricultural activity, waterborne commerce and urban development. Because values are determined by society, this factor is subject to change over time as societal views of resource values change. Therefore, it is important to separate out the evaluation of function and the determination of value. Functional assessment should be firmly grounded in the natural and physical sciences. Indicators of value should be developed by the appropriate discipline (i.e., economic indicators are quite different from biological indicators.).

Some functions of riparian areas are very well understood while others may be virtually unknown. Much of the discussion about functions of riparian areas has been inferred from research on wetlands or more mesic riparian ecosystems. The Wetland Evaluation Technique (WET) developed by the U.S. Army Corps of Engineers (COE) is an example (Adamus et al. 1991). The technique is a rapid approach to wetland evaluation based on information about correlative predictors of wetland functions. Predictors, or indicators, are based on extensive review of wetlands research. Because this technique was created for nationwide application, it did not take into account regional variations in wetlands and riparian areas.

Riparian areas in the arid and semi-arid Southwest sometimes "behave" differently than riparian areas in the eastern, midwestern and coastal areas. In actuality, these "behavioral differences" are the result of the system's response to a unique set of climatic, ecologic, hydrologic and geomorphic factors influencing the ecosystem. Consequently, scientists and land managers have had to exercise caution in applying studies conducted on wetlands or riparian areas that developed under one set of conditions to areas that developed under a different set of conditions.

One of the most complete evaluations of existing data on riparian functions in western ecosystems was conducted by Cooper et al. (1990) for the U.S. Environmental Protection Agency (EPA). The study first assessed the extent of scientific literature that exists on the subject of riparian area functions in the Intermountain West. This exercise was followed by a discussion of the functions and values associated with wetlands, as listed in WET (Adamus et al. 1991) and an evaluation of their applicability to western riparian areas. In addition, the study discusses whether there are sufficient scientific data to suggest that riparian areas perform a particular function and how to evaluate that function.

Cooper et al. (1990) attributed the following broad classes of functions to riparian areas:

1) sediment stabilization;
2) water quality functions;
3) production export;
4) flood flow alteration;
5) groundwater recharge/discharge, and;
6) terrestrial wildlife and aquatic diversity/abundance.

Both Cooper et al. (1990) and Adamus et al. (1991) provide detailed discussions regarding these functions. For purposes of this report, a brief description of each function is presented below. This is by no means a comprehensive summary of riparian and wetland functions. For additional discussions on riparian and wetland functions and values, the reader is encouraged to review Brown and Lowe (1978), Jahn (1978), Knight and Bortorff (1984), Soil Conservation Service (1987), DeBano and Schmidt (1989), Chaney et al. (1990), Williams (1990), Brinson (1992), Pitt (1992), and Finch and Ruggiero (1993).

1. Sediment Stabilization

Sediment stabilization includes consideration of two processes. The first is the removal of sediment from the water column and the second is the prevention of sediment from entering the water column. Sediment removal is accomplished through bed load or suspended sediment deposition within the channel or through overbank flooding. The type and density of riparian vegetation, both on the bank and in the channel, increases channel roughness which decreases the velocity of water, slowing erosion and enhancing deposition of sediments. Other factors affecting channel roughness are bed material, channel geometry, obstructions and degree of meandering.

Sediment contributions to a stream are typically from bank erosion and surface runoff. Riparian areas may modify water quality impacts from other stream reaches or upland areas by assisting the processes of sediment deposition, removal and filtration. Riparian vegetation plays an important role in preventing sediment deposition into the stream channel by stabilizing stream banks and stream beds. Trees and shrubs are excellent protectors of bank soil because their roots penetrate deeply and often provide a physical barrier between the stream and soil. Rushes, sedges and reed grass are especially effective in stabilizing submerged soil while reducing the erosive impact of waves and stream current (Seibert 1968).

Buffer strips of riparian vegetation serve to trap sediments from upland erosion reducing the amount that enters the stream. The width necessary for effective filtering (buffer zone) depends on characteristics of both the erosional area and the buffer area. In the riparian area, type and distribution of ground cover, slope and resistance of the buffer zone to deterioration are factors important to buffer zone effectiveness.

2. Water Quality Functions

Water quality functions include retention and removal of sediments and toxins as well as retention and transformation (cycling) of nutrients. Some wetlands and riparian areas accomplish these functions on either a net annual basis or during the growing season by:

1) physically or chemically trapping and retaining inorganic sediments;
2) physically or chemically trapping and retaining chemical substances generally toxic to aquatic life;
3) retaining or transforming inorganic phosphorus into an organic form;
4) retaining or transforming nitrogen into an organic form or transforming (removing) nitrogen into a gaseous form (Cooper et al. 1990).

Removal of metals from the water column requires processes such as ion exchange and adsorption to sediments and dissolved organic matter, precipitation as oxides, pH changes, and plant and microbial uptake (Cooper and Emerick 1987, Cooper et al. 1990).

Large quantities of nitrogen in the water column can result in degraded water quality through promotion of algal blooms and enhancement of populations of undesirable species (Sather and Smith 1984). The primary mechanism for removal is nitrification or denitrification by bacteria. Nitrogen compounds are effectively removed by saturated, low gradient wetlands where nutrients come into contact with reduced, fine-textured or organic soils (Cooper et al. 1990). It is not known whether well-drained, sandy alluvial soils along streams and rivers support this function. However, according to Skinner et al. (1984), soils near stream edges, even along high gradient streams, are usually wetter, with more abundant organic matter and little dissolved oxygen, and may be important sites for the regulation of nutrient inputs into surface waters. Thus, while the main portions of riparian forests and floodplains do not perform nitrogen removal functions, smaller portions of these ecosystems may.

3. Production Export

Production export pertains to the flushing of organic plant material from wetland and riparian lands into streams. The plant material is a food source for aquatic organisms. According to Cooper et al. (1990), very few studies address key questions on the value of riparian vegetation for food chain support. Research points to the importance of debris dams and other retention devices such as boulders, branches and roots in retaining litter in the streams where it can be processed to support large populations of aquatic insects. Beavers can also play an important role in retaining sediment and organic matter, thereby reducing the amount of nutrients going downstream.

4. Flood Flow Alteration

Flood flow alteration refers to the storage of water on or in the floodplain and or alteration of its velocity. The primary result of flood flow alteration is a reduction in downstream flood peaks and decreased frequency of downstream overbank flooding. This process can also result in an improvement in water quality as sediments are deposited outside the stream channel where they can be stabilized. Cooper et al. (1990) state that there are only a few reports on observed effects of riparian lands on flood flows. However, they present a number of methods to calculate flood flows at gaged and ungaged sites using various models and techniques. Characteristics or measurements used to calculate or estimate flood flows include stream type, source of flood (e.g., snowmelt, thunderstorm, etc.), drainage area, mean basin elevation, average annual precipitation, basin slope, bankfull width and land use.

5. Groundwater Discharge/Recharge

Groundwater discharge occurs when there is a net movement of groundwater to the surface. Groundwater will discharge into a riparian area when the regional or local water table is higher than the surrounding water table (Cooper et al. 1990). When this discharge occurs in a riparian area or wetland, the alluvial soils have the ability to store the water. It is then slowly released to surface systems (streams or marshes) at low water periods. The overall effect on low flows will depend on the amount of surface storage area available in the soils or alluvium.

Groundwater recharge is the net movement of surface water into groundwater. The groundwater may be at a considerable depth, such as a regional aquifer. In the arid and semi-arid Southwest, recharge to the alluvium tends to occur during high flow events. In mountainous areas, snowmelt is an important factor in providing a large and consistent supply of water for streamflow and recharge into alluvial aquifers.

6. Terrestrial Wildlife and Aquatic Habitat

Distinctions between wildlife functions and wildlife values are often clouded by incorrect use of terms in the literature. Wildlife may perform or support certain processes within the context of the ecosystem. This is a function. However, riparian areas may be valued for providing high quality wildlife or fisheries habitats. For this discussion, we group wildlife and fisheries diversity and abundance with riparian functions because of the precedent set by Adamus et al. (1991) and Cooper et al. (1990). This choice is due to the fact that development of indicators of wildlife diversity and abundance are based in the natural and physical sciences, as are other functional indicators, and are formulated in a similar manner.

Wetland and riparian areas are very productive ecosystems and provide important habitat for many wildlife species in Arizona (Brown et al. 1979, Ohmart and Anderson 1982, Anderson and Ohmart 1984). That productivity and importance is at least partly a reflection of the availability of water and rich alluvial soils. The combination of water and soils sets the stage for development of potentially diverse and structurally-complex vegetative communities. Structural diversity (different layers of vegetation, different ages of plants, and ground litter) in the plant community provides a wide diversity of habitats for wildlife (Kupchella and Hyland 1986).

Riparian areas provide many critical life support functions for wildlife. They may provide habitat components dealing with defense, escape cover, food or prey, feeding substrate, nest or birthing substrate, reproduction, resting substrate, and temperature regulation (Jones 1986). Different wildlife species require different situations to meet their specific habitat needs. Because of vegetative diversity and close proximity to water, riparian areas typically provide a wide variety of habitat components. Riparian areas, therefore, typically meet the needs of more wildlife species than the adjacent upland areas.

Some species of wildlife are tied to riparian areas throughout their lives (obligates), while others only depend on them during certain periods of their lives (facultative). Ohmart and Anderson (1986) report that more than 60 percent of vertebrates in the arid Southwest are obligate users of riparian areas. Another 10 to 20 percent are facultative users.

Obviously, fish require water, but they are dependent upon riparian areas for more than just water. Shade, escape and hiding cover, and food items (insects and organic debris) may be products of the surrounding riparian plant community (Meehan et al. 1977, Wesche et al. 1985). Indeed, the capability of streams to produce or support fish often is correlated with condition of riparian vegetation (Cuplin 1986). Riparian vegetation is an important food source for stream organisms (Mahoney and Erman 1984). Macroinvertebrates that consume aquatic vegetation and detritus provide fish with most of their food (Cuplin 1986). Leaf fall provides much of the detritus found in streams.

Amphibians are dependent on water for reproduction, but other life support functions may be provided by either water or the surrounding riparian area (Jones 1986). In the Sonoran Desert, about 80 percent of amphibian species are obligate or facultative users of riparian areas (Ohmart and Anderson 1982). Some reptiles are also tied to riparian areas during their life cycles (Jones and Glinski 1985, Jones et al. 1985). Of these, only two turtle species, one lizard species, and three snake species are considered riparian obligates (Ohmart and Anderson 1982). Reduction of naturally-occurring water and modification of habitats has been shown to affect composition of reptile and amphibian species in riparian areas (Jones 1988).

A number of studies have shown that riparian areas support very high densities of breeding birds, including neotropical migrants (Carothers et al. 1974, Anderson and Ohmart 1984, Johnson and Jones 1977, Hehnke and Stone 1978). The bald eagle, common black-hawk, gray hawk and zone-tailed hawk are four raptor species in Arizona that are dependent on riparian areas for nesting and foraging (Ohmart and Anderson 1982, Kochert 1986).

For some mammals, the presence of running water is more important than the associated plant community. Species dependent on perennial water include river otter, beaver, muskrat and water shrew. Associated with riparian areas but less dependent on water are some bats, ringtail cat, raccoon, Arizona gray squirrel and Apache-fox squirrel (Minckley and Brown 1982, Hoffmeister 1986). Beaver dams create conditions that increase growth and vigor of woody riparian species that, in turn, provide important habitat for breeding birds and other animals (Stromberg 1993a).

Not all riparian areas provide habitat for all wildlife. First, because they differ in plant species composition, in maturity, and in degree of disturbance, riparian areas differ in what habitat components they may provide. Second, animal species differ in what habitat components they require. Because of this, riparian areas are not equal wildlife habitats. It is difficult to assign ranking to riparian areas because habitat value varies according to which animal guild or species is selected for evaluation. The same riparian area may be excellent habitat for a particular species, but totally unsuitable for another species. Since riparian areas are mosaics of diverse plant communities, they provide some habitat components for most wildlife species most of the time. Following are examples of how riparian areas differ in providing wildlife habitat.

Cottonwood-willow riparian communities are generally recognized as being important habitat for nesting birds and neotropical migrants (Carothers et al. 1974, Ohmart and Anderson 1982, Anderson and Ohmart 1984). Tree species diversity in Sonoran cottonwood-willow riparian communities is low, but age class and structural diversity is high. And often these communities support an understory assemblage of plants that is more diverse than other riparian types (Stromberg 1993a). Reduction in the diversity of size and age classes adversely affects the abundance and diversity of birds and mammals that require a particular strata within the canopy (Ohmart and Anderson 1986). Some animals (e.g. yellow-billed cuckoo and blue-throated hummingbird) are almost entirely restricted to cottonwood-willow communities (Neff et al. 1979).

Mesquite bosques typically have three vegetational strata that include a tree canopy, a shrub and vine stratum, and an herbaceous understory (Stromberg 1993b). High diversity of plant species and high density of foliage at many heights contribute to an abundance and diversity of the avian community associated with bosques (Ohmart and Anderson 1986). Bosques have high productivity that is partly expressed by the production of abundant flowers and fruits. Flowers support a great number of insects that provide food over a long period of time for birds, bats and other animals. Fruits provide abundant and highly nutritious food for mammals such as javelina, coyote and cattle. Most mammals use a variety of habitats, but the range of at least one species (mesquite mouse) is restricted to mesquite bosques (Stromberg 1993b).

Interior mixed broadleaf communities typically occur at elevations above the previous two riparian communities. They consist of a wide variety of broadleaf trees such as walnut, ash, sycamore, and alder interspersed in varying degrees with oaks and conifers from adjacent mountains (Minckley and Brown 1982). Intensive wildlife studies are generally lacking for this riparian community, but numerous wildlife species are totally or primarily dependent on it (Neff et al. 1979). For example, the Arizona gray squirrel and Apache fox squirrel are largely confined to mixed broadleaf forests (Minckley and Brown 1982).

Wildlife relationships with riparian scrub communities are also poorly investigated, but there appears to be considerable interaction with animal populations from adjacent upland areas (Neff et al. 1979). For instance, thickets in low elevation riparian areas often support high densities of upland game species such as desert cottontail and Gambel's quail (Minckley and Brown 1982). Tamarisk (saltcedar) may dominate some riparian scrub communities and generally provides poor habitat for most wildlife species because there is low plant diversity, low canopy height, and low structural complexity (Rosenberg et al. 1991). Willow thickets at high elevations, on the other hand, may support a diverse bird community during part of the year (Carothers 1968).

C. Development of Indicators - A Methodology for Rapid Assessment of Riparian Area Wildlife Values

According to Cooper et al. (1990), to determine whether an area is supporting a particular function, the function (1) can be directly measured, (2) can be deduced from site specific data, or (3) inferred from the system's membership in a particular category. For example, nesting habitat for a neotropical migratory bird species may be implied if (a) a nesting pair of birds was observed, (b) suitable characteristics for a nesting site as well as abundant food supplies were observed, or (c) the area was categorized as a cottonwood-willow gallery forest, known to be preferred as nesting sites for this species. Obviously, the potential for error increases with the type of generalization applied.

Direct measurement of many of functions described in the previous section can be a time-consuming and expensive endeavor. Therefore, functions are often deduced from the characteristics of a site or inferred from scientific measurements made on a similar area. The broader levels of analysis (types 2 and 3, above) may require evaluation of more features or characteristics than the straight-forward measurement. Yet, this broader type of approach can be very effective in differentiating and identifying functional processes and attributes.

Assessment of functions at a broad level often involves the establishment of indicators. Indicators are features or characteristics which have a known or hypothetical correlation with an item or event of interest. Indicators are not intended to replace general knowledge about characteristics of an area, but rather to provide shortcuts to predicting whether a process is occurring or whether it has the potential to occur. Establishment of a reliable indicator requires verification through research and testing (direct measurements). Once a correlation is established between a functional process and its effect on the system, and the process is well understood, then indicators of a functional process can be identified.

Riparian evaluation procedures used by the EPA, COE, USFS and the BLM all depend on the application of indicators to varying degrees. In addition, these approaches each acknowledge the utility of the three levels of assessment ranging from general to specific, as listed above. In fact, USFS and BLM approaches structure their data collection and evaluation to reflect these levels. Data collection proceeds from the more general to the more specific, with evaluation occurring at whatever level of specificity is required for a particular application. The decision to pursue a general level evaluation over a specific level is typically driven by the purpose or objectives of the evaluation. That is, the type of evaluation applied will depend on the scale of the endeavor (statewide, regional, local), the necessary precision or accuracy, the time frame